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Contents

Explanatory notes

- Three dots (...) indicate that data are not available or are not separately reported.
- A dash (-) indicates that the amount is nil or negligible.
- A full stop (.) is used to indicate decimals.
- The word “dollars” refers to United States dollars, unless otherwise specified.
- A slash (/) between years (e.g. 2013/2014) indicates a 12-month period falling between the two years.
- Individual figures and percentages in tables may not always add up to the corresponding total because of rounding.

International financial cooperation to address the Latin American economic crisis[1]

José Antonio Ocampo

Abstract

The current economic crisis will be remembered, not only as the worst since the Great Depression, but also for the limited multilateral financial cooperation agreed, particularly for middle-income economies. Several Latin American countries have benefited from flexible and emergency credit lines from the International Monetary Fund (IMF), in addition to other IMF instruments. Members of the Latin American Reserve Fund (known by its Spanish acronym, FLAR) can access its resources. Multilateral development banks have taken steps to support Latin American countries, but resources are limited. The Inter-American Development Bank (IDB) and the Development Bank of Latin America (CAF) have reached their lending capacity limit and need to be capitalized. The World Bank has increased its lending to the region, but these loans amount to less than those granted in 2009–2010. The actions of the Central American Bank for Economic Integration (CABEI) are noteworthy, thanks to its recent capitalization.

Keywords

Economic crisis, international financial institutions, development banks, international cooperation, external debt, Latin America

JEL classification

F34, F55, G15, O19

Author

José Antonio Ocampo is a Professor at School of International and Public Affairs of Columbia University. Formerly, he was Under-Secretary-General for Economic and Social Affairs of the United Nations, Executive Secretary of the Economic Commission for Latin America and the Caribbean (ECLAC) and Minister of Finance of Colombia. Email: ocampo.joseantonio@yahoo.com.

[1] This paper was prepared for the United Nations Development Programme (UNDP) and published as part of its *COVID-19 Policy Documents Series* (UNDP LAC C19 PDS N°7). An updated and slightly shorter version is published here. Given the speed with which the situation is evolving, it is analysed in the light of the information available and policy decisions taken up to 1 June 2020. The author wishes to thank Marcela Meléndez and Miguel Ángel Torres for their comments on previous versions, and María Luisa Montalvo and Víctor Alejandro Ortega for their collaboration on its drafting.

I. Introduction

The coronavirus disease (COVID-19) pandemic, the worst in a century, has engendered a global economic crisis that has been described by the Managing Director of the International Monetary Fund (IMF) as the worst recession since the Great Depression of the 1930s (Georgieva, 2020). The containment measures, adopted to manage the public health problems, have had a profound effect on the economy, as they have paralysed "non-essential" activities, which may account for 50% or more of economic activity in many countries. The turmoil in the financial markets has also been profound and prompted the worst flight in history of portfolio capital from emerging economies, although the markets have recovered somewhat recently. At the same time, international trade has contracted sharply, deepening the process that had already started in late 2019 as a result of the global economic slowdown and the "trade wars", especially between the United States and China. In addition to this, the prices of an important group of commodities have dropped, reinforcing the negative trend seen over the last five years. Exports of services have also fallen, due in particular to the paralysis of tourism and air passenger traffic. In addition, remittances from migrant workers to their countries of origin will plummet and new controls are being imposed on international migration.

The pandemic arrived relatively late in Latin America, but began to have significant effects in terms of infected people and the mortality rate in several countries, especially Brazil.[2] In economic terms, the pandemic hit the region after five years of slow economic growth, which can be described as a "lost half-decade" (Ocampo, 2020). Apart from the direct impact of the containment measures decreed in several countries, or those that people have adopted voluntarily to protect themselves, the economies of the region are also feeling the effects of the global crisis. Latin America will suffer the steepest drop in economic activity in the developing world, echoing the pattern that it has experienced in recent decades, although with varying effects among the different countries. The 2020 recession will, moreover, be the worst since the Second World War, and there is thus the danger (and almost the certainty) that the lost half-decade will be turn into another lost decade.

Against this adverse backdrop, international economic cooperation has been very weak so far, in contrast to the strong multilateral collaboration led by the Group of 20 (G20) during the North Atlantic financial crisis of 2008–2009.[3] This article analyses the discussions surrounding and the decisions taken on international financial cooperation and the extent to which it benefits Latin America.[4] The article is divided into six sections, the first of which is this introduction. As a background, section II offers some considerations on the global context as well as that of Latin America. A general analysis of international financial cooperation is presented in section III. The analyses of monetary cooperation and the support from multilateral development banks and their impact on Latin America are discussed in detail in sections IV and V. Some brief conclusions are set out in section VI.

Academics have made enormous contributions to the ongoing discussions.[5] I am unable to do them justice here, although I will refer to proposals made by some authors. The analysis will be rooted in the international discussions of and decisions taken by the major multilateral agencies to address the financial problems faced by emerging economies.

[2] See the updates by IDB on the spread of the pandemic in the region in IDB (2020).

[3] I prefer this term to the more commonly used "global financial crisis" because, although its effects were global, the crisis was concentrated in the United States and Western Europe.

[4] My analysis of Latin America does not include Cuba, which is not a recipient of the international financial cooperation under analysis, or Haiti, which is, but through special mechanisms for very low-income countries, to which I make only marginal reference. The Bolivarian Republic of Venezuela also faces particular problems in its dealings with some of the international financial institutions mentioned throughout this article.

[5] See, among many others, Baldwin and Weder di Mauro (2020), Levy (2020), Stiglitz and others (2020), and my contributions with other colleagues in Gallagher, Ocampo and Volz (2020), Gallagher and others (2020), and Griffith-Jones, Marodon and Ocampo (2020).

II. The global and Latin American context

The recent IMF World Economic Outlook (IMF, 2020a) report projects a decline in global gross domestic product (GDP) based on market exchange rates of 4.2% in 2020.[6] This is the result of falls of between 5% and 7% in the major developed economies and 5% or more in the emerging and developing economies, with Latin America as the worst performing region among the latter group of countries. The sharp downturn reflects the devastating effects of the pandemic containment measures on economic activity: quarterly contractions that were already severe in the first quarter[7] and that may reach double digits in many economies in the second quarter. The basic IMF forecast assumes that these effects will gradually dissipate, but clearly there is uncertainty as to whether there will be the medical means to prevent further outbreaks.

This crisis, which is truly global in scope, will certainly be more severe than that suffered by the global economy during the North Atlantic crisis (-2.0% at market exchange rates in 2009, according to IMF figures), which did not occur in a large group of emerging and developing economies. Compared to the Great Depression, the current economic contraction has happened more quickly, but may be less deep and, above all, less protracted.[8] The basic IMF projection is that growth will be 5.4% in 2021, which would more than offset the 2020 recession, although not in all countries. However, if it takes longer than expected to contain the pandemic, IMF estimates that global output would be an extra 3% lower in 2020, and, if this is combined with a second outbreak in 2021, output would be almost 8% lower than projected in 2021.[9]

In light of this, developed countries have been adopting aggressive measures in terms of increasing public spending, reducing or delaying tax payments, and providing liquidity, and credit lines and guarantees for the business sector. In both fiscal and monetary terms, IMF concludes that the packages are stronger than those adopted to deal with the North Atlantic crisis, although with differences between countries (IMF, 2020b and 2020c). By contrast, China's recovery measures have been less pronounced than those adopted in 2009, because it has a smaller fiscal margin today, an issue that affects many emerging and developing economies more generally.

Initially, the effects on the financial markets were devastating. However, thanks to the central banks' forceful interventions, the market falls were less pronounced than in 2008–2009, and even led to a partial recovery from late March (IMF, 2020b). A notable effect was the worst portfolio outflows from emerging economies in history, exceeding US$ 100 billion (Brooks and Fortun, 2020 and IMF, 2020b). However, as will be seen in section IV, although risk spreads for these economies have remained high, bond yields and the cost of new financing have fallen to relatively moderate levels thanks to the decline in benchmark interest rates (those of United States Treasury Bonds), and several countries began to issue bonds on the international markets in mid-April, much sooner than in past crises.

Another effect of the crisis has been a sharp contraction in international trade. Trade volumes and value, which began to fall in late 2019, have plunged further.[10] The World Trade Organization (WTO, 2020) expects that trade volume will fall by between 13% under the baseline scenario and 32% under the most pessimistic one. The crisis may lead to the destruction or shortening of many international value

[6] The IMF headline estimate is -3.0%, calculated at purchasing power parity prices. This estimate is not comparable with those based on market exchange rates used by the United Nations, the World Bank and most private analysts.

[7] Down 6.8% in the case of China, the country that was affected the earliest, 4.8% in the United States and 3.8% in the eurozone.

[8] This is particularly true of the United States, which saw three consecutive years of economic contraction during the Great Depression, with a cumulative downturn of 27% according to the historical figures compiled by Maddison (2010), only returning to 1929 levels of growth a decade later.

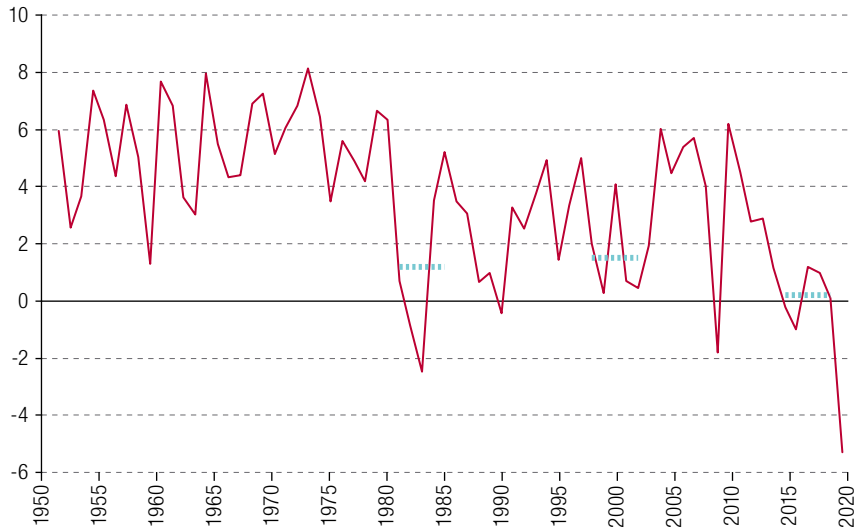
[9] These estimates are at purchasing power parity prices.

[10] See the statistics published monthly by the Netherlands Bureau of Economic Policy Analysis (CPB). These figures indicate that growth in the 12-month moving average of the volume of global exports was negative from October 2019, while that of global export values has been negative since August 2019 (CPB, n/d).

chains. For this reason, trade may recover much more slowly than it did in 2010, which more than offset the fall seen in 2009. With regard to commodities, the crisis has caused oil and other energy prices to plummet, a more modest fall in basic metals' prices and diverse trends for agricultural products.[11]

Latin America is dealing with these serious external shocks after five years (2015–2019) of anaemic growth, the worst since the Second World War, even worse than the five years of slowest growth during the Latin American debt crisis and the five years after the 1997 Asian financial crisis (see figure 1). In the last five years, regional GDP growth barely reached 0.2% (0.9% if the Bolivarian Republic of Venezuela is excluded). This poor performance reflects not only economic problems, but also complex political crises and transitions in several countries.

Figure 1
Latin America: GDP growth, 1950–2020[a]
(Percentages)



Source: Prepared by the author, on the basis of data from the Economic Commission for Latin America and the Caribbean (ECLAC).
Note: The dotted lines indicate average annual growth during the aforementioned three five-year periods of low growth, specifically 1980–1985, 1997–2002 and 2015–2019.
[a] Figures for 2020 are estimates.

However, Latin America's economic problems began long before the recent wave of economic and political instability. Economic growth in the region over the last three decades (1990–2019) was only 2.7% per year, half of that seen in the 30 years preceding the lost decade (average annual growth was 5.5% in the period 1950–1980). Almost all the economies of the region have grown less than during those 30 years (with the exception of Chile, the Plurinational State of Bolivia and Uruguay); the downturn was particularly serious in the Bolivarian Republic of Venezuela, Brazil and Mexico. This indicates that, regardless of the current crisis, the region's development patterns need to be considered in depth.

All the multilateral organizations (World Bank, 2020b; ECLAC, 2020a and 2020b; IMF, 2020b; Nuguer and Powell, 2020) forecast a major recession in Latin America in 2020, with only a partial recovery in 2021. As shown in table 1, these organizations expect a drop of around 5% for the region as a whole, with particularly severe downturns in Argentina, the Bolivarian Republic of Venezuela, Brazil, Ecuador and Mexico. Among the larger countries, Chile and Peru will be affected less and Colombia

[11] IMF (2020f) data on commodity prices indicate that the price of energy products has declined by 59.5% compared to the average for 2019 (oil prices are down by 65.0%), basic metals by 14.7% and agricultural products used as industrial inputs by 9.4%, but that food and beverage prices have fallen by just 5.5%. World Bank (2020a) projections for the whole year follow this pattern.

will perform comparatively well according to these projections.[12] In general, the smaller countries, with the exception of Ecuador, will perform better. For the region as a whole, the 2020 recession will be the worst since the Second World War (much worse, in fact, than that of 1983, the worst year of the Latin American debt crisis) and one of the most painful in history.[13]

Table 1
Latin America and the Caribbean: economic growth in 2019 and projections for 2020–2021
(Percentage growth rates)

	ECLAC		IMF	World Bank
	2019	2020	2020	2020
Argentina	-2.2	-6.5	-5.7	-5.2
Brazil	1.1	-5.2	-5.3	-5.0
Colombia	3.3	-2.6	-2.4	-2.0
Chile	1.1	-4.0	-4.5	-3.0
Ecuador	0.1	-6.5	-6.3	-6.0
Mexico	-0.1	-6.5	-6.6	-6.0
Peru	2.2	-4.0	-4.5	-4.7
Venezuela (Bolivarian Republic of)	-25.5	-18.0	-15.0	n.d.
Latin America and the Caribbean				
2020	0.1	-5.3	-5.2	-4.6
2021			3.4	2.6

Source: Prepared by the author, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), "Measuring the impact of COVID-19 with a view to reactivation", *Special Report COVID-19*, No. 2, Santiago, 21 April 2020; International Monetary Fund (IMF), *World Economic Outlook: The Great Lockdown*, Washington, D.C., April 2020; and World Bank, *Semiannual Report of the Latin America and Caribbean Region: The Economy in the Time of COVID-19*, Washington, D.C., April 2020.

The organizations recognize the region's poor economic performance over the last five years, as well as the economic shocks they face as a result of the COVID-19 pandemic. In addition to the aforementioned financial shocks, the contraction in international trade and the decline in commodity prices, it is expected that intraregional trade will fall sharply and tourism will collapse. On top of that remittances, from both abroad (especially from the United States and Spain) and within the region, will tumble by 19% in 2020 according to World Bank forecasts (2020c).

In terms of economic policy, the major constraint is the fiscal space available to the countries of the region, which is much more limited than it was during the North Atlantic crisis, a point that has been highlighted by several analysts from the Inter-American Development Bank (IDB). Izquierdo and Ardanaz (2020) note that the average deficit of the region's countries was 3% of GDP in 2019, compared to 0.4% in 2008, while the average public debt was 62% of GDP in 2019, compared to 40% in 2008.

The response of the countries of the region has been in line with international trends. Central banks have provided liquidity (with obvious restrictions for dollarized economies). Governments have adopted fiscal programmes, principally to support the health-care sector and poor and vulnerable households, and measures to reduce or defer payment of some taxes, but the scale of the packages varies widely. According to IDB estimates, the largest packages as a percentage of GDP are those of Brazil, Chile, El Salvador and Peru (Pineda, Pessino and Rasteletti, 2020). Some countries have introduced credit lines or loan guarantees on a large scale, most notably Chile, Colombia, Peru and Uruguay. Despite

[12] See the projections for Colombia of the Foundation for Higher Education and Development (FEDESARROLLO) (2020), under whose most optimistic scenario GDP is set to fall by 2.7%, but which also considers two alternative scenarios, under which GDP will contract by 5.0% and 7.9%, which seem more likely. The economic situation is even more complex for Peru, according to preliminary data for the first months of 2020.

[13] According to data from the 10 economies for which information is available dating back to 1900 (see table 1 of the Statistical Appendix of Bértola and Ocampo (2013)), the situation was only worse in 1914 and 1930. However, if the current crisis deepens, as it is very likely to do, it will be the worst in history.

this, the magnitude of support provided by the majority of the region's countries is modest compared to that mobilized by developed countries.

The social repercussions will be evident, as ECLAC has noted (2020b). Moreover, these will occur in a context of social conditions that have been deteriorating since 2014, as a result of poor economic performance. Underinvestment in health care is reflected in weak and fragmented health systems that do not guarantee universal access in many countries. The suspension of face-to-face classes has interrupted school feeding programmes, which several countries have sought to carry out in various ways, including through cash subsidies. The large digital divide means that students from low-income backgrounds are unable to access virtual education. Furthermore, labour informality means that a high proportion of households are left without income, possibly without the support provided by conditional transfers, especially those who are not considered to be poor but are vulnerable. Many micro-, small and medium-sized enterprises (MSMEs) may go bankrupt, which is a very worrying prospect, as they are responsible for creating a high proportion of the jobs in the region. As a result, ECLAC (2020b) estimates, under its medium scenario, that poverty levels will increase from 30.3% in 2019 to 34.7% in 2020, equivalent to nearly 29 million more people living in poverty.

III. An overview of international financial cooperation during the crisis

The international debate has highlighted that, although the pandemic affected Western Europe and the United States earlier and to a serious degree, and reached developing countries later, the latter are more vulnerable in economic and social terms. There are many reasons for this: containment measures are more costly for people with limited resources in developing countries, who live in small, crowded spaces, sometimes without access to running water; support mechanisms for sectors living in poverty do not exist or do not reach the target population; health-care systems are of a poor quality and do not cover the entire population; and labour informality rates are high and means that containment measures leave a wide range of workers without income. Added to this the fiscal space is narrower and governments' access to credit is more limited. For this reason, there is agreement on the need to adopt ambitious policies to support emerging and developing economies. The financial requirements of these countries are immense: US$ 2.5 trillion, according to estimates by both IMF (2020d) and the United Nations Conference on Trade and Development (UNCTAD, 2020a).

In the light of these vulnerabilities and needs, the international cooperation agreed upon to date is very limited, in terms of both the measures adopted and the resources to which emerging and developing economies will have access. This is particularly true of the group of middle-income countries, to which almost all Latin American countries belong. As detailed below, the measures taken with respect to lower-income countries have been somewhat more relevant —although still insufficient— and are much more likely to be stepped up.

The shortcomings of multilateral cooperation were particularly evident at the meetings of G20 and the Bretton Woods institutions in April. These meetings will be remembered, not only for being the first in history to be held virtually, but also for the limited international decisions taken in the face of the magnitude of the current crisis.

There have, of course, been expressions of international solidarity. At the end of March, the G20 Leaders committed to "do whatever it takes and to use all available policy tools to minimize the economic and social damage from the pandemic, restore global growth, maintain market stability, and strengthen resilience" (G20, 2020a). The G20 finance ministers and central bank governors expressed something similar in their statements at the meetings of the Bretton Woods institutions.

However, multilateral measures have not lived up to these promises. The actions being carried out diverge from those provided for in the G20 Global Plan for Recovery and Reform adopted at the G20 Summit in London on 2 April 2009 to address the crisis at that time (G20, 2009). This statement led to the most significant reform of IMF credit lines in the Fund's history, the largest issuance of IMF special drawing rights (SDRs), the capitalization of and massive increase in lending by multilateral development banks, and an ambitious reform of financial regulations. It also eventually led to work beginning on efforts to strengthen international tax cooperation, overseen by the Organization for Economic Cooperation and Development (OECD), to the adoption in 2012 of the IMF institutional view on capital flows, and to the increase and redistribution of IMF quotas. Unfortunately, it took five years to implement the latter because of how long it took the United States Congress to approve the corresponding resources.[14]

Compared to these actions and to the needs of emerging and developing economies, the measures announced at the meetings of the Bretton Woods institutions and parallel actions adopted by the G20 countries have been meagre. This limited international cooperation contrasts with the ambitious domestic policies adopted by developed countries. This is particularly true of the United States, whose domestic policies have been much more vigorous than those adopted to address the 2008–2009 financial crisis and whose support for international actions has been very limited during the current crisis, in contrast to the international leadership it exercised during the 2008–2009 crisis. European countries have also adopted clearly countercyclical policies, but they have been more open to multilateral cooperation. The contrast between the decisive domestic economic policies of developed countries and the limited international cooperation seems to be a key feature of the current crisis.

IV. International monetary cooperation and its effects on Latin America

The international agenda for monetary issues covers six areas: (i) the provision of international liquidity; (ii) the establishment and expansion of IMF credit lines; (iii) guarantees that IMF will have adequate resources; (iv) the possible coordination of the regulation of capital flows and of the decisions of credit rating agencies; (v) actions aimed at managing the over-indebtedness of several emerging and developing economies; and (vi) the active use and expansion of regional monetary arrangements (Gallagher and others, 2020a).

With regard to liquidity provision, the proposal that has received the most support has been the issuance of SDRs in the amount of at least US$ 500 billion, doubling the value of the issuance in 2009.[15] To make better use of this issuance, a special fund could be created for countries to lend to IMF the SDRs that they do not use, to finance its programmes, or to support other development projects (to capitalize multilateral banks or increase official development assistance). It would be preferable to distribute the SDRs based on criteria other than those used to determine national quotas,[16] but that would require a change in the IMF Articles of Agreement.

Given the share of Latin American countries in IMF quotas, this issuance of SDRs would imply an increase in their international reserves of US$ 37.740 billion, equivalent to slightly less than 5% of those reserves as at the end of 2019 and a little more than 40% of the net balance of the region's capital and financial account for that year.[17] The distribution by country would be that shown in table 2; as a percentage of GDP, it would be 0.7% on average, ranging from 0.6% to 0.8% for most of the countries, but it would be higher for those whose GDP in United States dollars has decreased significantly in recent years.

[14] For a detailed analysis of these issues, see Ocampo (2017).

[15] For a preliminary version of this proposal, see Gallagher, Ocampo and Volz (2020b). See also Collins and Truman (2020).

[16] As reflected in the long-standing discussions, alternative criteria could be different economies' level of development and demand for international reserves (Ocampo, 2017, chapt. II).

[17] The reference data are taken from ECLAC (2019).

Table 2
Latin America: IMF member country quotas

	IMF quota			Effect of a US$ 500 billion issuance	
	Millions of SDRs	Millions of dollars	Percentage of total	Millions of dollars	Percentage of GDP
Brazil	11 042	15 120	2.31	11 574	0.62
Mexico	8 913	12 204	1.87	9 342	0.77
Venezuela (Bolivarian Republic of)	3 723	5 097	0.78	3 902	2.52
Argentina	3 187	4 364	0.67	3 341	0.65
Colombia	2 045	2 799	0.43	2 143	0.65
Chile	1 744	2 388	0.37	1 828	0.62
Peru	1 335	1 827	0.28	1 399	0.63
Ecuador	698	955	0.15	731	0.68
Dominican Republic	477	654	0.10	500	0.59
Uruguay	429	588	0.09	450	0.76
Guatemala	429	587	0.09	449	0.62
Panama	377	516	0.08	395	0.61
Costa Rica	369	506	0.08	387	0.65
El Salvador	287	393	0.06	301	1.16
Nicaragua	260	356	0.05	273	2.09
Honduras	250	342	0.05	262	1.10
Bolivia (Plurinational State of)	240	329	0.05	252	0.63
Paraguay	201	276	0.04	211	0.53
Latin America	36 006	49 302	7.55	37 740	0.72

Source: Prepared by the author, on the basis of data from the International Monetary Fund (IMF) and the Economic Commission for Latin America and the Caribbean (ECLAC).
Note: SDR values are converted to dollars at the exchange rate as at 1 May 2020. The estimates as a percentage of GDP correspond to 2018, based on ECLAC estimates for that year.

More ambitious proposals have been put forward, for example to issue SDRs worth US$ 1 trillion (see, for example, Cardoso and others, 2020). While this would be useful, it would require the explicit approval of the United States Congress because the United States would receive more SDRs than its quota, so Congress cannot simply be informed. This would undoubtedly delay the issuance. Therefore, in order to avoid having to seek Congress's approval, the maximum issuance value must be equal to the total IMF quotas, some US$ 650 billion.

Although the proposal for a large issuance of SDRs had broad support among IMF member countries and the public, it was vetoed by the United States at the 2020 Spring Meetings of the Bretton Woods institutions, on the grounds that about 70% of the resources would go to G20 countries, most of whom do not need them (Mnuchin, 2020). Surprisingly, India supported this position. While it is true that just under two fifths of SDRs issued benefit emerging and developing economies, it is also true that this is the only opportunity that these countries have to share in the creation of international money (so-called "seigniorage" benefits). Many low-income countries would benefit significantly from the SDR issuance (Collins and Truman, 2020).

To help create international liquidity, the United States Federal Reserve re-established its currency swap lines with other central banks, following a practice it had already implemented during the North Atlantic crisis. However, only four emerging economies have access to this mechanism: Brazil, Mexico, the Republic of Korea and Singapore. It also set up a new mechanism: a repurchase agreement (repo) instrument, which allows the Federal Reserve to buy back the Treasury Bonds that countries wish to sell; however, this mechanism only benefits those countries with large amounts of foreign exchange reserves.

In terms of creating and extending credit lines, the most important reform has been the doubling of the IMF emergency credit lines, including the rapid financing instrument (RFI) available to middle-income countries.[18] In the context of simplifying and streamlining procedures, and the absence of *ex ante*

[18] See IMF (2020e) for more details on this and other IMF reforms.

conditionality, this reform has given rise to the rapid approval of a plethora of loans for a wide range of countries.[19] As at 1 May, seven Latin American countries had made use of these credit lines, totalling slightly more than US$ 3.3 billion (see table 3); no additional loans were requested by countries of the region in the remainder of the month of May.

Table 3
Rapid financing instrument loans granted to Latin American countries, 2020

Country	Millions of SDRs	Date of approval	Millions of dollars
Bolivia (Plurinational State of)	240.1	17 April	328.8
Costa Rica	369.4	29 April	505.8
Dominican Republic	477.4	29 April	653.7
Ecuador	469.7	1 May	643.2
El Salvador	287.2	14 April	393.3
Panama	376.8	15 April	515.9
Paraguay	201.4	21 April	275.8
Total	2 422.0		3 316.4

Source: Prepared by the author, on the basis of data from the International Monetary Fund (IMF).
Note: SDR values are converted to dollars at the exchange rate as at 1 May 2020.

In addition to this instrument there are other credit facilities, which some countries took advantage of before the current crisis: the pre-existing flexible credit lines to Mexico and Colombia (the latter was renewed on 1 May) and the new ones granted to Peru and Chile at the end of May,[20] standby arrangements for Argentina and Honduras, with the latter augmented on 1 June, and the extended arrangement under the extended fund facility for Ecuador, although this was suspended on 1 May[21] (see table 4). Thus, 13 countries of the region have already received some form of support from IMF. As flexible credit lines act as a kind of insurance for countries, they have not been disbursed yet; disbursements from the other credit lines total just over US$ 45.7 billion (most of it going to Argentina). The exception in terms of access is the Bolivarian Republic of Venezuela, whose request for a US$ 5 billion loan was rejected in March by IMF on the grounds that there is no clarity among the Fund's member States as to who is the legitimate president of that country.

Table 4
Regular IMF-approved loans to Latin American countries, as of May 2020

Date of approval		Maturity	Loan value		Amount disbursed
			Millions of SDRs	Millions of dollars	Millions of dollars
A. Flexible credit line (FCL)					
Mexico	22 November 2019	21 November 2019	44 563.5	61 019.9	0.0
Colombia	1 May 2020	30 April 2022	7 849.6	10 748.3	0.0
Peru	28 May 2020	27 May 2022	8 007.0	10 963.8	0.0
Chile	29 May 2020	28 May 2022	17 443.0	23 884.4	0.0
B. Standby Agreements (SBA)					
Argentina	20 June 2018	19 June 2021	40 714.0	55 748.9	43 698.8
Honduras[a]	15 July 2019	14 July 2021	387.2	530.2	376.3
C. Extended Fund Facility (EFF)					
Ecuador	11 March 2019	10 March 2022	3 035.0	4 155.8	1 653.9
Total			121 999.3	167 051.2	45 729.0

Source: Prepared by the author, on the basis of data from the International Monetary Fund (IMF).
Note: SDR values are converted to United States dollars at the exchange rate as at 1 May 2020.
[a] Includes the resources approved under the Standby Credit Facility (SCF) and the increase approved on 1 June 2020; the amount authorized on the latter date includes a disbursement.

[19] Countries may also make use of other IMF instruments, but the allotted value of emergency credit lines is generally less than the country's quota. This was the case for Ecuador, when an RFI was approved for 67.3% of its quota on 1 May.

[20] The flexible credit lines approved for Chile and Peru were 10 and 6 times, respectively, their quotas, much higher than those extended to Mexico and Colombia, which are 5 and 3.8 times their quotas, respectively.

[21] On the same date Ecuador was given access to the emergency credit line. Ecuador will however seek another long-term IMF loan.

Another recommendation that has been discussed is the creation of an IMF swap line. This recommendation was made by IMF staff two years ago (IMF, 2017b), but was rejected by the Executive Board. The G20 Eminent Persons Group on Global Financial Governance subsequently made a similar recommendation (G20 Eminent Person Group on Global Financial Governance, 2018). The IMF created the short-term liquidity line in April in response to this, but it is a very limited response. It will act as a revolving credit line for up to 145% of the country's quota and without ex ante conditionality, but only member countries "with very strong policies and fundamentals" will have access to it, as is the case with the flexible credit line. However, it is less attractive than the flexible credit line because fewer resources are available and it cannot be combined with other loans from the Fund. Therefore, it is highly likely that it will not be used.

In order to finance the increased demand for credit, IMF needs to expand its resources up to an amount estimated by the Managing Director at US$ 1 trillion. In this regard, an unfortunate decision was taken last year to defer the increase in quotas until 2023. It is regrettable that the G20 countries have not accelerated this process, given that it is widely recognized by these countries that this should be the Fund's core resource. The additional funds will come from the doubling of the New Arrangements to Borrow (NABs), approved in January 2020, to around US$ 500 billion, and from bilateral borrowing agreements with several countries. The main contribution of the United States will be its support for NABs.

A fourth line of action that has been proposed by several analysts is the possible coordinated regulation of capital flows in an effort to curb, in particular, capital flight from emerging economies. This action would be in line with the institutional view on capital flows approved by IMF in 2012 (IMF, 2012). Similarly, it has been proposed that credit rating agencies should suspend their downgrades (or the outlook on a rating) during the crisis, as these fuel capital flight.[22] Mexico and Colombia have already been affected by such decisions, although they have maintained their investment grade rating. Neither G20 nor IMF has taken a position on these issues.

The fifth issue, debt relief, has been the subject of a wide range of proposals, by both institutions (United Nations, 2020, UNCTAD, 2020b) and analysts (see, in particular, Bolton and others, 2020; Brown and Summers, 2020; Reinhart and Rogoff, 2020). This is an area where limited measures have already been taken in relation to low-income countries, but not middle-income countries.

IMF decided that 25 of its most vulnerable members (to which four more could be added in the near future) will be exempt from repayment and interest on their IMF debt obligations for six months, using resources from the Catastrophe Containment and Relief Trust (CCRT). In turn, the G20 countries offered to introduce a debt repayment standstill for countries supported by the International Development Association (IDA) for the rest of 2020, a measure that, according to Brown and Summers (2020), should be extended to the end of 2021. The Paris Club has already taken the necessary decision. It is not clear, however, whether private creditors will adopt it, as the G20 countries have requested. This programme does not cancel the debt, which will remain outstanding and continue to accrue interest.

With regard to middle-income countries, there are critical cases that require debt restructuring. The most important in Latin America are Argentina and Ecuador. While there are proposals for relatively widespread debt repayment standstill for emerging and developing economies (see in particular UNCTAD (2020a and 2020b) and Reinhart and Rogoff (2020)), other proposals favour voluntary mechanisms.

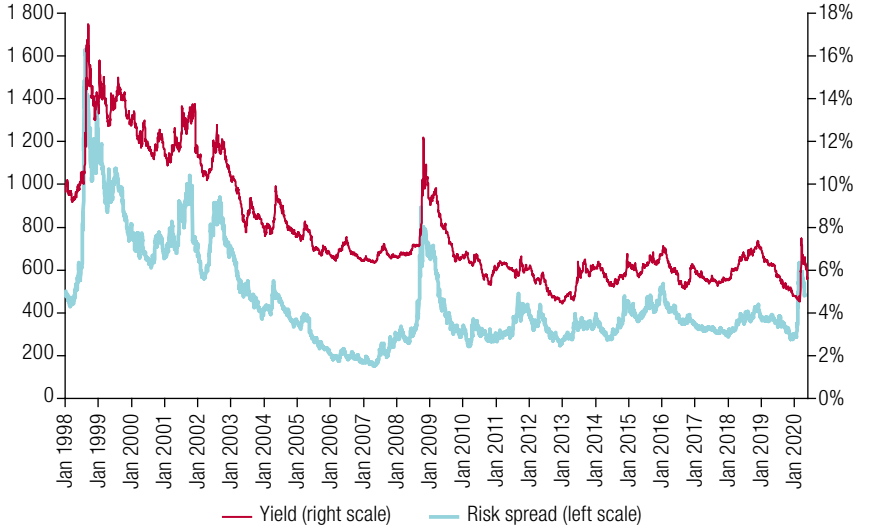
The most interesting proposal is that made by Bolton and others (2020), who suggest the World Bank or regional development banks create a central credit facility to which countries would go voluntarily, and which would facilitate a deferral of amortizations and the use of interests due to fund the response to the health emergency. Countries' obligations would remain in place and therefore the proposed facility would act as a rollover mechanism during the crisis. It would apply to all bilateral and commercial debts on an equal basis. Apart from its voluntary nature, the facility would be subject to intermediation and strict monitoring by the multilateral bank that manages it.

[22] See Gallagher and others (2020) for more discussion of this issue.

Beyond short-term measures, the United Nations and UNCTAD have suggested that an institutional mechanism should be created for restructuring sovereign debt, an issue that has been under discussion for the last two decades, with progress limited to the definition of principles and clauses that allow each country to renegotiate with its creditors, but without a specific institutional framework.[23]

It does not make sense for Latin America to adopt a uniform rule in this area. As figure 2 shows, although risk spreads on bonds issued by emerging economies have increased, they have remained below those seen during the North Atlantic crisis and especially after the Russian default in August 1998 (which, in turn, followed the 1997 Asian crisis). More importantly, with the sharp fall in the yield used as a benchmark to calculate these spreads (10-year United States Treasury Bonds), the bond yields of emerging economies have remained well below those reached during the two previous crises and even those seen during the turmoil in emerging economies' bond markets in 2018.

Figure 2
Risk spreads and yield on emerging economies bonds, 1998–2020
(Emerging Market Bond Index)



Source: Prepared by the author, on the basis of data from Bloomberg.

Moreover, bond markets for emerging economies have opened up more quickly than they did after the North Atlantic crisis, when it took just over 12 months after the collapse of the United States' investment bank, Lehman Brothers. This indicates that several investment funds in developed countries are again searching for yield. Two signs of this are the sharp reduction in risk spreads since the end of March (see figure 2) and that capital outflows from emerging economies, which peaked at US$ 66.1 billion in March, fell to US$ 11.3 billion in April and US$ 10 billion in May, when the flow of hard currency bonds became positive (JP Morgan, 2020).

Eight Latin American countries have already issued bonds: Panama at the end of March, and since mid-April Peru, Guatemala, Mexico, Paraguay, Chile and Colombia, two Colombian public-sector companies (Ecopetrol and Grupo Energía de Bogotá, both with minority private shareholders), two Chilean public-sector companies (Corporación Nacional del Cobre de Chile (CODELCO) and Metro de Santiago) and one Brazilian public-sector company (Petrobras). In addition, the Development Bank of Latin America (CAF) and the Central American Bank for Economic Integration (CABEI) have also issued bonds. Through the hard currency bond markets, US$ 24 billion has been raised between mid-April and 1 June 2020.

[23] See Ocampo (2017), chapt. V, for an overview of the discussion.

In this context, a uniform solution for the debt problems of the countries of the region –and for middle-income countries in general— does not make sense. There are three different situations that should be dealt with separately: (i) countries whose debts need to be thoroughly restructured; (ii) countries that can have recourse, at their discretion, to a debt standstill mechanism such as that proposed by Bolton and others (2020); and (iii) countries with access to new private financing that will continue to service their debts and combine that financing with loans from IMF and the multilateral development banks.

Lastly, it is worth highlighting the role of regional monetary mechanisms. These mechanisms have expanded significantly since the North Atlantic crisis and now have US$ 585.4 billion at their disposal, equivalent to approximately 60% of the resources available to IMF, although they are concentrated in European funds and the East Asian Chiang Mai Initiative (Gallagher and others, 2020). Active steps must be taken to deepen the relationship between IMF and regional financing arrangements in order to strengthen the global financial safety net, as has been recognized by both IMF (2017a) and Cheng and others (2018).

This collaboration must be based not only on complementarity, but also the independence of the institutions and respect for their respective mandates and governance structures, and should not follow any hierarchical principles.[24] Moreover, it is not appropriate to have a formal relationship with IMF programmes, which were the subject of much criticism during the eurozone crisis and is one of the reasons why the resources of the Chiang Mai Initiative have not been used.

In Latin America, there is the Latin American Reserve Fund (FLAR), with eight member countries. This Fund has a very successful record of supporting its members during the various crises they have faced, acting sometimes as a substitute for and sometimes as a complement to IMF resources. In any case, given the limited resources available to FLAR, IMF support is indispensable for large-scale programmes. As part of the measures to strengthen the global financial safety net, an important task is to expand the membership of this regional Fund, until it comprises all Latin American countries.

Table 5 shows the maximum amounts that member countries can receive as loans from FLAR, both in terms of total financing and through its specific credit lines (balance of payments, liquidity and contingency). The total amount available to member countries is just over US$ 6.5 billion. Nearly all of that amount is available because only one loan is currently active, to Ecuador (for balance of payments) for US$ 205 million, since the other credits, which had been granted to Costa Rica and the Bolivarian Republic of Venezuela, were settled at the beginning of 2020. As the capital contribution of the Bolivarian Republic of Venezuela to the Fund was used to pay off the loan, the Fund can only give that country limited support now.

Table 5
Capital contributions and maximum credit limits of the Latin American Reserve Fund (FLAR)
(Millions of dollars)

Country	Subscribed capital	Paid-up capital	Maximum credit limit	Maximum credit limit by type of financial support		
				Balance of payments support	Liquidity facility	Contingency facility
Bolivia (Plurinacional State of)	328.1	256.4	666.6	666.6	282.0	538.4
Colombia	656.3	512.9	1 282.3	1 282.3	512.9	1 025.9
Costa Rica	656.3	513.1	1 282.7	1 282.7	513.1	1 026.1
Ecuador	328.1	256.5	666.8	666.8	282.1	538.6
Paraguay	328.1	256.0	640.0	640.0	256.0	512.0
Peru	656.3	512.9	1 282.2	1 282.2	512.9	1 025.8
Uruguay	328.1	257.0	642.4	642.4	257.0	513.9
Venezuela (Bolivarian Republic of)	656.3	30.7	76.7	76.7	30.7	61.3
Total FLAR	3 937.5	2 595.4	6 539.7	6 539.7	2 646.6	5 242.0

Source: Prepared by the author, on the basis of data from Latin American Reserve Fund (FLAR).

[24] Therefore, the "lead agency" model proposed by IMF (2017a) should not be adopted.

The great advantage of FLAR is that its programmes do not have any ex ante conditionality, although countries requesting a loan must submit a macroeconomic programme to the Fund. Its main disadvantage is the amount of available resources, so FLAR programmes will almost certainly have to be supplemented by IMF loans. In this case, countries can use FLAR programmes as a complement or as a bridge to an IMF loan, taking advantage of the more streamlined system of the regional Fund to approve financing. Another disadvantage in the current crisis is that FLAR facilities can only be used for balance of payments needs and, therefore, cannot be used to finance governments at a time when demand for resources is very high. Thus, a temporary exception might be appropriate, allowing balance of payments credits to be used for fiscal purposes as well.

V. Multilateral development banks' cooperation

The development banks are one of the most important financial instruments available to the international community and a wide range of countries, both developed and emerging and developing economies. The fundamental objective of these institutions is to support long-term development policies —to foster innovation, improve infrastructure, and promote social and regional equity and environmental sustainability—, but their financing can also be used as a countercyclical instrument. Moreover, some projects associated with long-term strategies can be launched during crises to support economic recovery.

The network of development banks encompasses more than 400 institutions worldwide, with total assets of more than US$ 11 trillion, and they lend some US$ 2 trillion per year, according to estimates by the French Development Agency (AFD). They include the World Bank Group, as well as a number of regional (such as IDB and CAF),[25] subregional (CABEI) and interregional banks (the Islamic Development Bank), and a wide range of national banks of varying sizes. One of the major potential benefits is that the institutions act as a network, with the multilateral banks supporting the actions of national banks. If the development banks in this network were to increase their activity by 20%, they could mobilize an additional US$ 400 billion a year; by leveraging private resources, this amount could be doubled (Griffith-Jones, Marodon and Ocampo, 2020).

During the North Atlantic crisis, the multilateral development banks played an important countercyclical role (Ocampo and others, 2011), that was recognized explicitly by the banks themselves and by the economic authorities. The lessons of the past indicated that, in addition to the provision of liquidity in times of crisis by international monetary institutions, it was equally important that multilateral development banks provide long-term financing to support public spending and public and private investment.

Overall, these institutions increased their lending commitments to emerging and developing economies by 71% between 2008 and 2009; their disbursements grew by 45% in 2009 and continued to trend upwards in 2010 (Ocampo and others, 2011). This lag in disbursements occurred, despite the measures taken to accelerate them. Interestingly, the response to the needs of middle-income countries was more vigorous than that for low-income countries, with credit commitments to the latter falling from 32% in 2007 to 22% in 2009.

The banks' responses were determined in part by their limited capital. For this reason, as noted in section III, the G20 countries agreed to support the capitalization of the multilateral development banks in the Plan adopted at their London meeting in April 2009. The capitalizations of the Asian Development Bank and the African Development Bank were rapid and massive: a 200% increase in 2009 in both instances. The capitalization of IDB, approved in March 2010, was less ambitious (about 70%), happened gradually and was for an amount less than the Latin American and Caribbean countries

[25] As reflected by its growing membership and new name, adopted in 2010, CAF is a regional development bank, although the acronym of its former name (the Andean Development Corporation, or *Corporación Andina de Fomento*) is still used.

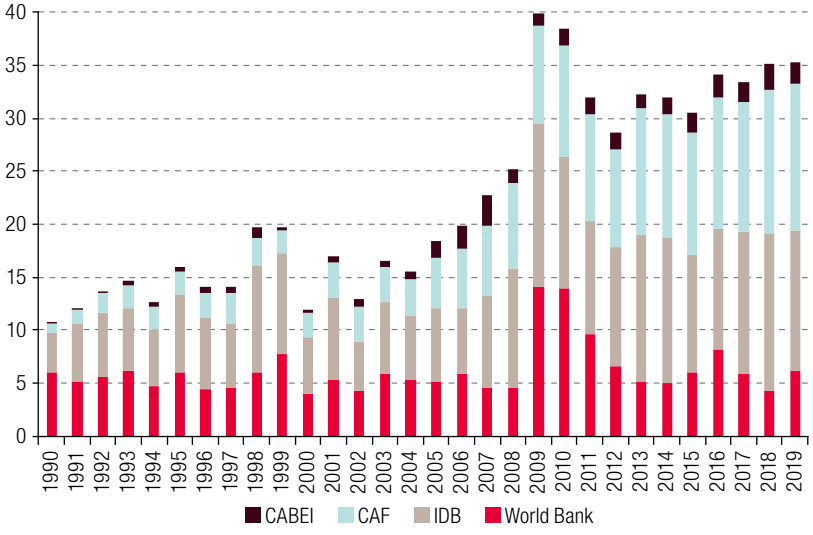
had hoped. The World Bank was capitalized in April 2010 and for an even more modest amount. It was part of a set of reforms aimed at increasing the share of emerging and developing economies in the capital of the World Bank.

This countercyclical response moderated, although it certainly did not completely offset, the impact of the sharp drop in private capital flows to these countries. Another area in which multilateral development banks played an important role was in the rapid provision of commercial credit lines, which were used by a wide range of private banks.

Two important lessons to be learned from the response of the multilateral banks during the North Atlantic crisis are, therefore, the need for good mechanisms for rapid disbursements during crises, and for their capital to be replenished more automatically. An alternative to accelerate disbursements that was used during the 2009 crisis and, as we will see, has been used by some institutions during the current crisis, is to allow already-approved loans to be reallocated for other emergency purposes. Another might be to defer debt service payments to the institutions —a practice that could, however, affect banks' credit ratings.

The relative importance of multilateral development bank support to Latin American countries has increased dramatically in recent decades. The World Bank played a leading role until the 1980s. However, as figure 3 shows, the amount it has loaned to the region has remained fairly stable since the 1990s. Nevertheless, the World Bank has continued to play a critical role during crises, as indicated by the increase in its lending to the region in 1998–1999 and especially in 2009–2010.

Figure 3
Multilateral development bank lending to Latin America, 1990–2019
(Billions of dollars)



Source: Prepared by the author, on the basis of data from World Bank, Inter-American Development Bank (IDB), Development Bank of Latin America (CAF) and Central American Bank for Economic Integration (CABEI).

The top lender to the region in the 1990s was IDB, before it was challenged by the rapid growth of CAF and CABEI. The uptick in the CAF lending trend has been particularly significant; it has provided as many loans as IDB in the last five years. Although CABEI is a much smaller institution, it has particular importance for the Central American countries and, in recent years, has been rivalling IDB as the main source of financing for the subregion.

It should be noted, however, that the capacity of the World Bank and IDB to respond to the 2008–2009 crisis was much larger than that of CAF and CABEI. This indicates that, during times of

crisis, the implicit support of the developed countries, in particular the United States, facilitates access to capital markets on advantageous terms. Conversely, CAF and CABEI may be affected, at least partially, by the fact that capital markets are closed to emerging economies during these periods. Nevertheless, both of these development banks joined the recent wave of Latin American bond issuances.

As table 6 shows, CAF was the bank with the highest growth in terms of authorized capital and equity between 2007 (before the outbreak of the North Atlantic crisis) and 2019. Both CAF and CABEI were capitalized earlier than the World Bank and IDB during the 2009 crisis. A new World Bank capitalization was approved in 2018: an increase in the paid-up capital of the International Bank for Reconstruction and Development (IBRD) of US$ 7.5 billion and of the International Finance Corporation (IFC) of US$ 5.5 billion. Overall, IFC capital has grown much more than that of IBRD since the 2008–2009 crisis (by 95%), based primarily on the reinvestment of profits. In turn, an increase in the capital available to CABEI from US$ 5 billion to US$ 7 billion was approved in December 2019 and made official in April 2020, so it now exceeds CAF in terms of the growth of its capital since 2007.

Table 6
Authorized capital and equity of the multilateral development banks serving Latin America, 2007–2019
(Billions of dollars)

Year	Authorized capital				Equity			
	IBRD	IDB	CAF	CABEI	IBRD	IDB	CAF	CABEI
2007	189 801	100 953	5 000	2 000	39 926	20 353	4 127	1 636
2008	189 801	100 938	10 000	2 000	41 548	19 444	4 554	1 708
2009	189 918	104 980	10 000	5 000	40 037	20 674	5 287	1 813
2010	189 943	104 980	10 000	5 000	37 555	20 960	5 753	1 929
2011	193 732	104 980	10 000	5 000	39 683	19 794	6 351	2 028
2012	205 394	116 880	10 000	5 000	36 685	20 681	6 865	2 142
2013	223 181	128 781	10 000	5 000	39 523	23 550	7 817	2 268
2014	232 791	144 258	10 000	5 000	38 985	23 697	8 763	2 396
2015	252 821	156 939	15 000	5 000	38 637	25 253	9 524	2 573
2016	263 329	170 940	15 000	5 000	37 063	26 460	10 474	2 723
2017	268 937	170 940	15 000	5 000	39 798	32 247	11 122	2 831
2018	274 730	170 940	15 000	5 000	41 844	32 929	11 863	3 198
2019	279 953	170 940	15 000	5 000	42 115	33 871	12 797	3 300
				Growth				
2007-2019	47.5%	69.3%	200.0%	150.0%	5.5%	66.4%	210.1%	101.8%

Source: Prepared by the author, on the basis of data from International Bank for Reconstruction and Development (IBRD), Inter-American Development Bank (IDB), Development Bank of Latin America (CAF) and Central American Bank for Economic Integration (CABEI).

All the banks providing services to the region have adopted special support measures during the current crisis: granting special, fast-tracked credit lines to tackle the crisis, albeit with modest resources; increasing the scale of credit programmes, within their capital restrictions; streamlining credit approvals; and, in several cases, allowing already-approved loans to be reallocated to meet urgent needs.

According to the remarks delivered by the World Bank Group President to the Joint Ministerial Committee of the Boards of Governors of the Bank and the Fund on the Transfer of Real Resources to Developing Countries (Development Committee) on 17 April 2020, the programme to address the crisis is based on three pillars: (i) to protect the poorest and most vulnerable households; (ii) to support businesses and save jobs; and (iii) to help developing countries implement emergency health operations and strengthen economic resilience (World Bank, 2020d). Two important elements of the packages announced are the significant weight of resources going to low-income countries —thus correcting one of the problems with the World Bank's actions during the crisis a decade ago— and the emphasis on measures aimed at

the private sector carried out through IFC, offering international trade loans, working capital support and medium-term financing to private companies struggling with breaks in their supply chains.

The immediate support package approved by the World Bank in mid-March made US$ 14 billion of new financing available to countries expeditiously. Fast-track facility resources have already been disbursed to six Latin American countries —Argentina, Ecuador, El Salvador, Honduras, Paraguay and Uruguay— in April and May, although the loans were for modest amounts, totalling US$ 135 million (each country received US$ 20 million each, except Argentina, which was loaned US$ 35 million).

In addition to the emergency programme, in late March 2020, the World Bank approved a US$ 160 billion package covering the next 15 months. This is substantially more than the annual average of World Bank loans approved in 2009–2010, which was US$ 64.4 billion. This broader package includes emergency loans and the possible reallocation of funds from existing projects. Five Latin American countries have already benefited from this broader package in April and May: Colombia, the Dominican Republic, Honduras, Panama and the Plurinational State of Bolivia. Together with emergency credits, the World Bank approved US$ 1.119 billion in lending to Latin America in April and May, which is higher than the monthly average for the last five years, but still less than the monthly average approved for the region in 2009–2010.

The President of the World Bank Group told the G20 finance ministers in March that recovery policies must be linked to structural reforms: "Countries will need to implement structural reforms to help shorten the time to recovery and create confidence that the recovery can be strong" (World Bank, 2020e). It is regrettable that he made this link to structural reforms, given that an increasing number of emerging and developing economies have rejected this view, as it bears very little relation to the economic emergency.

The programme announced by IDB to address the crisis is underpinned by the principle that the virus affects not only human health, but also the economy, the survival of many firms and families' finances, and that, if it is not properly managed, can create a social crisis. The Bank has identified four priority areas for its support programmes: (i) the immediate public health response; (ii) safety nets for vulnerable populations, specifically measures to protect the income of the most affected populations through existing transfer programmes, as well as extraordinary transfers to workers in the informal sector and support for companies in sectors particularly affected by the crisis; (iii) assistance to small and medium-sized enterprises (SMEs), through financing programmes and liquidity guarantees, foreign-trade financing, loan restructuring and support for strategic supply chains; and (iv) fiscal policies for the amelioration of economic impacts, in the form of support to countries in designing and implementing fiscal measures to finance the response to the crisis, plans for the execution of expenditures and public procurement, and measures to support the economic recovery.

The programme includes an adjustment of IDB lending instruments and a streamlining of approving processes. In terms of resources, it includes the allocation of an additional US$ 3.2 billion to the loan programme initially stipulated for 2020. These funds, added to the available resources already programmed for this year, would make up to US$ 12 billion available to countries. This amount, however, is very similar to the annual lending average over the last five years, which is why, more than the amount loaned, the priority has been reallocating resources and accelerating loan approvals, which have increased from US$ 2.6 billion to US$ 3.7 billion in the first five months of 2020 compared to 2019. In immediate terms, it has also offered countries the possibility of reallocating resources from already approved loans to meet the new priorities created by the emergency, in an amount equivalent to 10% of each loan or up to US$ 50 million (whichever is greater). IDB Invest, the private sector arm of the IDB Group, has contributed an additional US$ 5 billion to support the financing of production chains and trade, and banks in a context of severe liquidity constraints.

In addition, both IDB and non-regional partners are providing technical cooperation resources that prioritize exchange and learning platforms. Analyses of the effects of the various dimensions of the crisis and of alternative methods to address them, which are published in the blog "Ideas Matter", have also been very important.

Meanwhile, CAF is helping to tackle the emergency through four specific actions. The first is a contingent credit line, approved in early March, of up to US$ 300 million (up to US$ 50 million per country) to respond quickly to the needs of public health systems. The second is a rapid disbursement emergency credit line, approved in late March, of up to US$ 2.5 billion, to streamline the approval of operations that support the emergency measures being adopted by countries. The third is the possibility of reprogramming existing loans, even allowing their objectives and destinations to be changed. The fourth is prioritizing collaboration with national development banks to support SMEs. It is not clear, however, whether CAF can substantially increase its credits over the high levels reached in 2018–2019 without additional capital. In any case, it has accelerated loan approvals in the first five months of the year to US$ 3.9 billion, compared to US$ 2.3 billion in 2019. In addition, non-reimbursable technical cooperation resources of up to US$ 400,000 per country are available, which several members have already received.

Lastly, CABEI launched the Emergency of Support and Preparedness Programme for COVID-19 and Economic Reactivation on 31 March 2020, worth US$ 1.96 billion. The programme includes three credit components: US$ 1 billion in loans to support the liquidity management of central banks of founding and non-founding regional members;[26] US$ 600 million in emergency budget support; and US$ 350 million in liquidity support for the financial sector in countries to support MSMEs. Unlike IDB and CAF, the recent capitalization of CABEI and the bond issuance at the end of April will allow it to significantly increase its lending, up to around US$ 3 billion, representing growth of 45% in relation to the average for the last five years.

In the absence of additional capitalizations for IDB and CAF —the two most important multilateral banks for Latin America— the resources provided by these institutions to the countries of the region will increase modestly compared to the response to the North Atlantic crisis, even though the current crisis is more severe. CABEI is the notable exception. For this reason, actions in this area, as well as on the monetary front, must be strengthened substantially to tackle the severe economic and social problems caused by the COVID-19 pandemic.

VI. Conclusions

The current economic crisis will be remembered, not only as the worst since the Great Depression and one in which developed countries have adopted ambitious domestic policies, but also for the limited multilateral financial cooperation that has been agreed. This is particularly true of measures to support middle-income economies. Actions to help lower-income countries have been more substantial, but also insufficient. Clearly, the multilateral actions have fallen far short of the commitment "to do whatever it takes", made by the G20 Leaders at the end of March 2020.

In the area of international monetary cooperation, the most frustrating aspects have been the refusal to issue IMF SDRs, the failure to take a decision on or even to suggest bringing forward the increase in IMF quotas, and the lack of collective measures to tackle capital flight from emerging economies and to stop credit ratings agencies from downgrading countries. Latin American countries have benefited from IMF emergency loans, albeit for modest amounts, and flexible credit lines (in the case of four countries), and can access other IMF facilities if they so wish. The eight member countries of FLAR are also able to benefit from the support of this regional body, but it is recommended that they be allowed, at least temporarily, to use those resources for fiscal purposes. Efforts to expand the membership of FLAR should also be stepped up as a result of the crisis.

With regard to foreign debt, it is recommended that a diverse approach be adopted that supports ambitious foreign debt restructuring for countries that need it (Argentina and Ecuador) and creates a

[26] The founding regional members are Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, and the non-founding regional members are Belize, the Dominican Republic and Panama.

voluntary and multilaterally monitored debt standstill mechanism for those economies that may require such support. Meanwhile, the early recovery of the emerging economies' bond market that began in mid-April is good news, and has allowed several countries and public-sector firms, as well as CAF and CABEI, to access private financing. In addition to short-term measures, the creation of an institutional mechanism to renegotiate sovereign debts must be put back on the table.

The multilateral development banks have created several emergency credit lines to address the crisis, streamlined their procedures and several of them have allowed loans already approved to be rechannelled to tackle the health, social and economic emergencies caused by the COVID-19 pandemic. In Latin America, the work of CABEI, supported by the recent capitalization, has been the most noteworthy. The World Bank has increased its lending to the region, although these loans amount to less than those granted during the North Atlantic crisis. The two main multilateral banks for the region, IDB and CAF, have also adopted important measures, but they have reached the limit of their lending capacity and need to be recapitalized to provide more robust support to the countries of the region during the crisis. On the whole, in terms of resources, the multilateral banks' programmed support for Latin American countries is, so far, insufficient.

Lastly, the economic problems of a wide range of Latin American countries were already acute during the five years preceding the current crisis, and the sluggish growth during those years acted as a drag on and partly reversed the improvement in social indicators seen since the beginning of the century. Economic growth in the region has also been slow over the past three decades, and the region is still beset by multiple social problems, including having one of the worst income distributions in the world. Moreover, a contraction in global economic growth and trade, and fewer opportunities for Latin American migrants will be the grim legacy left behind by the crisis, among other adverse effects.

Therefore, beyond the crisis, the region's development strategy must be reformulated, to include a big push for scientific and technological development, reindustrialization, solid and depoliticized support for regional integration, and a firm commitment to reducing inequality and to making a major contribution to global efforts to combat climate change and protect biodiversity. On all these issues, which are beyond the scope of this article, the support of the development banking system will also be critical.

Bibliography

Baldwin, R. and B. Weder di Mauro (eds.) (2020), *Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes*, London, Centre for Economic Policy Research (CEPR).

Bértola, L. and J. A. Ocampo (2013), *El desarrollo económico de América Latina desde la independencia*, Mexico City, Fondo de Cultura Económica.

Bolton, P. and others (2020), "Necessity is the mother of invention: how to implement a comprehensive debt standstill for COVID-19 in low- and middle-income countries", London, Centre for Economic Policy Research (CEPR), 21 April [online] https://voxeu.org/article/debt-standstill-covid-19-low-and-middle-income-countries.

Brooks, R. and J. Fortun (2020), "COVID-19 capital flow exodus from EM", *Global Macro Views (GMV)*, No. 3830, Washington, D.C., Institute of International Finance (IIF), 2 April.

Brown, G. and L. H. Summers (2020), "Debt relief is the most effective pandemic aid", Project Syndicate, 15 April [online] https://www.project-syndicate.org/commentary/debt-relief-most-effective-covid19-assistance-by-gordon-brown-and-lawrence-h-summers-2020-04.

Cardoso, F. H. and others (2020), "A roadmap for confronting COVID-19 in Latin America", *Americas Quarterly*, 15 April [online] https://www.americasquarterly.org/article/a-roadmap-for-confronting-covid-19-in-latin-america/.

Cheng, G. and others (2018), "IMF-RFA collaboration: motives, state of play, and way forward. A joint RFA staff proposal", *Discussion Paper Series*, No. 4, Luxembourg, Publications Office of the European Union, October [online] https://www.esm.europa.eu/sites/default/files/esmdiscussionpaper4.pdf.

Collins, C. and E. Truman (2020), "IMF's special drawing rights to the rescue", 10 April, Peterson Institute for International Economics (PIIE) [online] https://www.piie.com/blogs/realtime-economic-issues-watch/imfs-special-drawing-rights-rescue.

CPB (Netherlands Bureau of Economic Policy Analysis) (n/d), "World trade monitor" [online] https://www.cpb.nl/en/worldtrademonitor.

ECLAC (Economic Commission for Latin America and the Caribbean) (2020a), "Measuring the impact of COVID-19 with a view to reactivation", *Special Report COVID-19*, No. 2, Santiago, 21 April.

___(2020b), "The social challenge in times of COVID-19", *Special Report COVID-19*, No. 3, Santiago, 12 May.

___(2019), *Preliminary Overview of the Economies of Latin America and the Caribbean 2019*, (LC/PUB.2019/25-P), Santiago.

FEDESARROLLO (Foundation for Higher Education and Development) (2020), *Prospectiva económica*, L. F. Mejía, X. Cadena and M. E. Delgado (eds.), Bogotá, 30 April.

Gallagher, K. P., J. A. Ocampo and U. Volz (2020), "It's time for a major issuance of the IMF's special drawing rights", *Financial Times*, 20 March [online] https://ftalphaville.ft.com/2020/03/20/1584709367000/It-s-time-for-a-major-issuance-of-the-IMF-s-Special-Drawing-Rights/.

Gallagher, K. P. and others (2020), "Safety first: expanding the global financial safety net in response to COVID-19", *GEGI Working Paper*, No. 0037, Boston, Boston University, April.

Georgieva, K. (2020), "Confronting the crisis: priorities for the global economy", Washington, D.C., International Monetary Fund (IMF), 9 April [online] https://www.imf.org/en/News/Articles/2020/04/07/sp040920-SMs2020-Curtain-Raiser.

Griffith-Jones, S., R. Marodon and J. A. Ocampo (2020), "Mobilizing $400 billion: using the visible hand of development banks", Washington, D.C., Center for Global Development, 10 April [online] https://www.cgdev.org/blog/mobilizing-400-billion-using-visible-hand-development-banks.

G20 (Group of 20) (2020a), "Extraordinary G20 Leaders' Summit: statement on COVID-19", paper presented at the Extraordinary G20 Leaders' Summit, Riyadh, 26 March [online] http://www.g20.utoronto.ca/2020/2020-g20-statement-0326.html.

___(2020b), "Communiqué", paper presented at the Virtual Meeting of the G20 Finance Ministers and Central Bank Governors, Riyadh, 15 April [online] http://www.g20.utoronto.ca/2020/2020-g20-finance-0415.html.

___(2009), "Global Plan for Recovery and Reform", paper presented at the G20 Leaders' Summit, London, 2 April [online] http://www.g20.utoronto.ca/2009/2009communique0402.html.

G20 Eminent Persons Group on Global Financial Governance (2018), *Making the Global Financial System Work for All: Report of the G20 Eminent Persons Group on Global Financial Governance*, October [online] https://www.globalfinancialgovernance.org/assets/pdf/G20EPG-Full%20Report.pdf.

IDB (Inter-American Development Bank) (2020), "COVID-19: situation update in Latin America and the Caribbean" [online] https://www.iadb.org/en/coronavirus/current-situation-pandemic.

IMF (International Monetary Fund) (2020a), *World Economic Outlook: The Great Lockdown*, Washington, D.C., April.

___(2020b), *Global Financial Stability Report: Markets in the Time of COVID-19*, Washington, D.C., 14 April.

___(2020c), "Chapter 1: policies to support people during the COVID-19 pandemic", *Fiscal Monitor*, Washington, D.C., 15 April.

___(2020d), "Press briefing by Kristalina Georgieva following a conference call of the International Monetary and Financial Committee", Washington, D.C., 27 March [online] https://www.imf.org/en/News/Articles/2020/03/27/tr032720-transcript-press-briefing-kristalina-georgieva-following-imfc-conference-call.

___(2020e), "The managing director's global policy agenda, spring meetings 2020: exceptional times, exceptional action", *Policy Papers*, No. 20/020, Washington, D.C., 14 April.

___(2020f), "IMF Primary Commodity Prices", June [online] https://www.imf.org/en/Research/commodity-prices.

___(2017a), "Collaboration between regional financing arrangements and the IMF", *Policy Papers*, Washington, D.C., 31 July.

___(2017b), "Adequacy of the global financial safety net – Considerations for fund toolkit reform", *Policy Papers*, Washington, D.C., 19 December.

___(2012), "The liberalization and management of capital flows: an institutional view", *Policy Papers*, Washington, D.C., 14 November.

Izquierdo, A. and M. Ardanaz (2020), "Fiscal policy in the time of coronavirus: constraints and policy options for Latin American and Caribbean countries", Ideas Matter, Inter-American Development Bank (IDB), 31 March [online] https://blogs.iadb.org/ideas-matter/en/fiscal-policy-in-the-time-of-coronavirus-constraints-and-policy-options-for-latin-american-and-caribbean-countries/.

JP Morgan (2020), EM Flows Weekly, 28 May.

Levy, S. (2020), "Suggestions for the emergency", *COVID-19 Policy Documents Series*, No. 2 (UNDP LAC C19 PDS 2), New York, United Nations Development Programme (UNDP), March.

Maddison, A. (2010), "Maddison database 2010", Groningen Growth and Development Centre, University of Groningen [online] https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-database-2010.
Mnuchin, S. (2020), "U.S. Treasury Secretary Steven T. Mnuchin's Joint IMFC and Development Committee Statement", United States Department of the Treasury, 16 April [online] https://home.treasury.gov/news/press-releases/sm982.
Nuguer, V. and A. Powell (coords.) (2020), "Policies to fight the pandemic", *Latin American and Caribbean Macroeconomic Report*, Washington, D.C., Inter-American Development Bank (IDB), April.
Ocampo, J. A. (2020), "Can Latin America avoid another lost decade?", Project Syndicate, New York, 3 January [online] https://www.project-syndicate.org/commentary/latin-america-lost-decade-low-growth-by-jose-antonio-ocampo-2020-01?barrier=accesspaylog.
___(2017), *Resetting the International Monetary (Non)System*, Oxford, Oxford University Press.
Ocampo, J. A. and others (2011), "La gran recesión y el mundo en desarrollo", *Cooperación para el desarrollo en tiempos de crisis*, J. A. Alonso and J. A. Ocampo (coords.), Mexico City, Fondo de Cultura Económica.
Pineda, E., C. Pessino and A. Rasteletti (2020), "Policy and fiscal management during the pandemic and post-pandemic in Latin America and the Caribbean", 1 May [online] https://blogs.iadb.org/gestion-fiscal/en/policy-and-fiscal-management-during-pandemic-and-post-pandemic-latin-america-and-the-caribbean/.
Reinhart, C. and K. Rogoff (2020), "Suspend emerging and developing economies' debt payments", Project Syndicate, New York, 13 April [online] https://www.project-syndicate.org/commentary/suspend-emerging-and-developing-economies-debt-payments-by-carmen-reinhart-and-kenneth-rogoff-2020-04.
Stiglitz, J. E. and others (2020), "How the economy will look after the coronavirus pandemic", *Foreign Policy*, Washington, D.C., 15 April [online] https://foreignpolicy.com/2020/04/15/how-the-economy-will-look-after-the-coronavirus-pandemic/.
Tooze, A. (2020), "The coronavirus is the biggest emerging markets crisis ever", *Foreign Policy*, Washington, D.C., 28 March [online] https://foreignpolicy.com/2020/03/28/coronavirus-biggest-emerging-markets-crisis-ever/.
UNCTAD (United Nations Conference on Trade and Development) (2020a), "The COVID-19 shock to developing countries: towards a 'whatever it takes' programme for the two-thirds of the world population being left behind", *Trade and Development Report Update* (UNCTAD/GDS/INF/2020/2), Geneva, March.
___(2020b), "From the great lockdown to the great meltdown: developing country debt in the time of COVID-19", *Trade and Development Report Update* (UNCTAD/GDS/INF/2020/3), Geneva, April.
United Nations (2020), *Debt and COVID-19: A Global Response in Solidarity*, New York, 17 April [online] https://www.un.org/sites/un2.un.org/files/un_policy_brief_on_debt_relief_and_covid_april_2020.pdf.
World Bank (2020a), *Commodity Markets Outlook: Implications of COVID-19 for commodities*, Washington, D.C., April.
___(2020b), *Semiannual Report of the Latin America and Caribbean Region: The economy in the time of COVID-19*, Washington, D.C., April.
___(2020c), "COVID-19 crisis through a migration lens", *Migration and Development Brief*, No. 32, Washington, D.C., April.
___(2020d), "World Bank Group President Malpass: remarks to the Development Committee", 17 April [online] https://www.worldbank.org/en/news/statement/2020/04/17/world-bank-group-president-malpass-remarks-to-the-development-committee.
___(2020e), "Remarks by World Bank Group President David Malpass on G20 Finance Ministers Conference Call on COVID-19", 23 March [online] https://www.worldbank.org/en/news/speech/2020/03/23/remarks-by-world-bank-group-president-david-malpass-on-g20-finance-ministers-conference-call-on-covid-19.
WTO (World Trade Organization) (2020), "Trade set to plunge as COVID-19 pandemic upends global economy", *Press Release* (Press/855), Geneva, 8 April [online] https://www.wto.org/english/news_e/pres20_e/pr855_e.pdf.

Mapping social conflicts in natural resources: a text mining study of extractive activities

Ramiro Albrieu and Gabriel Palazzo

Abstract

Applying text mining techniques, a methodology was developed to measure the number of social conflicts related to the exploitation of non-renewable natural resources. The study focuses on conflicts in four mining countries (Australia, Canada, Chile and Peru) between 2003 and 2016, based on more than 20,000 articles from the leading newspapers of each country. A statically significant correlation was found between the main index and mineral rents as a percentage of gross domestic product (GDP). However, the results should be interpreted with caution since endogeneity issues have not been addressed and the indices could be biased by various, country-specific factors. This study's main outcome is a database with different indices of soft conflicts related to the exploitation of non-renewables natural resources and its media coverage in Australia, Canada, Chile and Peru.

Keywords

Social conflict, natural resources, non-renewable resources, mining, statistical data, Australia, Canada, Chile, Peru

JEL classification

J23, J24, O33

Authors

Ramiro Albrieu is an associate researcher in the Economics Department of the Center for the Study of State and Society (CEDES). Email: ralbrieu@cedes.org.

Gabriel Palazzo is a research assistant in the Economics Department of the Center for the Study of State and Society (CEDES). Email: gabrielmpalazzo@gmail.com.

I. Introduction

The exploitation of underground natural resources is a controversial issue. On the one hand, it can boost government revenues and provide the economy with the necessary income for growth, what Hirschman (1977) called indirect linkages. On the other hand, there is a perception, both in the literature and among the general public, that the social costs of these exploitation activities are not given due consideration when governments (or companies) decide to deplete a given non-renewable natural resource. This is particularly true when it comes to the effects of current actions on the well-being of future generations, but also to their contemporary local effects.

The climate change agenda and, more specifically, the literature on green accounting and its main applications (such as the System of Environmental-Economic Accounting (SEEA) developed by the United Nations) seeks to address the issue of intergenerational equity (United Nations, n/d). The World Bank (2006 and 2011) estimates of adjusted net saving tackle the intergenerational problem by correcting standard accounting savings (the sum of present and future well-being) and measuring investments in human and physical capital, the depletion of natural resources, and environmental damage caused by carbon dioxide and other emissions. However, the issue of intragenerational equity has been harder to address.

This article seeks to contribute to the literature on the exploitation and depletion of natural resources by finding proxy measures for social conflicts at the national and local (or regional) levels. The main goal is to draw attention to conflicts related to the exploitation of natural resources that national institutions and the private sector must address. To that end, patterns of words related to social conflicts were identified in articles about the mining sector published in the leading newspapers of four countries that are major producers of minerals, namely Australia, Canada, Chile and Peru. The main contribution of this study has been the creation of a database to explore causal effects and correlation in an effort to ensure better conflict management in the future.

The advantage of these indices is that they are able to capture minor conflicts and to measure the intensity of different conflicts. But a major weakness is that they may contain biases as a result of the different degrees of lobbying by the extractive industries, government or other agents on the media. However, if the impact of lobbying remained stable over time, the indices in the country sample will only be biased at the country level. This could be easily resolved by using fixed-effect regression models. Problems arise if lobbying varied over time or was subject to temporal shocks. Nevertheless, even if there is some bias, it is still interesting to evaluate the media coverage of social conflicts related to natural resources.

This article is organized as follows. Section II contains a brief overview of the literature on text mining in economics and explains the methodology applied to measure social conflict. Section III presents the main results at the country level, addresses regional disparities within countries, and defines the different levels of violence in the conflict indices measured. Section IV contains the regression models used to evaluate the relationship between conflicts and a country's mineral income and overall economic performance. Lastly, the conclusions are set out in section V.

II. Quantifying social conflicts in extractive industries

1. Literature review

The methodology used in this study is rooted in text mining techniques. These techniques allow conclusions to be reached, foster computational research and detect statistical patterns by studying the words present in a text.

Online newspapers contain vast amounts of qualitative information that can be processed using new software to obtain quantitative assessments for hard-to-quantify economic variables. Gupta and Lehal (2009) describe text mining as "the discovery by computer of new, previously unknown information, by automatically extracting information from different written resources" (p. 60).

The literature on the use of these techniques in economics has grown over time. Tetlock (2007) is one of the pioneers in this area, constructing a measure of media pessimism, mining the daily "Abreast of the Market" column in the Wall Street Journal. Using basic vector autoregressions (VARs), he finds that high values of media pessimism robustly predict downward pressure on market prices, followed by a reversion to fundamentals. Tetlock's findings suggest that measures of media content serve as a proxy for investor sentiment. By the same token, García (2013) constructs an index of market sentiment by counting the number of positive and negative words of two financial columns ("Financial Markets" and "Topics in Wall Street") from the New York Times, which were both published daily over the period 1905–2005. In accordance with Tetlock (2007), García finds that media content can predict trading volume. Using a parsimonious time-series model, García also finds that news content helps to predict daily stock returns, particularly during recessions. Aromí (2013) applies a similar methodology to evaluate how information flows from newspapers influenced the performance of the financial market in Argentina from October 1996 to December 2012. He carries out time-series regression models on stock returns, the determinants of which are media sentiment measures that he has constructed, the lags of these variables and the stock returns lags, among other control variables. Aromí finds evidence compatible with the presence of market participants who overreact to information flows. To obtain a quantitative index all these studies used a dictionary approach, counting positive and negative words to generate a numerical index.

Baker, Bloom and Davis (2013) use text mining techniques to construct an index that quantifies the uncertainty surrounding economic policy and its impact on investment demand in the context of the 2007–2009 economic recession in the United States. They built an economic policy uncertainty (EPU) index which sought to capture the prevailing uncertainty about tax, spending, regulatory and monetary policies. The EPU index is based on an automated text search for terms related to economic policy uncertainty in 10 leading newspapers published in the United States.

Social conflicts over natural resources have a much longer history than the text mining methodology used in this paper. Since the 1980s, the conventional view that natural resource endowments promote economic development has been called into question, with many contending that those very endowments are at the root of underdevelopment. Sachs and Warner (1995) attribute the lower growth exhibited by countries with a high share of commodity exports for the period 1970–1989 to the curse of natural resources. More recently, Brunnschweiler and Bulte (2009) state that there are no less than three different dimensions of the curse of natural resources: (i) slower economic growth; (ii) violent civil conflict; and (iii) undemocratic regimes.

Several reasons may link the exploitation of natural resources to social unrest and political conflicts. Possible hypotheses put forward by Sachs and Warner (1995) and Leite and Weidmann (1999) are that natural resource-rich countries exhibit higher inequality and social polarization because the ruling elite takes advantage of its political power to lobby for resources, fostering rent-seeking behaviour. Collier and Hoeffler (1998, 2004 and 2005) analyse different causes of civil wars and rebellions, among which an abundance of natural resources seems to have a considerable effect. Collier and Hoeffler (2004) contrast the hypothesis that rebellions may be explained by atypically severe grievances with the idea that they are caused by atypical opportunities for building a rebel organization. Their results support the opportunity hypothesis. They interpret the positive relationship between primary commodity exports and higher conflict risk as being due to the opportunities such commodities provide for extortion, making rebellion feasible and perhaps even attractive.

Along a similar line, Nafziger and Auvinen (2002) and Sinnott, Nash and De la Torre (2010) suggest that conflicts could be arise because different social groups do not receive what they consider to be their fair share, indicating a predatory State, weak regulations and elites that leverage resources to extract rents rather than promote economic growth. Sinnott, Nash and De la Torre (2010) identify the social consequences of mining and oil exploitation, which have high potential to generate social tensions and conflicts, in many cases because of their adverse environmental impact and poor working conditions. In turn, the "Dutch Disease" theory and the Prebisch-Singer hypothesis offer explanations as to why the exploitation of natural resources and its impact on the economy can generate social unrest among certain segments of the population (Singer, 1950; Prebisch, 1950).

Brunnschweiler and Bulte (2009) argue that it is necessary to instrument the variables involved. The authors find that there is endogeneity between these variables and reverse causality, whereby peace reduces a country's dependence on natural resources and that it is not the dependency on commodity exports that creates social conflict, which runs contrary to the resource curse thesis; in fact, they find that an abundance of resources could have a positive impact on economic growth. Mehlum, Moene and Torvik (2006), like Brunnschweiler and Bulte (2009), Arezki and van der Ploeg (2007), Haber and Menaldo (2011), and Leite and Wiedmann (1999), claim that the quality of institutions determines whether natural resource abundance is a blessing or a curse. Meanwhile, Giordano, Giordano and Wolf (2005) and Evans (2010) posit that natural resource scarcity may increase the risk of future sociopolitical conflicts. Robinson, Torvik and Verdier (2006) built a political economy model to analyse the impact of natural resources on development. They propose a model where politicians permit the over extraction of natural resources and then engage in inefficient redistribution of the resulting revenues to try to influence elections. However, they conclude that in countries with institutions which limit the ability of politicians to use clientelism to bias elections, resource booms tend to raise national income.

At the time of writing, few studies have used text mining to examine the relationship between natural resource exploitation and sociopolitical conflicts. To our knowledge, the methodology adopted by UNDP/Fundación UNIR (2012) is the closest to ours since they also use media coverage to analyse conflicts. For that study of social conflict in Latin America, data were collected from 54 newspapers published in 17 Latin American countries from October 2009 to September 2010. The authors identify three different spheres of conflict: (i) social reproduction (which account for the largest share of conflicts in the period analysed and includes those related to work/wages, land and incomes); (ii) institutional conflicts (related to demands for practical improvements in the provision of public goods, administrative management and the legitimacy of public authorities); and (iii) cultural conflicts (related to ideological-political issues, public safety and the environment, among other things).

Another example in this field is Dube and Vargas (2013), who use newspaper articles to characterize violent civil conflicts in Colombia. They present evidence that a rise in the price of oil intensified violence in areas transporting and producing more oil, while a fall in the price of coffee increased violence in municipalities growing more coffee. The key difference between these activities is the labour intensity gap. On one hand, the fall in coffee prices reduces workers' wages and lowers the cost of recruiting workers into armed groups. This is called opportunity cost effect. On the other hand, the oil shock substantially increases local government revenue, encouraging paramilitary groups to move into oil areas to control these resources. This is called the rapacity effect. Unlike the present study, however, Dube and Vargas use a dataset from the Conflict Analysis Resource Center (CERAC) collected from newspaper articles, rather than constructing a new database using text mining technique.

Lastly, the empirical strategy used in this paper is borrowed from Palazzo (2017), who created social conflict indices related to the exploitation of a broad set of natural resources in Argentina over the period 1996–2014. This was a major contribution to the development of the methodology and procedure for verifying whether those indices reliably showed some stylized facts about civil conflicts related to agriculture, mining, oil, fishing and forestry activities in Argentina.

2. Empirical strategy used

We have developed a methodology that measures the quantity of sociopolitical conflicts related to the exploitation of mineral resources, that might be applied to other natural resources (see Palazzo, 2017). A text mining bag-of-words model was used, which consisted of counting the number of hostile words in each article that referenced the extractive industries in a particular location and time period. The number of articles about conflicts serves as a proxy for the level of conflict at a particular point in time and in a particular place. We then used this information to create a set of indices (on, for example, the ratio of hostile words to total words per article) to capture the intensity of conflicts.

The majority of the literature on social conflicts examines civil wars where the number of dead people is the measure of intensity. Our index differs from those constructed by other authors, by offering a soft measure of conflict that takes into account strikes, lockouts, protest marches and political struggles. In addition, the conflicts are unequivocally related to the extractive industries because of the nature of the methodology.

The data was taken from Factiva (Dow Jones, 2020), a website that collects and stores a large number of newspapers from around the world and classifies the articles by industry and sector. We have chosen the areas of Mining/Quarrying and Primary Metals Industries, to ensure that each news article concerns the sector under analysis.

Ideally, more than one newspaper per country would have been used in order to avoid or smooth out media biases. However, despite the fact that Factiva covers a broad range of newspapers, not all of them are available for the whole period under consideration and the number of newspapers covered is not the same for all the countries analysed. This data restriction meant that the period of time and the number of newspapers used to build the indices had to be limited. If more than one newspaper per country had been used, then the time period of available data would have been reduced to less than three years. We therefore decided to use only one newspaper per country and thus extend the time frame covered by the database to 2003–2016. As noted above, this is the database's major weakness, as the indices might be biased as a result of the different degrees of lobbying by the extractive industries, governments or other agents on the media with regard to coverage of conflicts in each country.

However, if the impact of lobbying remained the same over time, the indices in the country sample will only be biased on the country level. This is not a real concern because the variation will be still informative of increases or decreases in conflict levels. Problems will arise if the intensity of the lobbying varied over time. In the event that pressure from lobbyists varies across the country but remains stable over time, it will limit the country-level analysis, but it can be easily resolved by applying a fixed-effects regression model. However, steps should be taken in the future in an effort to avoid or minimize this potential pitfall.

The newspapers with the largest circulation were used for each country analysed, namely *El Mercurio* for Chile, *El Comercio* for Peru, the *Herald Sun* for Australia and *The Globe and Mail* for Canada. Data were available from November 2002 for *El Mercurio*, October 2002 for *El Comercio*, July 1997 for the *Herald Sun* and December 1986 for *The Globe and Mail*. Since most newspapers carry articles referring to other countries, we deleted those articles that contained the name of other countries and did not mention the name of the country of interest. The time period covering 2003 to the first semester of 2016 was chosen in order to have a balanced panel of data.

The identification of conflicts was crucial to the process. In line with UNDP/Fundación UNIR (2012), this study adopts a classic definition of social conflict as a process of contentious interaction between social actors and institutions which mobilize with different levels of organization and act collectively in order to improve conditions, defend existing situations, or advance new alternative social projects. A social conflict arises when a social group, actor or movement (workers, entrepreneurs, *campesinos*, indigenous peoples, teachers, civic movements, students, trade unions, academics, etc.) expresses a collective malaise in a hostile manner through demands and violent tactics designed to exert pressure (strikes, marches, riots, demonstrations, occupations of facilities, etc.) against any public or private body (p. 283).

Taking this definition, a dictionary-based approach was adopted to detect these patterns in the news articles. The hostile words category of the Harvard IV-4 dictionary[1] was used, with 687 entries in English at the time of writing. These were then translated into Spanish and the database was expanded to a total of 1,326 words by adding Spanish synonyms for those hostile words (see annex A1).

To avoid any possible complications arising from the conjugation of verbs and the agreement of nouns and adjectives, the common word endings in English and Spanish were removed using R software. Then, all words are rewritten in lower case letters, punctuation and accents were excluded, and common words in each language (like connectors) were deleted to avoid counting extra words that did not add any meaning and may be used more or less often in each language.

Lastly, the statistical program R allowed us to systematize this process to generate the indices for each country, which were then disaggregated by administrative area. Text mining techniques were subsequently carried out again; by checking to see if an article contained the name of the administrative area, the main cities and/or the mining sites in that area, the articles were categorized by region.

Three alternative indices were created that served as proxy variables for the number of social conflicts related to natural resources (Palazzo, n/d) and could be used for different purposes. They are:

- **Conflict news**: Let $CN_{i,t}$ be newspaper articles that include hostile words about the country or region i at time t, thus the conflict news index for each country or region is $CN_i=\sum_t CN_{i,t}$ and the total conflict news index for each period $CN_t=\sum_i CN_{i,t}$. This index may have numerous biases because, for example, it does not control for whether an increase in the number of hostile words is solely attributable to that fact that more reports are published on the matter.
- **Standardized conflict news**: In accordance with Baker, Bloom and Davis (2013), let $TN_{i,t}$ be newspaper articles about the extractive industries in country or region i published in period t, thus the standardized conflict news index is $SCN_{i,t}=CN_{i,t}/TN_{i,t}$.
- **Conflict intensity**: Based on García (2013) and Aromí (2013), the intensity of a conflict is measured at a specific point in time and space as the ratio of the number of hostile words to the total number of words inside the subset of conflict news. Let $CW_{i,t}$ be the number of hostile words found in the conflict news index and $TW_{i,t}$ the total number of words in those articles, thus conflict intensity in country or region i during the period t is $CI_{i,t} = CW_{i,t}/TW_{i,t}$.

III. Social conflicts related to extractive activities

1. Country comparisons

A total of 20,119 newspaper articles were collected about extractive industries from the four newspapers analysed covering the period between the first quarter of 2003 and the second quarter of 2016. Of these articles, 78% were classified as conflict news (see table 1),[2] indicating that the public is generally pessimistic about extractive activities. This was to be expected given that our unit of analysis is newspaper articles.

When the data are disaggregated by country, some differences arise. First, the percentage of standardized conflict news $(SCN_{i,t})$ is higher in the developed countries —around 92% for both Australia and Canada—, while in Chile and Peru it is between 63% and 66%. With regard to conflict intensity, the values are higher for the developed countries, with the figure for Canada slightly higher than that for Australia.

These results are descriptive of the general findings of this paper and the database that we have constructed. However, they should not be interpreted as meaning that conflict levels are higher

[1] See [online] http://www.wjh.harvard.edu/~inquirer/homecat.htm.

[2] Our main indices, disaggregated by month and year, are freely available at https://sites.google.com/view/gabrielmpalazzo/original-databases. Our codes in R format are available upon request.

in Australia and Canada than in Chile and Peru. Firstly, since we are comparing indices created from different newspapers, a higher proportion of standardized conflict news or conflict intensity could be explained by the preferences or interests of different readerships as well as the different writing styles of the newspapers' journalists. In addition, the differences in levels among the countries analysed coincide with languages differences; we therefore cannot discount the fact that native speakers of the two languages may express facts and their opinions in a different manner. Lastly, as was noted above, the differences might be attributable to different biases in the media. These results should therefore be interpreted as indices composed of different constants and the analysis should focus on how behaviour changes over time and the responses following relevant shocks from exogenous variables.

Table 1
Australia, Canada, Chile and Peru: national patterns in social conflicts related to extractive activities, first quarter of 2003–second quarter of 2016
(Total number of articles and percentages)

Country	Total number of articles on extractive activities $TN_{i,t}$	Conflict news $CN_{i,t}$	Standardized conflict news *(standardized index)* $SCN_{i,t}$ *(percentages)*	Conflict intensity $CI_{i,t}$ *(percentages)*
Australia	2 709	2 502	92.36	3.70
Canada	6 871	6 349	92.40	4.53
Chile	8 095	5 375	66.40	2.76
Peru	2 444	1 543	63.13	2.89
Total	20 119	15 769	78.37	3.81

Source: Prepared by the authors, on the basis of articles obtained from *El Mercurio*, *El Comercio*, *The Globe and Mail*, and *Herald Sun* newspapers.

Turning to time patterns (see table 2), three different subperiods can be detected with regard to the conflict news index, $CN_{i,t}$. The first, extending roughly from 2003 to 2006, where social conflict appears to be increasing; a second where conflict steadily decreases (2007–2009); and a third (2010–2016) where it remains generally stable (despite two spikes in 2010 and 2014). However, the standardized index $SCN_{i,t}$, reveals a different picture: the trend was relatively stable during the period 2003–2007, reflecting that conflict news grew *pari passu* with total news, before jumping and stabilizing at higher levels through the period 2008–2013; lastly, it fluctuates over the 2014–2016 period, peaking in 2015.

Table 2
Australia, Canada, Chile and Peru: time patterns in social conflicts related to extractive activities, 2003–2016
(Total number of articles and percentages)

Year t	Total number of articles on extractive activities $TN_{i,t}$	Conflict news $CN_{i,t}$	Standardized conflict news *(standardized index)* $SCN_{i,t}$ *(percentages)*	Conflict intensity $CI_{i,t}$ *(percentages)*
2003	822	695	84.55	4.02
2004	1 394	1 049	75.25	3.42
2005	1 497	1 091	72.88	3.20
2006	2 128	1 637	76.93	3.62
2007	1 952	1 270	65.06	3.63
2008	953	664	69.67	3.47
2009	774	529	68.35	4.02
2010	938	755	80.49	4.42
2011	670	495	73.88	4.03
2012	669	541	80.87	4.03
2013	732	535	73.09	3.98
2014	908	502	55.29	3.75
2015	908	697	76.76	3.91
2016	406	373	91.87	2.99

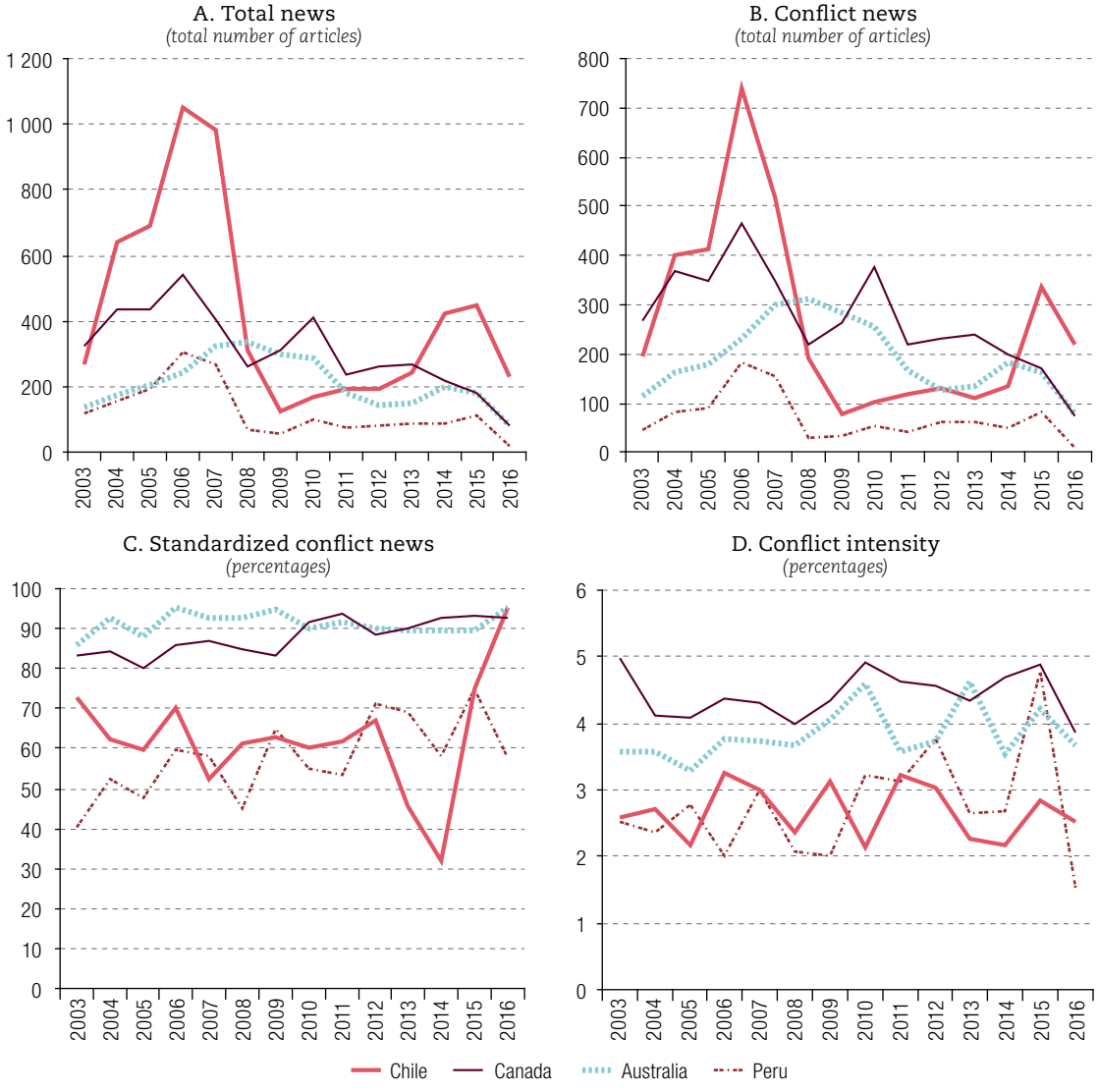
Source: Prepared by the authors, on the basis of articles obtained from *El Mercurio*, *El Comercio*, *The Globe and Mail*, and *Herald Sun* newspapers.

With regard to the conflict intensity, the $CI_{i,t}$ index indicates a steady increase in the intensity of social conflicts related to extractive activities between 2003 and 2010, before starting to diminish, albeit slowly.

Lastly, figure 1 shows the country-specific evolution of social conflict over time. Regarding both the total news index $TN_{i,t}$ and the conflict news index $CN_{i,t}$, it is clear that they peaked during the 2004–2008 period. In turn, the standardized index reveals that the aforementioned country differences are present over the whole period under analysis. The indices for Chile and Peru are more volatile than those of Australia and Canada, and social conflict in Chile grew significantly over the last two years of the period under analysis. Two interesting points arise with regard to conflict intensity. Firstly, that the Peru index is more volatile than the others; meaning that, unlike the other countries, Peru is subject to "explosions" of intense conflicts. Secondly, the conflict intensity remained relatively low in Chile during the whole period.[3]

Figure 1

Australia, Canada, Chile and Peru: social conflicts related to extractive activities, 2003–2016



Source: Prepared by the authors.

[3] It should be borne in mind that conflicts can arise in a specific territory but companies from different countries might be involved. For example, Canadian companies could be involved in conflicts in Africa or Chile. The methodology used was unable to address these data challenges and if the news appears in the Canadian newspaper then it will be allocated as conflict news for that country.

The main advantage of the text mining technique is that it allows a huge amount of unstructured data to be processed without qualitative analysis. However, it could be informative to match some of the peaks to important events. For example, in November 2010 there was peak in mining conflict news in Canada which coincided with the controversial attempt by the Australian firm BHP Billiton to acquire Potash Corp, which was blocked by the Canadian Prime Minister, Stephen Harper. This is reflected in figure 1 by a rise in conflict news during 2010 in Canada. Another example is a strike for higher wages in Chile in December 2005 by the employees of the Ferrocarril de Antofagasta a Bolivia (FCAB), a privately-owned mining railway from Antofagasta in northern Chile to Bolivia. Around that time there was also some controversy since the Chilean peso appreciated against the United States dollar and mining firms were complaining about the hit to their profits. Moreover, during the first months of 2006, some members of the opposition raised questions in parliament about the hiring of consultants and services carried out by the Coporación Nacional del Cobre de Chile (CODELCO), the Chilean State-owned copper mining company. All of these events coincide with a spike in the conflict news index for Chile in 2006.

These are some examples of the types of conflicts that the indices are capturing. However, we do not have an objective measure of conflicts to check the accuracy of the indices. It is not conclusive to try to check the accuracy of the indices against the newspaper articles, since they are the primary source of information for building the indices. Nevertheless, the indices are a first step towards documenting civil conflicts related to extractive activities in the future.

2. Regional comparisons

To disaggregate conflicts by administrative area, we used the text mining approach to categorize each article by state, territory, province, region or department to see whether it contained the name of that administrative area, the capital cities or the names of mining sites in those areas

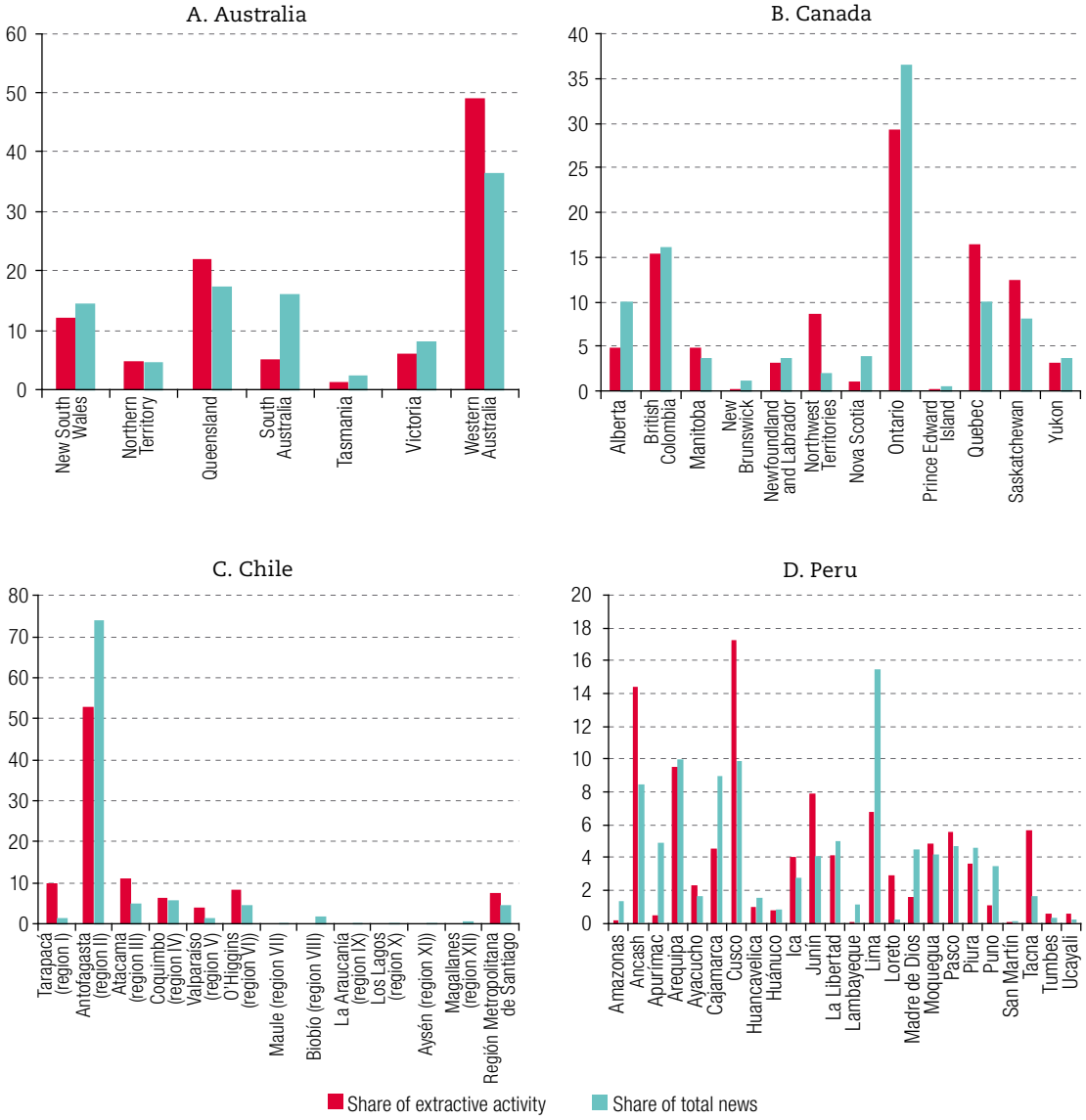
As was expected, the administrative areas that accounted for a higher share of total news articles related to mining are those where extractive industries are present. Figure 2 shows the relationship between administrative areas' shares of national mining gross domestic product (GDP) around 2013 and 2014 and their share of total news articles on mining for each country.

The results reveal a clear correlation between both indices, particularly for Ontario (Canada), Western Australia (Australia) and region II, Antofagasta, (Chile), where the main producer regions have the highest number of news articles about mining. The number of articles drops as the mining sector becomes less important.

The correlation is weaker in Peru but remains high. Lima accounts for the highest share of news articles on mining but is ranked fifth in terms of extractive activity (7%). Although it is not the main mining department (Cusco and Ancash are the most important), it is not unreasonable for mining news to be reported in the capital city, where parliament and national politicians are located. These results are in line with the findings of Palazzo (2017).

To obtain regional values for the standardized conflict index and conflict intensity index, regional maps of social conflicts related to the extractive industry were compiled. To analyse regional differences within each country, four distinct subgroups were considered: considerably above average, above average, below average and considerably below average. The two subgroups that are considerably above or below the average refer to instances where the index reaches higher (lower) values than the average value plus (minus) one standard deviation. The other two subgroups exhibit values above or below the average but within normal standards of deviation (see map 1).

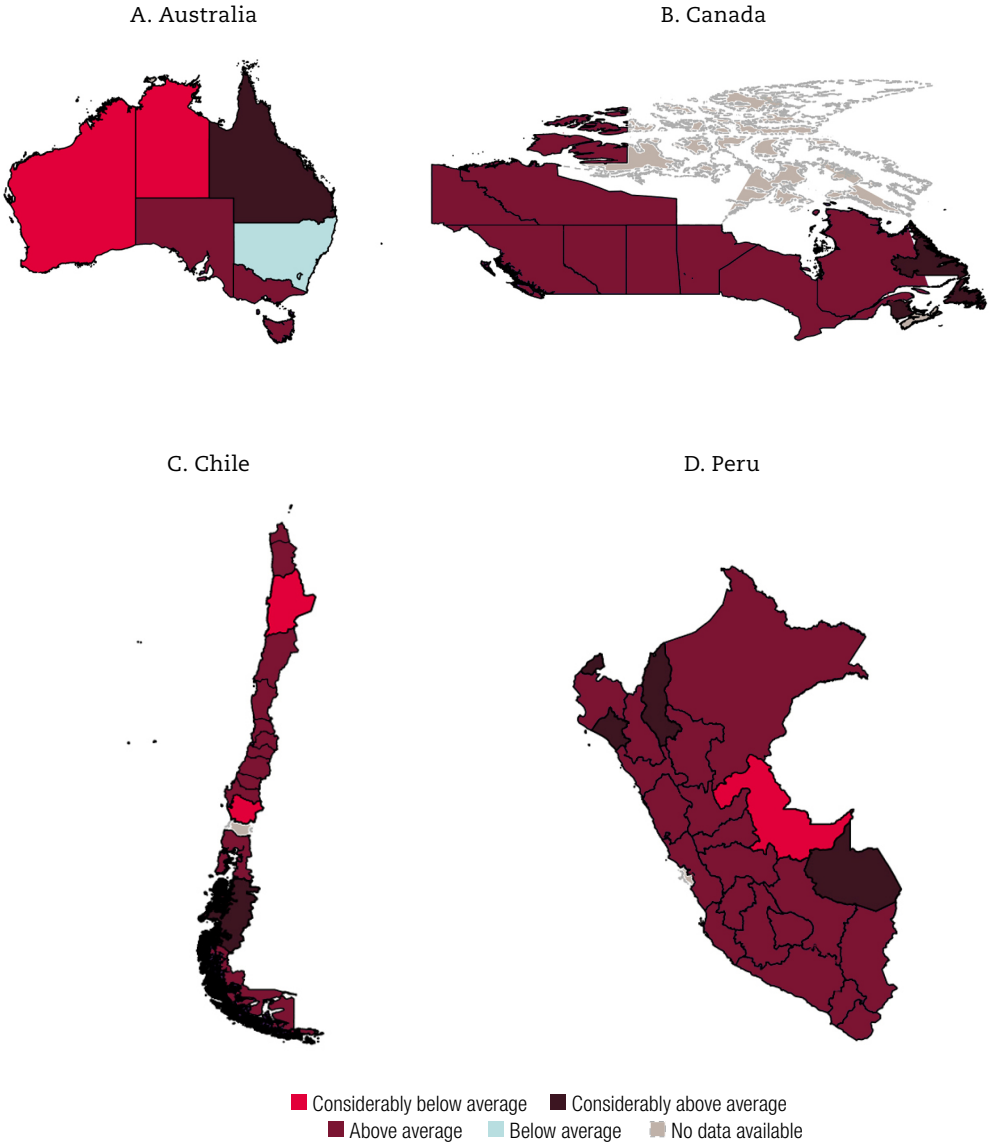
Figure 2
Australia, Canada, Chile and Peru: share of extractive activities and mining news articles, by administrative area, first quarter of 2003–second quarter of 2016
(Percentages)



Source: Prepared by the authors.
Note: No data were available for the following administrative areas: Australian Capital Territory (Australia), Nunavut (Canada), Los Ríos (region XIV), Arica and Parinacota (region XV) and Ñuble (region XVI) (Chile), and Callao (Peru). They are therefore not included in these indices.

Starting with the standardized conflict index, in Australia, Queensland has a particularly high level of conflict. For one thing, the proportion of negative news surpasses 95% (92.3% is the average for the country as a whole). Meanwhile, Western Australia and the Northern Territory have relatively low levels of conflict (about 90% of the news articles contain hostile words). The total variability, however, is relatively low (the coefficient of variation is 0.023).

Map 1
Australia, Canada, Chile and Peru: standardized conflict index by administrative area, first quarter of 2003–second quarter of 2016



Source: Prepared by the authors.
Note: No data were available for the following administrative areas: Australian Capital Territory (Australia), Nunavut (Canada), Los Ríos (region XIV), Arica and Parinacota (region XV) and Ñuble (region XVI) (Chile), and Callao (Peru). They are therefore not included in these indices.

In Canada, the conflict index is also close to 92%. New Brunswick and Newfoundland, two eastern provinces, stand out for their high share of negative news, over 95%, while Nova Scotia has the lowest (84.5% of the news articles contain hostile words). This outlier means that the total variability index for Canada is higher than that of Australia.

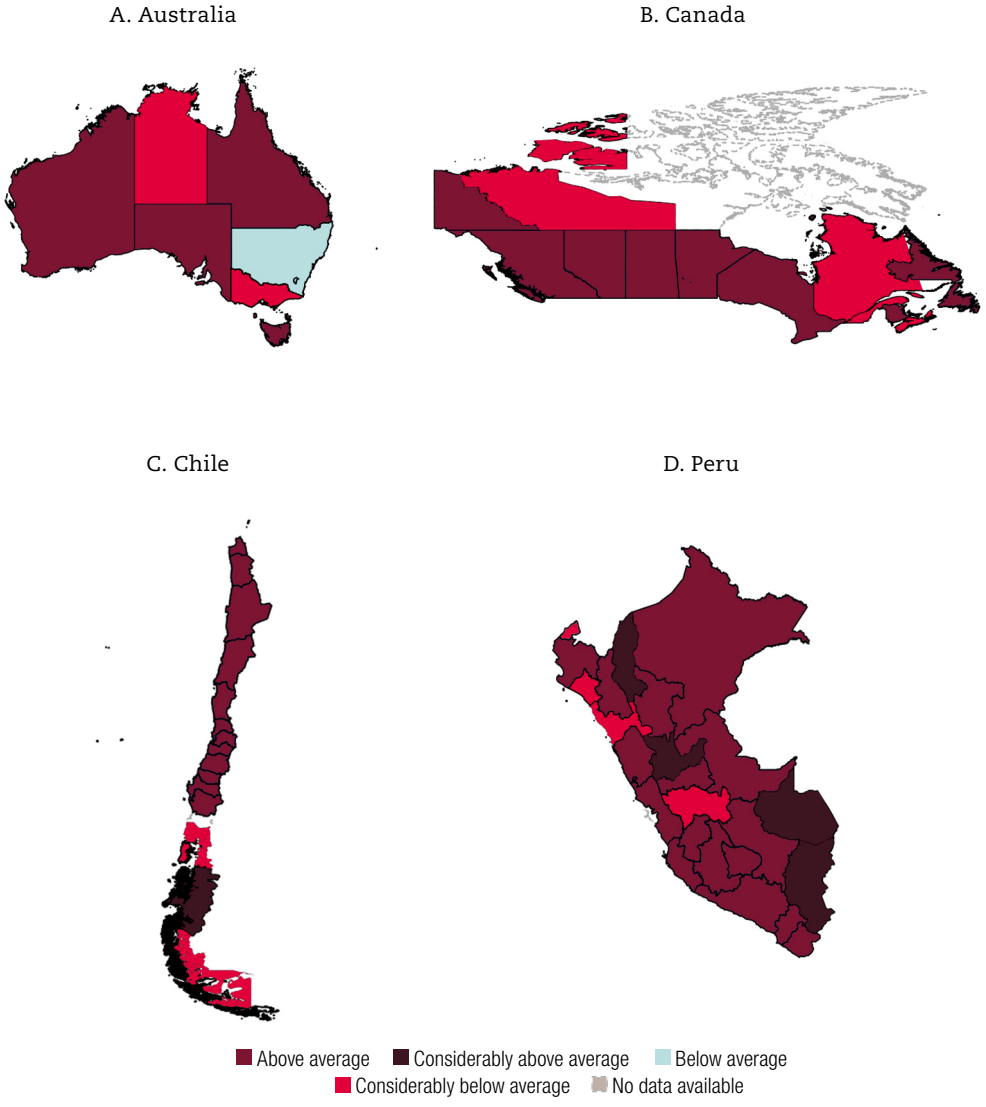
Chile has a lower level of conflict: its index is close to 80%. The differences among the regions are more marked than in the previous cases, and consequently the coefficient of variation is higher (0.12). The index exceeds 85% in some regions, while in others it is less than 70%. Three regions that are not traditionally mining areas are in the first group, namely Aysén (region XI), Los Lagos (region X) and Magallanes (region XII). It is interesting to note that one of Chile's major mining areas, Antofagasta

(region II), is —together with La Araucanía (region IX)— among the regions with the lowest levels of conflict (with just 61% of negative news articles).

Lastly, in Peru, the contrast among the different departments is even starker: some have a conflict index of less than 50%, while for others it is nearly 90% (the coefficient of variation rises to 0.23). Three departments are particularly prone to conflict, specifically Amazonas, Madre de Dios and Tumbes, while Ucayali has the lowest level of conflict associated with extractive activity.

With regard to the conflict intensity index (see map 2), Victoria is the Australian state with the greatest conflict intensity; almost one in every 20 words in the relevant news articles is hostile. Meanwhile, Queensland, which has the highest level of conflict, recorded a lower level of conflict intensity, as was expected. At the other end of the spectrum, the Northern Territory had the lowest level of conflict and the lowest intensity ratio (one in every 30 words is a hostile word).

Map 2
Australia, Canada, Chile and Peru: conflict intensity index by administrative area, first quarter of 2003–second quarter of 2016



Source: Prepared by the authors.
Note: No data were available for the following administrative areas: Australian Capital Territory (Australia), Nunavut (Canada), Los Ríos (region XIV), Arica and Parinacota (region XV) and Ñuble (region XVI) (Chile), and Callao (Peru). They are therefore not included in these indices.

The conflict intensity is much more homogeneous across the administrative areas of Canada: the variation coefficient is 0.045 and the percentage of hostile words varies between 4.0% and 4.7%. Two areas stand out for their low conflict intensity: the Northwest Territories and Nova Scotia.

Regional disparities in the intensity of social conflicts are more pronounced in the developing countries. In Chile, for example, regions such as Aysén (region XI), Maule (VII) and O'Higgins (VI) recorded high levels of conflict intensity, while Magallanes (XII) and Los Lagos (X) recorded the lowest. As a result of these differences, the variation coefficient is 0.20.

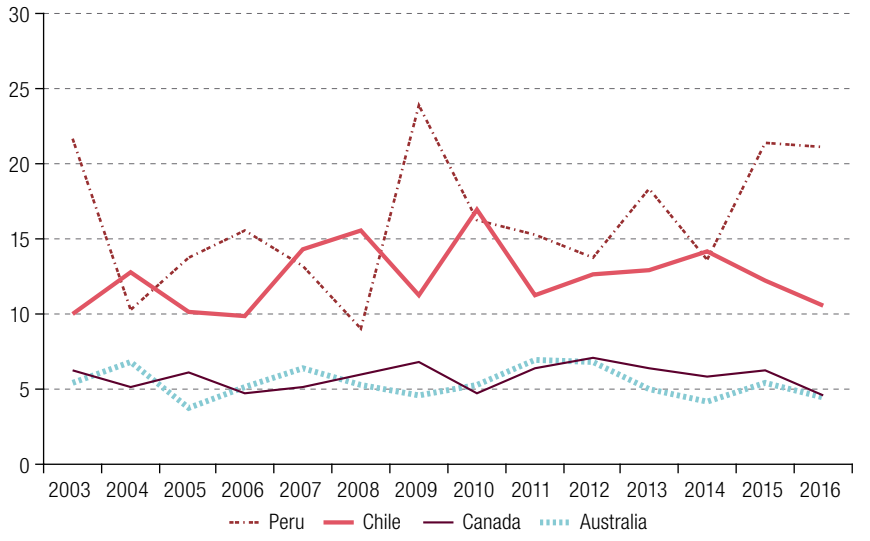
The disparities in Peru are even greater. In four departments (Madre de Dios, Huánuco, Puno and Amazonas) the conflict intensity was high, with at least one in every 30 words related to conflict, while it was low in four others (Junín, La Libertad, Lambayeque and Tumbes). The variation coefficient for Peru is the highest of the four countries under analysis, at 0.25.

3. Intensity of conflict violence

It may sound counterintuitive that the results of the indices of social conflicts related to extractive activities are higher in developed countries than in developing ones. Although possible methodological reasons for this have already been identified and the best way to use the indices has been explained, some possible explanations for the different types of conflicts that the indices are capturing in the country sample are set out below. One testable hypothesis is that the developed country indices are capturing softer conflicts than those for developing countries. The indices are built in such a way that, for example, the word "death" has the same weight as "disagreement". Thus, conflict intensity should be redefined in a manner that will allow us to discriminate between violent and non-violent conflicts.

To that end we developed an violent conflict index based on the share of hostile words in a given period and country that can be classified as violent, that is $VC_{i,t} = VW_{i,t}/CW_{i,t}$, where $VC_{i,t}$ is the index and $VW_{i,t}$ is the sum of violent words (the subgroup of hostile words that are violent can be found in annex A1). $CW_{i,t}$ is the sum of hostile words defined above. The results are presented in figure 3.

Figure 3
Australia, Canada, Chile and Peru: violent conflicts related to extractive activity, 2003–2016
(Percentages)



Source: Prepared by the authors.

As was expected, violent conflicts related to extractive activities were more common in the developing countries. In Australia and Canada, the share of violent conflicts in total hostile conflicts was consistently around 5%. In the case of Chile, the results yield an average around 11% for the whole 2003–2016 period, while in Peru the average is around 15%. Our main hypothesis is that these findings might be related to weaker governance or the fact that fewer mechanisms are available to resolve and address social demands in developing countries which leads to surges of violent conflict. Moreover, inequality is greater and polarization more pronounced in developing countries, causing civil conflicts to be more violent than those in developed countries.

It should also be borne in mind that some soft conflicts in developing countries might receive less media coverage owing to the greater lobbying power of elites, including the owners of mining deposits, to soften unfavourable news (for more in-depth analysis of this hypothesis, see Nafziger and Auvinen, 2002, and Sinnott, Nash and De la Torre, 2010). However, further analysis is needed to understand this difference between developed and developing countries, as well as a bigger sample of countries.

IV. Some stylized facts from the database

1. Common drivers or country-specific trends?

Further analysis of the correlation between the conflict indices in our sample produces some interesting results. Table 3 contains the correlation matrix, using the annual frequency of the different conflict indices.

Table 3
Australia, Canada, Chile and Peru: correlation matrix

A. Conflict news					B. Standardized conflict news *(standardized index)*			
Country	Chile	Peru	Canada	Australia	Chile	Peru	Canada	Australia
Chile	1				1			
Peru	0.9337	1			-0.023	1		
Canada	0.6876	0.6976	1		-0.2708	0.514	1	
Australia	0.1821	0.1894	0.2793	1	0.0544	0.1963	-0.056	1
C. Conflict intensity					**D. Violent conflict intensity**			
Country	Chile	Peru	Canada	Australia	Chile	Peru	Canada	Australia
Chile	1				1			
Peru	0.0559	1			-0.4069	1		
Canada	0.0165	0.5365	1		-0.3009	0.3782	1	
Australia	-0.1647	0.2451	0.3076	1	0.0878	-0.2599	-0.024	1

Source: Prepared by the authors.

The correlation analysis, using annual data, shows that, without any control, conflicts related to extractive activities in the sample countries do not covariate. Only the conflict news for Chile, Peru and Canada show some positive and significant correlation. Australia does not correlate in a positive and statistically significant way with any of them. These results were confirmed using quarterly data and by performing a factor analysis (see table 4).[4]

[4] Eight monthly observations were excluded from the conflict intensity index for Chile because their values were five times the standard deviation above the mean. These extreme values were only present in Chile and could have introduced bias into the correlation matrix analysis.

Table 4
Australia, Canada, Chile and Peru: factor loadings[a] and unique variances

	A. Conflict news			B. Standardized conflict news *(standardized index)*		
Country	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
Chile	0.8047	-0.0213	0.352	-0.2342	0.3098	0.8491
Peru	0.7634	0.0028	0.4172	0.2368	0.3054	0.8506
Canada	0.565	0.0043	0.6807	0.4341	-0.0043	0.8115
Australia	0.1375	0.0916	0.9727	0.0658	0.0323	0.9946
	C. Conflict intensity			D. Violent conflict intensity		
Country	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
Chile	0.5141	-0.096	0.7265	-0.098	0.1821	0.9572
Peru	0.505	0.0926	0.7364	0.28	-0.1119	0.9091
Canada	0.2574	0.0478	0.9315	0.3582	0.1113	0.8593
Australia	-0.0343	0.2837	0.9183	-0.4298	-0.0217	0.8148

Source: Prepared by the authors.
[a] The factor loadings represent both how the variables are weighted for each factor and also the correlation between the variables and the factor.

Uniqueness shows the proportion of common variance of the variable not associated with the factors. The conflict news uniqueness figure is high for all the countries, but particularly Australia. The uniqueness figures are also very high for the standardized conflict news, conflict intensity and violent conflict intensity, averaging 0.876, 0.828 and 0.885, respectively. These results may indicate that conflicts related to extractive activities arise because of local political and economic situations and that different countries manage common shocks in very different ways depending on their institutional frameworks, industries and general social structures. Figure 4 depicts the main factor of the indices and a commodity metals price index from the International Financial Statistics (IFS) database of the International Monetary Fund (IMF).

There are no evident conclusions to be drawn from figure 4 and it should be borne in mind that the uniqueness of each index is very high. However, figure 4 does indicate that the conflict intensity and violent conflict intensity indices (figures 4C and 4D) are not related to fluctuations in the commodity metal prices index. Therefore, no econometric analysis was carried out for these indices.

With regard to the evolution of conflict news (figure 4A), there is an uptick in both metal prices and conflict news until 2007, but the trends diverged thereafter as commodity metal prices soared in 2008. One possible explanation for this divergence might be that the media outlets in the countries of our sample were focused on the international financial crisis. Another reason could be that the number of total conflicts related to extractive activities became more country specific after that crisis.

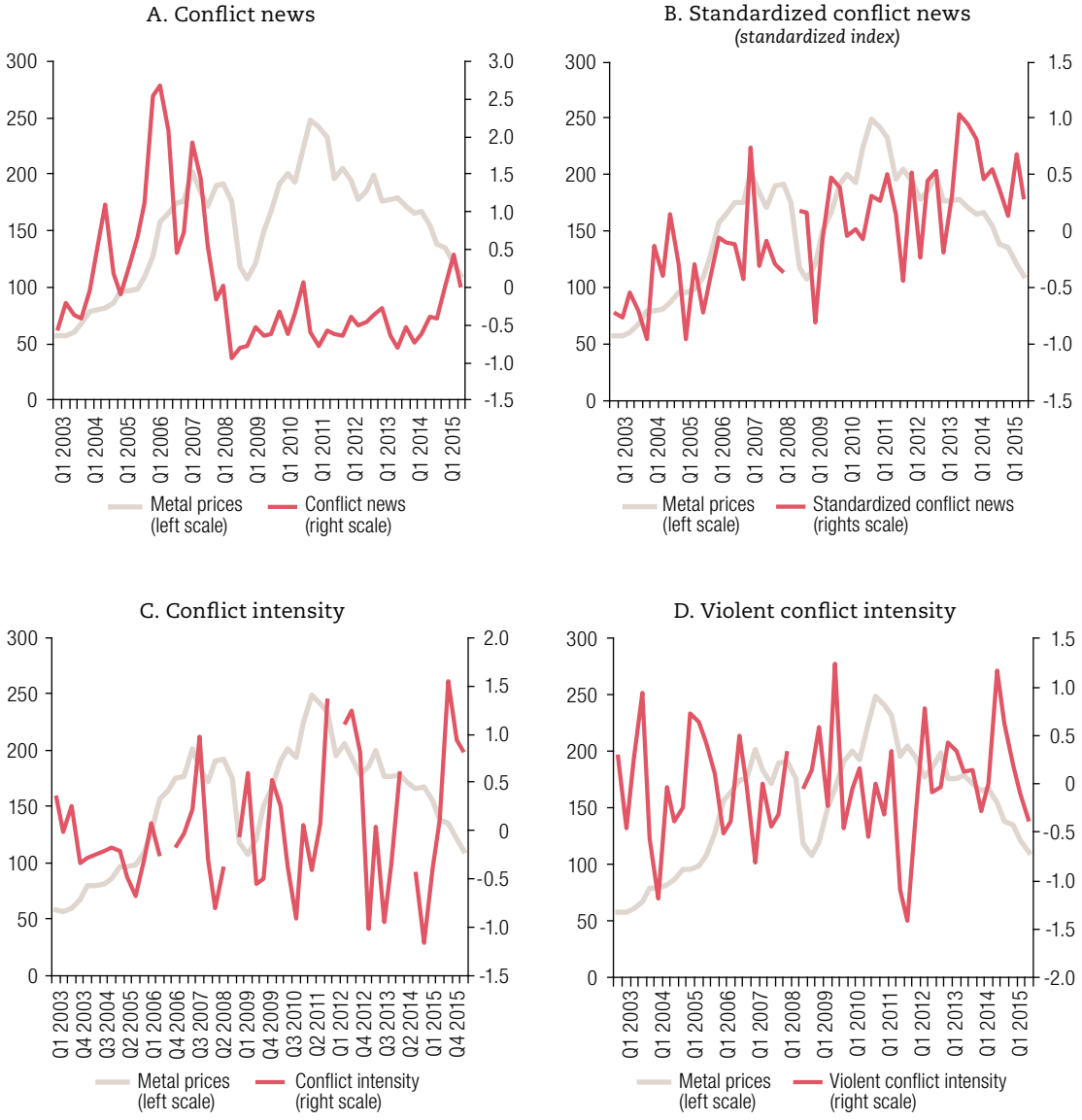
If the first explanation is correct, this issue may be rectified using the standardized conflict news index, the purpose of which is to correct the total number of conflict news articles by dividing them by the total number of news articles related to extractive activities. The main factor of the standardized conflict news index (figure 4B) follows an upward trend for the whole time period analysed. The positive relationship between both series might be spurious if both series are I(1).

An augmented Dickey-Fuller test was therefore performed. The null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. Since both series show a unit root process,[5] but the first difference is stationary, we tested for a cointegration relationship using the Engle-Granger methodology.[6]

[5] The number of lags was selected using the Akaike information criterion (AIC).

[6] See table A2.1 in annex A2 for augmented Dickey-Fuller tests on variables and residuals. This test was performed on the residuals to check for cointegration relationship. The correct critical value for each test is reported.

Figure 4
Australia, Canada, Chile and Peru: commodity metal prices[a] and main factor loading



Source: by the authors, on the basis of International Monetary Fund (IMF), "International Financial Statistics (IFS)", 2020 [online database] https://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B&sId=1409151240976.

[a] Commodity metals price index, 2005 = 100, includes copper, aluminium, iron ore, tin, nickel, zinc, lead and uranium price indices.

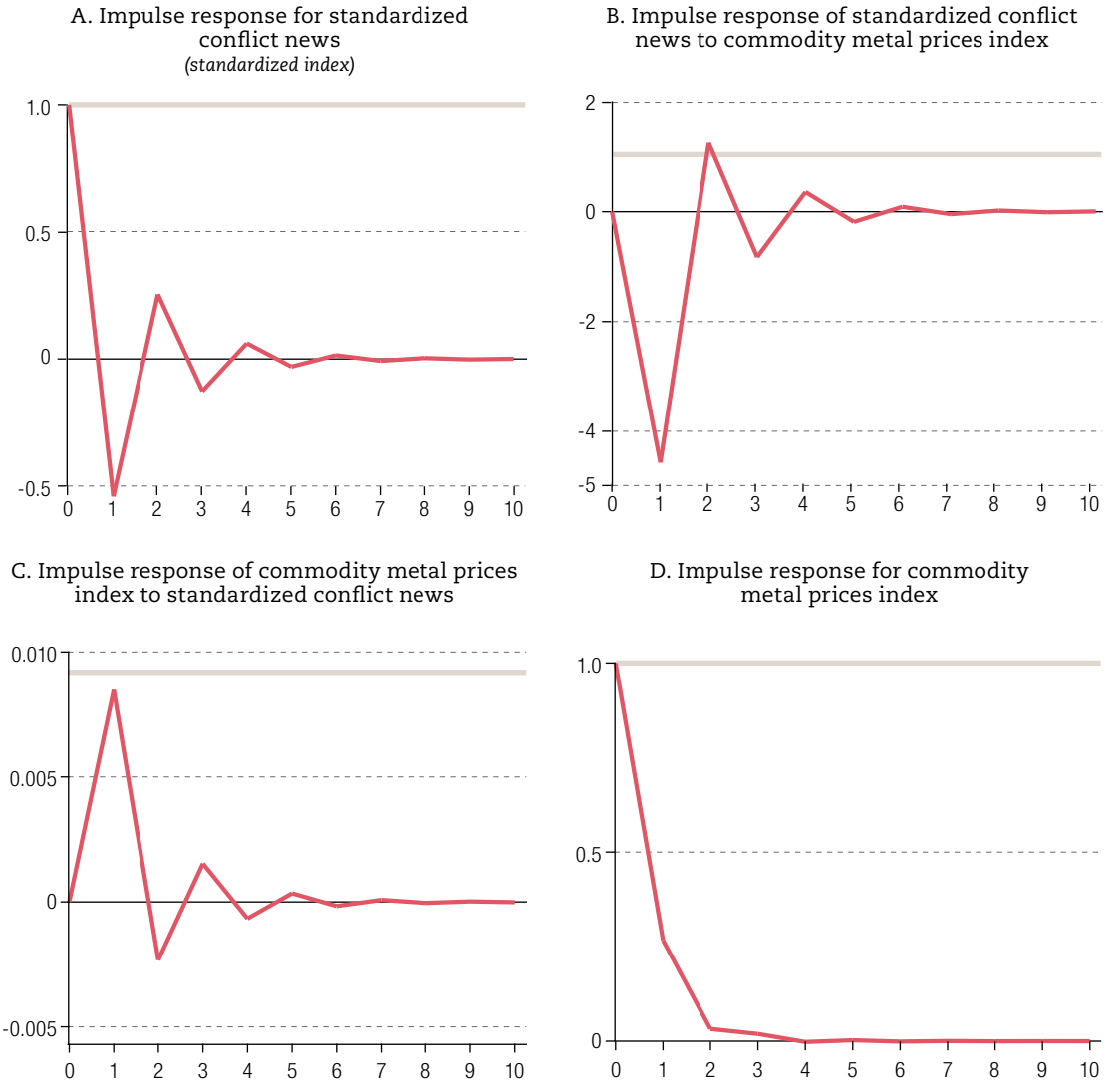
Using a different numbers of lags as suggested by the likelihood-ratio (1 lag), Schwarz Bayesian information criterion (SBIC) (1 lag), Akaike information criterion (AIC) (3 lags), final prediction error (FPE) (3 lags) and Hannan–Quinn information criterion (HQIC) (2 lags) tests, we cannot reject the null hypothesis of no cointegration. The null hypothesis of no cointegration is only rejected when we select zero lags, but this is not suggested by any lag selection criteria. We then performed a vector autoregression (VAR) analysis of the differences among these variables. Since the countries analysed are major producers of metals, conflict trends common to all countries might also cause some variation in prices, owing to higher or lower production. A VAR model was estimated, using one lag (as suggested by the all different tests performed) without imposing any restriction. The following VAR(1) model was used:

$$y_{1,t} = c_1 + a_{1,1}y_{1,t-1} + a_{1,2}y_{2,t-1} + e_{1,t}$$

$$y_{2,t} = c_1 + a_{2,1}y_{1,t-1} + a_{2,2}y_{2,t-1} + e_{1,t}$$

where, $y_{1,t}$ is the first difference of the IFS commodity metal price index and $y_{2,t}$ is the first difference of the first loading factor of the standardized conflict news index $(SCN_{i,t})$ (which is called $FI_{SC_{i,t}}$ in table A2.2). Figure 5 shows the impulse response function (see table A2.2 in annex A2 for additional results).

Figure 5
Australia, Canada, Chile and Peru: impulse response function for commodity metal prices and main factor loading



Source: Prepared by the authors.
Note: Graphs by irfname, impulse variable and response variable.

Figure 5C shows that a structural innovation in commodity metal prices predicts an increase in the standardized conflict index for the next quarter. This is not precisely estimated and if a Cholesky decomposition (ordering the commodity metal prices index first) is imposed the coefficient does not differ from 0 at normal significant levels, but still keeps the sign. This is an interesting prediction from a simple VAR model and may be a fruitful line for research in the future. It is also in line with the findings of Dube and Vargas (2013) regarding oil price shocks in Colombia.

2. Panel regressions

This section contains deeper analysis of the relationship between conflicts, prices, mineral rents and general economic performance, using our panel database and correlating our indices to commodity metal prices, mineral rents as a percentage of GDP and per capita GDP (at constant 2010 United States dollars). The last two variables are taken from the World Bank Development Indicators database (World Bank, 2019). Annual data are used as the time pattern of our main potential determinants is annual.

The analysis is performed on the standardized conflict news ($SCN_{i,t}$), conflict intensity ($CI_{i,t}$), violent news as a percentage of conflict news and violent conflict intensity ($VC_{i,t}$) indices. All regression models use country fixed-effects and year fixed-effects estimators.[7] Our preferred regression model is the following:

$$ln(SCN_{i,t}) = \beta_0 + \beta_1\, ln(MR_{i,t}) + \beta_2\, ln(GDP_{i,t}) + f_i + f_t + \epsilon_{j,t}$$

where $MR_{i,t}$ is mineral rents as a percentage of GDP of country i in year t; $GDP_{i,t}$ is the GDP of each country for each year; and f_i and f_t are time and country fixed-effects. However, we also tested replacing $MR_{i,t}$ with the commodity metal price index, and the level of GDP with the GDP growth rate. All our regressions should be interpreted with caution since reverse causality has not been properly taken into account in our analysis. However, the type of conflict does not seem as important a factor in causing a fall in production that affects commodity prices. The main results are presented in table 5.

Table 5
Year and country fixed-effects regressions of the standardized conflict news index

Variables	1 ln *(standardized conflict news (scn) index)*	2 ln *(sc_index)*	3 ln *(sc_index)*	*4* *ln* *(sc_index)*	5 ln *(sc_index)*	6 ln *(sc_index)*
ln *(mineral rents percentage of GDP)*	0.222***	0.214***	0.226***			
	(0.0709)	(0.0725)	(0.0751)			
ln *(metal_prices_index)*				0.0559	-0.00492	0.0449
				(0.0789)	(0.0972)	(0.0814)
ln *(per capita GDP - constant 2010 United States dollars)*		0.212			0.368	
		(0.317)			(0.346)	
First difference_ln *(per capita GDP - constant 2010 United States dollars)*			-0.385			1.224
			(1.844)			(1.958)
Constant	-0.372***	-2.433	-0.364***	-0.620	-3.946	-0.600
	(0.0668)	(3.085)	(0.0785)	(0.380)	(3.146)	(0.385)
Observations	52	52	52	52	52	52
R-squared	0.412	0.420	0.413	0.248	0.272	0.256
Country and year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	4	4	4	4	4	4

Source: Prepared by the authors.
Note: Coefficient significant at *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors shown in parentheses.

[7] Visual inspection of the standardized conflict news ($SCN_{i,t}$) index may reveal that those series are not I(1). However, we performed Im-Pesaran-Shin test in Stata using AIC-selected lag, which led us to reject, with a p-value of 0.0185, the null hypothesis that all the panels contain a unit root.

We find a positive and significant covariance between mineral rents as a percentage of GDP and the standardized conflict news index. This variable is stable and keeps its sign and significance even when per capita GDP or the first difference of per capita GDP is included, indicating that this variable is the relevant determinant, not the commodity metal price index, which is not significant when it is included alone or with the per capita GDP or the first difference of per capita GDP. Mineral rents as a percentage of GDP might be more accurate as it varies by country, while the commodity metal price index is the same for all the countries analysed.

One possible interpretation of our results is that higher mineral rents cause more conflicts to break out because different agents try to appropriate a higher percentage of those rents. These agents could be the government, domestic firms, foreign firms or workers. This is in line with the literature on the aforementioned resources curse (such as Brunnschweiler and Bulte, 2009), as well as with Dube and Vargas (2013) findings with regard to the "rapacity effect". Palazzo (2017) also arrives at a similar conclusion with regard to agricultural goods in Argentina.

Analysis of the index of violent news articles as ratio of total conflict news articles does not reveal any clear relationship between this variable and the commodity metal price index, mineral rents as a percentage of GDP and per capita GDP (see table A2.3). Additionally, our attempts to identify determinants for conflict intensity and violent conflict intensity were not successful. Lastly, we ran the same regression model, adding and changing some independent variables, but none of them were statistically significant.[8]

All these results should be treated with caution because our sample is small and endogeneity issues were not properly addressed. However, the correlation between the standardized conflict news index and mineral rents is interesting as it is in line with the literature on the resources curse. These results reinforce our previous findings, whereby the common factor of the standardized conflict news index $(SCN_{i,t})$ seems to be predicted by a rise in commodity metal prices.

V. Conclusions

This paper examines the incidence and intensity of social conflicts related to extractive activities in four mining countries by applying text mining techniques to articles from the leading newspapers in each country for the period 2003–2016. The main outcome of this analysis is different measures of conflicts and conflict intensity that are available for further research.

It should be borne in mind that the country-specific differences identified could arise because of media biases, differences in expressions and ways to communicate news depending on the language used, and the different preferences or interests of the different newspapers' readerships which influence how journalists write their articles, among other things. Identifying these biases is a first step in trying to understand and measure civil conflicts related to extractive activities. Despite these potential biases, the major findings are as follows.

Firstly, we identified differences among Canada, Australia, Chile and Peru, as well as by year for each country. In the developed countries the level of conflict news was stable and consistently higher than that recorded in developing countries. In the latter, the media coverage of extractive activities tended to be more favourable, but some conflicts did arise during the period under consideration.

Secondly, we computed differences between the two groups of countries. With regard to the developed countries, the level of conflict news in Canada followed an upward trend (although it started

[8] For example, we tested to see if the political cycle affected civil conflicts related to extractive activities. The political cycle variable was created by defining a dummy equal to 1 if a general election was held in the country in a particular year. If the election was held before the first quarter, the previous year was defined as the election year. Results are available upon request.

from a lower level), and the intensity of conflict in Canada was higher than in Australia. In the developing countries, both the level and the intensity of social conflict in Peru increased, while in Chile there was no clear trend, even though it was notable for the fact that conflict intensity was low and stable. When social conflicts were categorized as violent or non-violent, we found a bias in developing countries towards violent conflicts.

Thirdly, analysis of social conflicts related to extractive activities produced some interesting results when disaggregated by subnational administrative area. We found that the number of news articles obtained using the text mining technique is correlated to the economic importance of extractive industries in a particular area. In addition, the average level of conflict in the developed countries for the period as a whole was fairly homogeneous across the subnational administrative areas, while the disparities were profound in the developing countries. The conflict intensity is also quite homogeneous in the developed countries and heterogeneous in the developing countries, especially in Peru.

Fourthly, we explored the extent to which national conflicts were interrelated. A common factor analysis was performed, which indicated that conflict levels are determined by the particular situation in each country. However, a positive common factor is related to the general index of commodity metal prices. Therefore, higher metal prices might be a predictor of a higher level of conflicts.

Lastly, this finding was tested by performing panel data regressions. A positive relationship was found between the standardized conflict news index and mineral rents as a percentage of GDP. This result is line with the rapacity effect identified by Dube and Vargas (2013) and the literature on the resources curse. However, our results should be taken with caution since our sample is small and we do not address endogeneity issues properly.

Bibliography

Arezki, R. and F. van der Ploeg (2007), "Can the natural resource curse be turned into a blessing? The role of trade policies and institutions", *IMF Working Paper*, No. 07/55, Washington, D.C., International Monetary Fund (IMF).

Aromí, J. (2013), "Media news and the stock market: evidence for Argentina" [online] https://docplayer.net/56643583-Media-news-and-the-stock-market-evidence-for-argentina.html.

Baker, S., N. Bloom and S. Davis (2013), "Measuring economic policy uncertainty", *Chicago Booth Research Paper*, No. 13-02, January.

Brunnschweiler, C. and E. Bulte (2009), "Natural resources and violent conflict: resource abundance, dependence, and the onset of civil wars", *Oxford Economic Papers*, vol. 61, No. 4, October.

Collier, P. and A. Hoeffler (2005), "Resource rents, governance, and conflict", *The Journal of Conflict Resolution*, vol. 49, No. 4, August.

___(2004), "Greed and grievance in civil war", *Oxford Economic Papers*, vol. 56, No. 4.

___(1998), "On economic causes of civil war", *Oxford Economic Papers*, No. 50.

Dow Jones (2020), "Factiva" [online] https://professional.dowjones.com/factiva/.

Dube, O. and J. Vargas (2013), "Commodity price shocks and civil conflict: evidence from Colombia", *The Review of Economic Studies*, vol. 80, No. 4, October.

Evans, A. (2010), "Resource scarcity, climate change and the risk of violent conflict", *World Development Report 2011 Background Papers*, No. 62050, Washington, D.C., World Bank, September.

García, D. (2013), "Sentiment during recessions", *The Journal of Finance*, vol. 68, No. 3, June.

Giordano, M., M. Giordano and A. Wolf (2005), "International resource conflict and mitigation", *Journal of Peace Research*, vol. 42, No. 1, January.

Gupta, V. and G. Lehal (2009), "A survey of text mining techniques and applications", *Journal of Emerging Technologies in Web Intelligence*, vol. 1, No. 1, August.

Haber, S. and V. Menaldo (2011), "Do natural resources fuel authoritarianism? A reappraisal of the resource curse", *American Political Science Review*, vol. 105, No. 1, February.

Hirschman, A. (1977), "A generalized linkage approach to development, with special reference to staples", *Essays on Economic Development and Cultural Change: in Honor of Bert F. Hoselitz*, M. Nash (ed.), Chicago, The University of Chicago Press.
Humphreys, M. (2005), "Natural resources, conflict, and conflict resolution: uncovering the mechanisms", *The Journal of Conflict Resolution*, vol. 49, No. 4, August.
Leite, C. and J. Weidmann (1999), "Does mother nature corrupt? Natural resources, corruption, and economic growth", *IMF Working Paper*, No. 99/85, Washington, D.C., International Monetary Fund (IMF), July.
Mehlum, H., K. Moene and R. Torvik (2006), "Cursed by resources or institutions?", *The World Economy*, vol. 29, No. 8, August.
Nafziger, E. and J. Auvinen (2002), "Economic development, inequality, war, and State violence", *World Development*, vol. 30, No. 2, February.
Palazzo, G. (2017), "Minería de datos, conflictos sociales y explotación de recursos naturales: un aporte metodológico", *Compendium: Cuadernos de Economía y Administración*, vol. 4, No. 7.
___(n/d), "Original databases: conflicts and natural resources" [online database] https://sites.google.com/view/gabrielmpalazzo/original-databases.
Prebisch, R. (1950), *The economic development of Latin America and its principal problems* (E/CN.12/89/Rev.1), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
Robinson, J., R. Torvik and T. Verdier (2006), "Political foundations of the resource curse", *Journal of Development Economics*, vol. 79, No. 2.
Sachs, J. and A. Warner (1995), "Natural resource abundance and economic growth", *NBER Working Paper*, No. 5398, Cambridge, National Bureau of Economic Research (NBER), December.
Singer, H. (1950), "U.S. foreign investment in underdeveloped areas: the distribution of gains between investing and borrowing countries", *The American Economic Review*, vol. 40, No. 2, May.
Sinnott, E., J. Nash and A. de la Torre (2010), *Natural resources in Latin America and the Caribbean: beyond booms and busts?*, Washington, D.C., World Bank.
Tetlock, P. (2007), "Giving content to investor sentiment: the role of media in the stock market", *The Journal of Finance*, vol. 62, No. 3, June.
UNDP (United Nations Development Programme)/Fundación UNIR (2012), "La protesta social en América Latina", *Cuaderno de Prospectiva Política*, No. 1, Buenos Aires, Siglo XXI.
United Nations (2014), *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting* (ST/ESA/STAT/Ser.F/112), New York.
___(n/d), "System of Environmental-Economic Accounting" [online] https://seea.un.org.
World Bank (2019), "World Development Indicators" [online database] https://databank.worldbank.org/source/world-development-indicators.
___(2011), *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium*, Washington, D.C.
___(2006), *Where Is the Wealth of Nations? Measuring Capital for the 21st Century*, Washington, D.C.

Annex A1

Hostile and violent words used for the text mining exercise

Hostile words in English: abhor, abolish, abrasive, abscond, absentee, abuse, accost, accursed, accusation, accuse, acrimonious, acrimony, admonish, adversary, afflict, aggravate, aggravation, aggression, aggressive, aggressiveness, aggressor, aggrieve, agitator, alienate, allegation, altercation, ambush, anarchist, anarchy, anger, angry, anguish, animosity, annihilate, annihilation, annoy, annoyance, antagonism, antagonist, antagonistic, antagonize, argue, argument, arm, armed, arrest, arrow, assail, assailant, assassin, assassinate, assault, attack, attacker, austere, avenge, aversion, avert, avoid, avoidance, bandit, banish, barbarian, barbarous, bastard, battle, battlefield, beastly, beat, behead, belie, belittle, belligerent, belt, bereave, berserk, besiege, betray, betrayal, beware, bit, bitchy, bite, bitter, blame, blind, block, bloodshed, bloodthirsty, blurt, bomb, bombard, bombardment, bother, bout, boycott, brandish, brawl, breach, break, bristle, broke, brusque, brutality, brute, brutish, bug, bullet, burglar, burglary, butchery, callous, cannibal, cannon, capture, cataclysm, caught, censure, challenge, charge, chase, chastise, cheat, chide, chip, choke, clash, collide, collision, combat, combatant, compel, compete, competition, competitive, competitor, complain, complaint, compulsion, conceal, conceit, condemn, condemnation, condescending, condescension, conflict, confront, confrontation, conspiracy, constrain, contaminate, contamination, contempt, contemptible, contemptuous, contend, contest, contradict, convict, corruption, coup, cranky, crass, criminal, cripple, critic, criticize, crooked, crop, cross, cruel, cruelty, crush, crushing, curse, curt, cut, cynical, dagger, damage, damn, damnable, damned, deadlock, deadly, deceit, deceitful, deceive, deception, deceptive, defeat, defensive, defiance, defiant, defile, defy, degrade, demean, demolish, demon, demoralize, denial, denounce, deny, deplore, depose, deprive, deride, derision, derogatory, desert, despise, destroy, destruction, destructive, deterrent, detest, devastate, devastation, devil, devilish, devious, diabolic, diabolical, disagree, disagreeable, disagreement, disapprove, disavow, disavowal, disbelief, discord, discordant, discourage, discredit, discrepant, discrimination, disgust, dislike, dismiss, disobedience, disobedient, displeasure, dispose, disputable, dispute, disrupt, disruption, dissatisfied, dissent, dissention, distort, distrust, disturb, disturbance, ditch, divorce, drag, dump, egotistical, endanger, enemy, enforce, engulf, enrage, entanglement, epithet, escape, exception, exclude, exclusion, excommunication, execute, execution, exile, expel, exploit, fail, fallout, ferocious, ferocity, feud, fiend, fierce, fight, fighter, fire, fist, fled, floor, foe, fool, force, foreboding, fought, frighten, frown, frustrate, fun, furious, fury, germ, goddamn, grab, grapple, grenade, grudge, grumble, guerrilla, gun, gunmen, hamper, hang, harass, harassment, harm, harsh, hassle, hate, hater, hatred, haunt, heartless, hedge, heinous, hidden, hide, hinder, hindrance, hit, horrify, horror, hostile, hostility, humiliate, hunt, hunter, hurt, hustle, hustler, impair, impatience, impede, impediment, implicate, indictment, indignation, infect, infection, infiltration, inflame, infringement, infuriate, inhibit, inhibition, inhumane, injunction, injurious, injury, insolence, insolent, interfere, interference, interrupt, interruption, intrusion, irk, irritable, irritation, jagged, jail, jeer, jeopardize, jerk, kick, kidnap, kill, killer, knife, knock, laid, lawless, liar, lie, limit, liquidate, liquidation, litigant, litigation, lying, mad, malice, malicious, malignant, mangle, manslaughter, marksman, massacre, merciless, misbehave, mislead, missile, mob, molest, monster, monstrous, murder, murderous, mutter, nag, nasty, naughty, needle, negate, neglect, nigger, nightmare, obliterate, obnoxious, obstinate, obstruct, offend, offender, offensive, ominous, opponent, oppose, opposition, oppress, oppression, ostracize, oust, outlaw, outrage, pan, parasite, pass, penalty, penetrate, penetration, persecute, persecution, pinch, pistol, plague, plight, poisonous, pollute, posse, prejudice, pretend, pretence, prosecution, protest, provocation, provoke, prowl, punch, punish, push, quarrel, quarrelsome, quibble, rage, raid, raise, ravage, reactive, rebel, rebellion, rebellious, rebuff, rebuke, rebut, recalcitrant, refusal, refuse, reject, rejection, renounce, renunciation, repel, reproach, repulse, resent, resentful, resentment, resist, resistance, restrain, restrict, retaliate, retard, revenge, revolt,

revolution, revolutionary, rid, ridicule, rifle, rip, rival, rivalry, robber, robbery, rogue, ruffian, ruinous, rumple, rupture, ruthless, ruthlessness, sabotage, sarcasm, sarcastic, savage, scandalous, scare, scared, scold, scorch, scorn, scornful, scoundrel, scowl, scuffle, seethe, segregation, sever, shadow, shaft, shatter, shock, shoot, shot, shove, shred, shrew, shrug, shudder, shun, shut, sick, siege, sinister, skirmish, slam, slander, slanderer, slanderous, slap, slash, slaughter, slayer, sleazy, slight, sly, smack, smash, smear, snarl, snatch, spank, spear, spite, spiteful, split, spoil, stab, stall, stamp, startle, steal, stern, stifle, sting, stole, stolen, stone, stop, storm, stormy, strangle, strife, strike, stringent, strip, struck, struggle, stubborn, stubbornly, stubbornness, stun, subdue, subversion, subvert, sunder, suppress, suppression, suspect, suspicion, suspicious, sword, taboo, taint, tamper, tantrum, taunt, tear, tease, temper, tempest, tense, terrorism, terrorize, theft, thief, thorny, thrash, threat, threaten, thwart, tire, tired, TNT, torment, tough, traitor, trample, trap, treacherous, treachery, treason, treasonous, trick, trigger, turbulent, ultimatum, undermine, unfair, unjust, unjustified, unleash, unruly, unsafe, untruth, unwilling, unwillingness, uprising, upset, usurp, vengeance, venom, venomous, vicious, victim, vie, villain, violate, violation, violence, violent, wait, walk, war, warlike, warrior, weapon, weed, wench, whack, whine, whip, wicked, wickedness, wily, witch, witchcraft, withheld, withhold, withstand, worry, wound, wrath, wreck, wrestle, wrong.

Violent words in English: aggressive, aggressiveness, ambush, arm, armed, assault, attack, beat, belt, bloodthirsty, bomb, brutality, bullet, butchery, crush, crushing, deadly, fire, guerrilla, gun, gunmen, kill, killer, monster, monstrous, murder, rebel, rebellion, slash, slayer, violence, violent, warrior, whip.

Hostile words in Spanish: abatir, abdicación, abdicar, abofetear, abolición, abolir, abominación, abominado, abominar, aborrecer, aborrecido, aborrecimiento, aborrezco, abrumar, abuchear, abucheo, abusar, abusivo, abuso, abyecto, acéfalo, acérrimamente, acérrimo, aciago, acobardar, acogotar, acorralamiento, acorralar, acosamiento, acribillar, acritud, acuchillar, acusación, adulterino, aflicción, afligido, afligir, agitación, agitador, agobiar, agobio, agolpamiento, agraviante, agraviar, agravio, agredir, agresión, agresividad, agresivo, agresor, ahogamiento, ahogar, ahogo, ahorcamiento, ahorcar, ahuyentar, ajusticiar, ajusticiamiento, alabarda, alboroto, alegación, alegato, alevosía, alienar, altercado, alzamiento, alzarse, embaucador, amedrentar, amenaza, amenazador, amenazar, ametralladora, ametrallar, amilanar, amohinado, amonestar, amotinador, amotinarse, amputar, anarquía, anárquico, anarquista, anatema, angustia, angustiado, animadversión, animosidad, aniquilación, aniquilamiento, aniquilar, anormalidad, antagónica, antagonismo, antagonista, antihigiénico, anticristo, apedrear, apercibir, apesadumbrado, apesadumbrar, aporrear, aprehender, apremio, apresamiento, apresar, aprieto, aprisionamiento, aprisionar, apuntar, apuñalar, arma, armamento, armas, arpía, arrebatar, arredrar, arremeter, arremetida, arrestar, arresto, arrinconar, arrogancia, arrogante, artero, artimaña, asaltado, asaltador, asaltante, asaltar, asalto, asco, asechada, asechanza, asechar, asediar, asesinar, asesinato, asesino, asfixia, asfixiar, asolación, asolar, asustar, atacante, atacar, ataque, atemorizar, atentado, atentar, aterrador, aterrar, aterrarse, aterrorizar, atizo, atormentado, atormentar, atosigamiento, atosigar, atracador, atracando, atracar, atraco, atraco, atrocidad, atroz, austero, avasallamiento, avasallar, bandolero, bastardo, batalla, batallador, batallando, batallar, bayoneta, belcebú, bélico, belicosidad, belicoso, beligerante, bellaco, bestialidad, blasfemar, blasfemia, boicot, boicotear, boicoteo, bomba, bombardear, bombardeo, bravucón, bribón, bronca, cacheteada, cachetear, cachiporra, calamidad, calumnia, calumniador, calumniando, calumniar, calumnioso, calvario, camorrista, canalla, carabina, castigar, castigo, cataclismo, catástrofe, caustico, celada, censura, censurar, cercenar, chantaje, chantajista, chiflado, chiflarse, cicatero, cínica, claudicar, cleptómano, coacción, coercer, cohecho, cohibir, cólera, colérico, coletazo, combate, combatiendo, combatiente, combatir, combatividad, combativo, complot, complotar, compulsión, condena, condenado, condenar, confabulación, confabular, confiscación, confiscar, conflagración, conflagración, conflicto, confrontación, confrontar, conjuración, conjurar, conminación, conspiración, conspirador, conspirar, constreñir, consternar, constreñir, contaminación, contaminado, contaminar, contender, contendiente, contestatario, contienda, contradecir, contradictorio, contraponer,

contraproducente, contrincante, controversia, controvertir, contumacia, convicto, convulsión, convulsionar, corrompido, corrupción, corruptela, crimen, criminal, crispar, cruel, crueldad, cuartelazo, cuatrero, cuchillo, cuestionar, culpa, culpable, culpar, daga, damnificación, damnificado, damnificar, dañino, decapitar, defensivo, defraudado, defraudando, defraudar, defraudo, degollar, degollina, degradar, degradarse, dejadez, delincuente, demonio, denegar, denigración, denigrante, denigrar, denigrativo, denuncia, denunciar, deponer, deportación, deportar, depravado, depredar, derogación, derribar, derrotar, derruir, desacato, desacreditar, desacuerdo, desafiante, desafiar, desafuero, desagradable, desagraviar, desalentar, desalmado, desalojar, desalojo, desanimar, desaparecer, desapoderamiento, desaprobación, desaprobar, desaprueba, desasosiego, desastre, desatender, desatinar, desautorización, desautorizar, desavenencia, desazón, desbaratar, descabezado, descalabrar, descalificación, descalificar, descarado, descaro, descontento, descorazonar, descuartizar, descuidar, descuidero, descuido, desdecir, desdén, desdeñoso, desdichado, desencantado, desengañar, desequilibrarse, deserción, desertar, desertor, desesperación, desesperanzar, desestimar, desfalco, desfigurar, desgana, desgarrar, desgraciado, deshacer, deshacerse, deshecho, deshilachar, deshizo, deshonesto, deshonra, deshonrar, desidia, desigualdad, desilusión, desilusionar, desistimiento, desistir, desleal, deslealtad, desmantelado, desmantelar, desmembrar, desmentir, desmoralizar, desnucar, desobediencia, desobediente, desolación, desolar, desparecer, despecho, despectivo, despedazado, despedazar, despedido, despedir, despiadado, despidos, despojado, despojar, desposeer, déspota, despotismo, despotricar, despreciable, despreciado, despreciar, desprecio, desprestigiar, desquiciado, desquiciar, desquitar, desquitarse, desquite, destacamento, desterrado, desterrar, destierro, destituido, destituir, destripar, destrozado, destrozar, destrucción, destructivo, destructor, destruir, desunión, desunir, desvergonzado, desvergüenza, detención, detestable, detestar, detesto, detonación, detonador, detonar, detractar, desunión, devastación, devastar, diablo, diabólico, dictadura, difamación, difamador, difamar, difamatorio, difunto, dimisión, dimitir, díscolo, disconformidad, discordante, discordia, discrepancia, discrepante, discrepar, discriminación, discriminar, discusión, discutiendo, discutir, disensión, disentimiento, disentir, disgustado, disgustar, disgusto, disimulo, dislocación, dislocar, disolución, disoluto, disonancia, disputa, disputable, disputar, disputarse, distorsionar, disturbio, disuasivo, disuasorio, doblegarse, dolorido, dominación, embarullar, embate, embaucar, embestida, embestir, emboscada, emboscar, embrollar, embuste, embustero, embustir, emponzoñar, enajenar, enardecer, enardecido, encarcelamiento, encarcelar, encizañar, encolerizado, encolerizar, encrespar, enemigo, enemistad, enemistar, enemistarse, enervar, enfadado, enfadar, enfadarse, enfado, enfrentado, enfrentamiento, enfrentar, enfurecer, enfurecido, enfurecimiento, engañando, engañar, engaño, engañosa, engañoso, engatusar, engendro, engorro, engreimiento, enjuiciamiento, enjuiciar, enloquecer, enloquecido, enmascarar, enojado, enojar, enojo, ensañamiento, entorpecer, entristecer, envenenar, enviciar, envilecer, epidemia, escandalo, escaramuza, escarmentar, escarmiento, escarnio, escepticismo, escéptico, esclavitud, esclavizar, esclavo, escopeta, esfumarse, espada, espantar, espantarse, espinoso, espurio, estacazo, estafa, estafador, estafando, estafar, estafo, estallar, estallido, estigma, estigmatizar, estrago, estrangulación, estrangulamiento, estrangular, estremecer, estremecimiento, estremezco, estropeado, estropear, estuprar, evadir, evadirse, evasión, exabrupto, exasperación, exasperar, exclusión, exilio, expatriación, expatriado, expiación, explosión, explosionar, explosivo, explotar, expropiación, expulsar, expulsión, exterminar, exterminio, extinción, extirpar, extorsión, extralimitación, falsificación, falsificando, falsificar, fanfarrón, farfullar, farsa, farsante, fascismo, fastidiar, fastidio, fastidioso, fatal, fatídico, felonía, flagelar, flagelo, flecha, follón, forajido, forzado, forzar, fraccionar, fractura, fracturado, fracturar, fragmentar, francotirador, fratricida, fratricidio, fraude, frustración, frustrar, frustrarse, fuga, fugar, fugarse, funesto, furia, furioso, furtivo, fusil, fusilar, fusta, fusta, fustigar, gánster, garrocha, garrote, gatillo, golpe, golpeado, golpear, golpeo, golpismo, golpiza, granada, granuja, gresca, grilletes, grima, guerra, guerrear, guerrero, guerrilla, guerrillero, guillotinar, hastiado, hecatombe, herida, herido, herir, hipócrita, holocausto, homicida, homicidio, horrendo, horror, horrorizar, horrorizarse, hostigarían, hostigamiento, hostigar, hostil, hostilidad, hostilidades, hostilizar, huelga, huida, huir, humillante, humillar, hurtado, hurtando, hurtar, hurto, huyo,

ignorado, ignorancia, ignorar, ilegal, ilegalidad, ilegitimo, ilícito, impedimento, impedir, impeler, impertinente, impiedad, implacable, implosión, impostor, improcedente, improperio, impúdico, impugnar, impurificar, imputación, imputar, inaceptable, incautación, accidentado, incinerar, incitación, incitar, incomodar, incomodidad, incompatibilidad, incompatible, inconmovible, inconsolable, incordiar, incordio, incredulidad, incrédulo, increpar, incriminación, incriminar, inculpación, inculpar, incumplimiento, indebido, indecente, indecoroso, indemnizar, indiferente, indignación, indignado, indigno, indisciplina, indocilidad, indolencia, indomable, ineptitud, inequidad, inescrupuloso, infamador, infamante, infamar, infame, infamia, infección, infectar, infecto, infestación, infestar, inficionar, ingrato, inhabilitación, inhabilitar, inhibición, inhibir, inhumano, injuria, injuriar, injurioso, injusticia, injustificado, injusto, inmerecido, inmolación, inmolado, inmolar, inmoral, inmundo, innoble, inoculación, inquina, insalubre, insano, insatisfecho, inseguro, insensible, insidia, insidioso, insolencia, insolente, instigación, instigador, instigar, insubordinación, insubordinado, insubordinarse, insultante, insultar, insulto, insumisión, insumiso, insurgente, insurrección, insurreccionarse, insurrecto, interferencia, interferir, intimidación, intimidar, intranquilidad, intranquilo, intransigencia, intransigente, intromisión, intrusión, inutilizar, invadido, invadir, invasión, iracundo, irascible, irracional, irracionalidad, irrazonable, irrespetuosidad, irreverencia, irrisorio, irritable, irritación, irritado, irritante, irritar, irrumpir, irrupción, jactancioso, jorobar, juzgar, laceración, lacerar, ladino, ladrón, lanceta, lapidar, lastimar, litigar, latigazos, látigo, leonino, letal, levantamiento, levantarse, levantisco, libertino, linchar, liquidación, liquidar, lisiar, litigante, litigar, litigio, llanto, lloriqueo, lucha, luchado, luchando, luchar, lucifer, luzbel, machacar, machete, madame, magnicida, magnicidio, magullado, magulladura, magullar, mal, malandrín, mal comportarse, maldad, maldecir, maldición, maldijo, maldito, maleante, maledicencia, malevolencia, malévolo, malhechor, malhumorado, malicia, malicioso, malignidad, maligno, malintencionado, malquerencia, malsano, maltratado, maltratar, maltrecho, malvado, malversación, malversado, malversando, malversar, malverso, marginar, masacrar, masacre, mascullar, matanza, matar, matón, mendacidad, mendaz, menoscabar, menospreciar, mentir, mentira, mentiroso, merodeo, metralleta, mezquino, milicia, militar, mintiendo, miserable, miseria, misil, mofa, mofar, molestar, molestia, molesto, molido, monstruo, monstruosa, monstruosidad, monstruoso, montaraz, mordacidad, mordaz, morder, mordida, mordió, mortal, mortandad, mortífero, mortificación, mortificado, mortificar, mosquetón, muerte, muertes, muerto, multa, munición, marginación, mutilar, navaja, nefasto, negligencia, nigromancia, nocivas, nocivo, obcecado, obligado, obligar, obliterar, obsceno, odiado, odiar, odio, ofender, ofendido, ofensa, ofensiva, ofuscación, ofuscado, ojeriza, ominoso, oponente, oponer, oponerse, oposición, opresión, oprimir, opuesto, ostentación, ostracismo, paliza, parricida, parricidio, patrulla, pécora, pegar, pego, pelea, peleón, pellizcar, pelotón, penado, penalizar, pendencia, pendenciero, penitencia, perjudicar, perjudicial, perjuicio, pernicioso, persecución, persecución, perseguir, persuadir, perturbación, perturbar, perversidad, perverso, pervertido, pervertir, pesadilla, pesadumbre, petulante, peyorativo, pillaje, pillar, piquete, pisotear, pistola, pistolero, pistolete, pleiteante, pleito, polémica, polemizar, polución, pólvora, ponzoña, ponzoñoso, porrazo, prejuicio, prescripción, presidiario, profanación, proscribir, proscripción, proscripto, protesta, protestar, provocador, proxeneta, pugna, pugnando, pugnar, pulverizar, punzar, puñal, puñalada, puñetazo, pútrido, quebrado, quebrantamiento, quebrantar, quebranto, quebrar, queja, quejar, quejarse, quejas, quejido, quejoso, querella, querellante, querellar, quiebra, quiebre, rabia, rabiar, rabieta, rapiñar, rapto, rastrero, ratero, reaccionario, rebelarse, rebelde, rebeldía, rebelión, recaída, recalcitrante, recelo, rechazar, rechazo, reclamar, reclamo, recluir, reclusión, recluso, recriminación, recriminar, refrenar, refriega, refunfuño, refutar, regañar, regaño, regicidio, rehuir, rehusar, rémora, rencor, rencoroso, renegar, renuncia, renunciar, repeler, reprobar, reprender, reprensión, represalia, represión, reprimenda, reprimir, reprobar, reprochar, reproche, repudiar, repudio, repugnancia, repugnante, repugnar, repulsión, repulsivo, resarcimiento, resarcir, resentido, resentimiento, resentir, resistencia, resistente, resistir, responsabilizar, resquemor, restringir, reticente, retorcido, retrogrado, revancha, reventado, reventar, revocación, revuelta, reyerta, rezongar, ridiculizar, ridículo, rifle, riñendo, rival, rivalidad, rivalizar, robado, robando, robar, robo, rufián, ruin, ruina, ruinoso, ruptura, sablista, sabotaje, sabotear, sacrificar, sacrificio, sádico, sadismo, salvajada, salvaje, sanguinario, saqueador, saqueo, satán, satanás, satánico,

secuestrado, secuestrar, secuestro, sedición, sedicioso, segregación, segregar, sentencia, siniestro, sinvergüenza, soborno, socarronería, sofoco, sojuzgar, soliviantar, sollozo, someter, sopapear, soslayar, sospecha, sospechar, sospechoso, sublevación, sublevado, sublevarse, subversión, subversivo, subvertir, subyugar, sumisión, suspicacia, suspicaz, tabú, temerario, tergiversar, terrorismo, terrorista, tiranía, tiranizar, tirotear, tiroteo, tirria, torturado, torturar, tosigo, totalitarismo, toxico, tozudez, trágico, traición, traicionar, traicionero, traidor, traidores, tralla, trampa, trampear, tramposo, transgresión, transgresor, trastornado, trastornar, trastornarse, traumar, traumatismo, trifulca, triturar, trompazo, truhan, tumulto, turba, turbulento, ultimátum, ultrajar, ultraje, ultrajante, usurero, usurpado, usurpando, usurpar, usurpo, vandalismo, vapuleado, vapulear, vendetta, venganza, viciar, vicioso, victima, vil, vileza, vilipendio, villano, vindicta, violación, violar, violencia, violento, virulento, vividor, zaheridor, zaherir, zozobra, zurriago.

Violent words in Spanish: agresivo, combativo, provocador, violento, agresividad, belicosidad, combatividad, provocación, emboscada, celada, trampa, asechanza, artería, artimaña, emboscar, trampear, asechar, armas, armamento, armado, asaltar, atracar, robar, agredir, acometer, irrumpir, invadir, ataque, embate, irrupción, combate, lucha, agresión, golpear, golpe, sanguinario, choque, asalto, atropello, atentado, coletazo, bomba, explosivo, granada, munición, bala, brutalidad, bestialidad, ferocidad, crueldad, atrocidad, monstruosidad, irracionalidad, vandalismo, salvajada, grosería, masacre, matanza, mortandad, hecatombe, catástrofe, degollina, aplastar, triturar, reventar, destripar, moler, aplastamiento, mortal, mortífero, letal, fatídico, fatal, funesto, disparar, tirotear, ametrallar, despedir, expulsar, destituir, guerrilla, guerrillero, milicia, arma, pistola, revólver, pistolete, ametralladora, metralleta, pistolero, atracador, bandido, forajido, delincuente, gánster, terrorista, asesino, matar, asesinar, ahorcar, ahogar, decapitar, desnucar, degollar, fusilar, guillotinar, asfixiar, electrocutar, envenenar, linchar, asesinato, crimen, homicidio, delito, muerte, parricidio, fratricidio, magnicidio, regicidio, criminal, homicida, monstruo, engendro, deforme, monstruosa, rebelarse, incitar, sublevarse, insubordinarse, levantarse, alzarse, amotinarse, insurreccionarse, rebelión, levantamiento, revuelta, alzamiento, revolución, subversión, conspiración, conjuración, sedición, insurrección, motín, acuchillar, apuñalar, lesionar, violencia, exabrupto, coacción, profanación, furia, ensañamiento, violación, implacable, furioso, guerrero, soldado, militar, látigo, azote, fusta, tralla, vergajo, flagelo, zurriago, latigazos, azotando, litigar, azotar, fustigar, flagelar.

Annex A2

Table A2.1
Augmented Dickey-Fuller test for unit root

Variable	Number of lags	*T*-Statistic	1% critical value	5% critical value
Metal prices index	lags(2)	-2.106	-3.587	-2.933
D.Metal prices index	lags(1)	-4.379	-3.587	-2.933
Factor No. 1 – Standardized Conflict Index	lags(3)	-1.927	-3.628	-2.95
D.Factor No. 1 – Standardized Conflict Index	lags(4)	-4.407	-3.655	-2.961
Predicted error	lags(0)	-4.613	-4.124	-3.461
Predicted error	lags(1)	-2.707	-4.124	-3.461
Predicted error	lags(2)	-1.534	-4.124	-3.461
Predicted error	lags(3)	-1.231	-4.124	-3.461

Source: Prepared by the authors.

Table A2.2
Vector autoregression results: factor No. 1 – standardized conflict index and metal prices index

Vector autoregression						
Sample: Q3 2003 – Q4 2015, but with a gap			No. of obs = 47			
Log likelihood = -216.7898			AIC = 9.480418			
FPE = 44.92575			HQIC = 9.569297			
Det (Sigma_ml) = 34.7905			SBIC = 9.716607			
Equation	Parms	RMSE	R-sq	Chi^2	$P>chi^2$	
D_metal_prices_index	3	14.5725	0.0737	3.737807	0.1543	
D_f1_sc	3	0.442755	0.2788	18.17191	0.0001	
	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
D_metal_prices_index						
metal_prices_index						
LD.	0.266852	0.145429	1.83	0.067	-0.01818	0.551888
f1_sc						
LD.	-4.57089	4.260941	-1.07	0.283	-12.9222	3.780397
_cons	2.260713	2.096179	1.08	0.281	-1.84772	6.369148
D_f1_sc						
metal_prices_index						
LD.	0.008484	0.004419	1.92	0.055	-0.00018	0.017144
f1_sc						
LD.	-0.54093	0.12946	-4.18	0.000	-0.79466	-0.28719
_cons	-0.0027	0.063688	-0.04	0.966	-0.12752	0.122131

Source: Prepared by the authors.

Table A2.3
Year and country fixed-effects regressions of the standardized violent conflict news index

Variables	1 ln *(standardized conflict news (scn) index)*	2 ln *(sv_index)*	3 ln *(sv_index)*	4 ln *(sv_index)*	5 ln *(sv_index)*	6 ln *(sv_index)*
ln *(mineral rents % of GDP)*	0.0344	0.0393	0.0866			
	(0.104)	(0.107)	(0.106)			
ln *(metal_prices_index)*				-0.0108	0.00591	0.0232
				(0.103)	(0.129)	(0.103)
ln *(per capita GDP - constant 2010 United States dollars)*		-0.130			-0.101	
		(0.470)			(0.458)	
First difference_ln *(per capita GDP - constant 2010 United States dollars)*			-4.425*			-3.809
			(2.612)			(2.488)
Constant	-1.215***	0.0467	-1.120***	-1.173**	-0.260	-1.235**
	(0.0985)	(4.572)	(0.111)	(0.496)	(4.169)	(0.489)
Observations	52	52	52	52	52	52
R-squared	0.382	0.383	0.430	0.380	0.381	0.419
Country and year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	4	4	4	4	4	4

Source: Prepared by the authors.
Note: Coefficient significant at *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors shown in parentheses.

The ECLA technique of programming and economists in Argentina in the mid-twentieth century[1]

Mariano Arana

Abstract

This article analyses the origin and development of the technique of programming of Jorge Ahumada, of the Economic Commission for Latin America (ECLA),[2] and its importance for economists and economic development planning institutions. To that end, it examines the circulation of the technique in various organizations in Argentina and shows how planning gained legitimacy alongside the main economic policy debates of the mid-twentieth century, while describing the institutional circulation of experts and their texts in the country. The ECLA contribution was found to have a direct impact on local institutions, which reinforced the idea of accelerated growth with economic stability and contributed significantly to the theoretical training of economists in Argentina.

Keywords

Economic development, economic planning, ECLA, economists, training programmes, vocational training, economic history, Latin America

JEL classification

A11, B41, C61

Author

Mariano Arana holds a bachelor's degree in Economics and a specialization in University Teaching in Economic Sciences from the University of Buenos Aires (UBA), as well as a master's degree in Economic Policy from the Latin American Faculty of Social Sciences (FLACSO). He is also a researcher and teacher at the Institute of Industry of the National University of General Sarmiento (UNGS). Email: marana@campus.ungs.edu.ar.

[1] A summarized version of this work was presented at the sixteenth Jornadas Interescuelas/Departamentos de Historia event, during thematic round table 106 entitled: "La planificación y el Estado argentino: agencias, expertos, modelos foráneos e impacto regional (1933–1983)". The comments from Diego Pereyra, Hernán González Bollo, Aníbal Pablo Jáuregui and the reviewing judges are gratefully acknowledged. The author alone is responsible for any errors in the text.

[2] Pursuant to Economic and Social Council resolution 1984/67 of 27 July 1984, the Commission's name was changed to Economic Commission for Latin America and the Caribbean (ECLAC) to reflect its expanded scope of work.

I. Introduction

In the early 1950s, there were several antecedents to the planning experience in Latin America, including the Soviet management methods focused on sectoral balances; efforts in the United States to study the aggregate instruments shaping the economy since the Great Depression; the French focus on investment with the aim of modernizing productive sectors; and lastly, the testing of five-year plans in Latin America. The first three approaches were studied at ECLA with a view to proposing a different type of planning. The aim of the new methodology was to evaluate and communicate possible economic trajectories based on the existing structure. The technique of planning —or programming— developed by ECLA was intended to be neutral enough to bring about decisions that would foster the transparency and efficacy of political powers. Celso Furtado considered planning as neutral as the input-output technique (1988, p. 117).

The technique of programming was a methodology developed by the Economic Development Division of ECLA, headed by Celso Furtado and including Juan Noyola, Regino Boti, Alexandar Ganz and Pedro Vuscovic. In his first decade at ECLA, Jorge Ahumada, who was part of the team led by Raúl Prebisch and who worked with the Commission until 1961, was responsible for reviewing the links between planning and economic development. With his initiatives, he proposed a novel combination of aggregate planning focused on production sectors (usually found in input-output tables) and investment planning focused on the search for selection and evaluation criteria for productive techniques and projects, with a higher level of aggregation based on the use of growth theories and aggregate macroeconomic models. The aim of the present work is to recognize the origin and development of this technique and its importance for economists and institutions responsible for economic development planning, by studying its changes in the 1950s and circulation in various institutions in Argentina.

Section II describes the origins of the technique of programming through the analysis of the initial documents on the subject. It identifies theoretical influences and problems that the technique was meant to resolve, delves deeper into the image of the economist as an aggregate planner and examines the development of these ideas in ECLA publications, while analysing technical instruments and their link to the profiles required of the economists of the time. Section III, before the conclusions, describes on the one hand, the emphasis on planning in training institutions and public management organizations in Argentina, and on the other hand, the ties with ECLA and the circulation of these ideas among economists and civil servants. In both instances, there is a focus on the importance of the founding works from an economic theory and policy perspective. The conclusion drawn is that, through the planning experience, ECLA contributed directly to strengthening the idea of accelerated growth with economic stability in local institutions and had a significant impact on the theoretical training of Argentine economists in economic development. Lastly, while it describes the institutional circulation of experts and their texts in Argentina in the mid-twentieth century, this work also shows that planning gained legitimacy alongside the main economic policy debates of the time, from a theoretical and technical standpoint.

II. The technique of programming and project planners

At the fourth session of ECLA, held in Mexico City in 1951, one of the points raised was the importance of technical assistance for economic development in Latin American countries, and thus the need to train Latin American economists in economic development. In 1952, the United Nations Technical Assistance Programme for Economic Development began to be implemented in Chile to train specialists, under the

direction of Jorge Ahumada. Initially, the courses trained 12 to 14 professionals at a time, but this number later increased to more than 40 people at a time. The programme was geared towards specialists from the decision-making centres of various Latin American governments, especially ministries. It included more than 250 hours of lectures over the course of three months, as well as 130 hours of round tables and other research activities.

In his role as economist at ECLA and of the United Nations Technical Assistance Administration, Ahumada published a programme document entitled "El empleo de la contabilidad del ingreso nacional en la planificación del desarrollo económico" (1952). In that work, Ahumada made reference to "rational action" in the selection of development planning methods and objectives, although he recognized the absence of a comprehensive theory on growth and of a methodology to plan it. The technique of programming responded to the objective of achieving the maximum growth rate compatible with stability and freedom of choice for the consumer. Stability was understood as the absence of problems relating to unemployment, inflation and the balance of payments. As a methodological base, Ahumada cited *The Structure of American Economy, 1919–1939: An Empirical Application of Equilibrium Analysis* by Wassily Leontief (1951), which described input-output techniques,[3] identified the importance of studying the gap between potential and real growth, and reviewed the contribution of some North American works (including those of S. Kutnetz, E. D. Domar, Cobb-Douglas, R. Goldsmith, P. Samuelson and W. Fellner) in the use of production functions to estimate system capacity.

Ahumada also used the Keynesian model of Evsey Domar, which explained the double function of investment (in terms of the multiplier effect, amplifier of output and of capital stock, and potential output), along with the characteristics of balanced economic growth with full employment, and which outlined the conditions of stability which ensured that growth in effective output was equal to that of potential output. This brought to light the lack of systemic guarantees of these conditions of stability and growth and the need to act on investment functions to move closer to the stated objectives. Ahumada incorporated this risk into his work by highlighting that if investment triggered a multiplier effect (positive or negative depending on the direction), it would also be a destabilizing factor and therefore, the magnitude of the multiplier would have to be reduced to achieve stability and increase savings (Ahumada, 1952). Ahumada (1951) explained that development was equivalent to the achievement of the maximum rate of income growth compatible with stability under conditions of full employment. Hence, managing investment was fundamental, as it could result in inflation or unemployment, depending on whether it was excessive or deficient.

Ahumada's interest in the role of investment in development led him to explore the selection and evaluation criteria of investment projects. He argued that public and private criteria differed in terms of the object of maximization, especially since public criteria had to consider the impact of investment on total value added, meaning that they had to incorporate the indirect effects on other areas of production (forward and backward linkages) (Ahumada, 1955).

In 1957, Ahumada participated in a conference on economic development in Latin America organized by the International Economic Association (IEA) and held in Rio de Janeiro, which brought together thinkers such as Ragnar Nurkse, Celso Furtado, Howard Ellis, Felipe Pazos, Gottfried Haberler, Theodore Schultz and Albert Hirschman, among others. Concerned with providing a prescription for investment priorities that could be used by government financial agencies, he deepened his criticism of neoclassical resource allocation criteria. He pointed out that these criteria overlooked the fact that the social opportunity cost of a commodity was represented by its price only if each factor contributed the same value in different productive uses and argued that it was necessary to replace that criterion of maximization, since, on the one hand, the various uses of factors yielded different value contributions

[3] Leontief published the first edition of this volume in 1941. Although there have been works relating to input-output analysis since the 1920s, they only became well-known in the mid-twentieth century in Western academic circles.

and, on the other, balance was an exceptional condition and not the norm (Ahumada, 1961; Boianovsky, 2013). The contributions of this conference were incorporated the following year into the *Manual on Economic Development Projects*, within the framework of the ECLA/TAA Economic Development Training Programme.

> Ahumada feels that the application of orthodox economic theory has given undue prominence to those criteria which imply the maximization of profits (for example, the benefits-costs criterion). When this latter criterion is applied, market prices are corrected to allow for social costs. Nevertheless, it still implies maximization of profits. At the same time, the economy cannot be balanced while there is a state of equality in all directions between the prices of factors (ECLA, 1958, pp. 237–238).

However, the author warned of the impossibility of determining aggregate growth without first estimating the distribution of investment and, at the same time, this investment depended on the pace of growth in income (Ahumada, 1955 and 1961). For this reason, a suggested investment plan based on the volume of savings that would allow for a projection of output (given the historical relationship between capital and output) was needed. The task was to identify the investment needed to fulfil the plan, to estimate possible changes in demand by using the income elasticity technique and to identify sectors of change to anticipate possible development friction and imbalances (pitfalls).

The technique for making the plan compatible had to be chosen by observing the effects on all sectors with different criteria, depending on whether the objectives were to achieve specific produced quantities (or fulfil manifested needs) or a specific level of productive efficiency. The plan had to contain evidence of internal coherence to avoid shortages of goods and services, considering the parity of savings with investment, of supply with aggregate demand, and of the distribution of investment with expected changes in the demand structure.

1. The aggregate planner

In 1956, the Faculty of Economic Sciences of the University of Buenos Aires (FCE-UBA), under the direction of Norberto González, organized a course on development issues, which was taught by professors and researchers in collaboration with senior staff of ECLA (Chirom, 1985). As a student in 1957, Mario Brodersohn (Arana, 2015b) took the intensive ECLA course at FCE-UBA along with Adolfo Canitrot, Bernardo Grinspun and Félix G. Elizalde. The three-month programme could be followed on either a part-time or full-time basis. Most of the professors were from ECLA. Ahumada was the head of the Commission's economic area and also participated as a professor, along with the first Minister of Economy of Cuba, Regino Boti.[4] Roque Carranza[5] taught the input-output model and Raul Prebisch gave some lectures. A scholarship was subsequently created for a course taught by Felipe Herrera[6] at ECLA headquarters in Santiago. Brodherson and Alieto Guadagni were scholarship recipients.

The year before the definitive institutionalization of economists in Argentina with the creation, in 1958, of economics degree programmes at the University of Buenos Aires (UBA), the Catholic University of Argentina (UCA) and the National University of the South (UNS), Ahumada presented a draft of the intensive course entitled "Teoría y programación del desarrollo económico" in Buenos Aires,

[4] In addition to Ahumada and Boti, the ECLA courses in Latin America were taught by Manuel Balboa, Dudley Seers, Hollis Chenery, Ricardo Cibotti, John Galbraith, Aníbal Pinto, Adolfo Dorfman, Leopoldo Portnoy, Osvaldo Sunkel and Alberto Fracchia, among others (ECLA, 1961).

[5] He served as Technical Secretary of the National Development Council (CONADE) of Argentina between 1963 and 1966, where he helped to develop the National Development Plan 1965–1969.

[6] Minister of Finance of Chile in 1953 and President of the Inter-American Development Bank (IDB) between 1960 and 1970.

to be taught at FCE-UBA between September and December 1958.[7] The text was oriented towards aggregate planning through the study of techniques that combined the uses of the macroeconomics of effective demand (and its multiplier and accelerator effects) with Harrod-Domar-style growth models, linked with input-output techniques (in some cases with simpler uses, like sector models), in a context of asymmetries between centres and peripheries and structural heterogeneity in the different regions. The innovation was not only in the emphasis and ways of combining the existing toolkit, but also in the fact that the new concepts were intended to make it possible to analyse the differential characteristics of the countries of the region, since development was not understood as a spontaneous process.[8] In that sense, it is possible to highlight the content of this training as a general model for peripheral economies.

The aggregate planning model included 10 parameters in a system of 22 equations and 32 variables, with data from two consecutive years. Aggregate programming involves the assessment and setting of targets for end demand of goods and services, then the calculation of the production required for each sector, in order to avoid bottlenecks. The result was reflected in a table entitled "Production budget and availability of goods and services", which not only combined the distribution of production among sectors, but also among uses (consumption, investment and other) and recipients (functional distribution of income).

In his work "Notas para una teoría general de la planificación",[9] Ahumada once again placed emphasis on programming as a means of ensuring rational decision-making and on the neutrality of the technique. For the author, planning was a technique to develop policies rationally (Ahumada, 1977, p.4), whereby the planner created alternatives from which the political authority could choose. "Planning is ethically and politically neutral" (Ahumada, 1977, p. 4), so both diagnosis and planning are technical tasks. Meanwhile, he believed that setting goals was strictly political. In this work, he expressed a logical approach to neoclassical problems of resource scarcity and maximization of well-being, which resulted in problems of choice (of consumption and production, among others). The work also includes reflections on theorems and axioms regarding Kenneth Arrow's paradox or impossibility theorem.

From its launch until 1956, the ECLA programme trained 187 economists from Latin America, 1 from Egypt and one from Iran —60 in Santiago and 80 in Bogotá in 1955 and 49 in Rio de Janeiro the following year. Eight-month programmes were also conducted in Santiago for specialists granted scholarships (ECLA, 1957). By 1958, 93 participants had already been trained in Santiago, 72% of whom were economists, while the rest were engineers or agronomists. Eight participants were from Argentina (ECLA, 1959b). From 1955 to 1961, ECLA trained 1,087 participants in 15 intensive courses outside Chile. Two courses were conducted in Argentina with a total of 141 participants. The intensive course launched on 20 September 1958 at FCE-UBA had 33 full-time students and 39 observers. In 1966, the programme included 1 basic planning course, 4 special courses (on education, housing, health and economic development, and planning for labour leaders) and 10 intensive courses across the countries of the region, which were taught to roughly 700 scholarship holders (ILPES, 2012a).

[7] This course was also taught in 1967, when its validity was recognized within the training programmes of the Latin American Institute for Economic and Social Planning (ILPES). In 1958, ECLA also published its *Manual on Economic Development Projects*.

[8] These new concepts include attempts to quantify potential output and evaluate "reproducible tangible wealth" (productive assets subject to depreciation) as a unit of capital intensity. In addition to the uses of the input-output table, price and income elasticities, the trend in the terms of trade and the fundamental macroeconomic equation, social and individual maximization criteria were differentiated in investment project evaluations.

[9] The text reprinted by ILPES in 1977 is taken from *Cuadernos de la Sociedad Venezolana de Planificación* published in 1966. However, there is a version published by the Centre for Development Studies (CENDES) of the Central University of Venezuela in February 1962, which was used for an internal seminar on planning given by Professor Luis Lander. The course on planning theory and practice taught by Carlos Mattos at ILPES in 1984 also included references to this text.

2. Aggregate, sectoral and regional planners

In 1953, ECLA published the "Preliminary study on the technique of programming economic development", which is a methodological reflection of the *Economic Survey of Latin America and the Caribbean* published by the Commission since 1949. It had been outlined at the fourth session of the Commission under the title "Theoretical and practical problems of economic growth" which recognized the need to adopt development programmes and mentioned the theoretical elements for assessment and the difficulties faced by peripheral countries. In that instance, it was said that it was necessary to take advantage of the knowledge developed in the central countries to theoretically interpret economic development problems and to train economists in Latin American countries:

> With this purpose in mind, it would be necessary to organize seminars in which the ECLA economists, together with competent directors appointed for this purpose, might dedicate a part of their time to pooling their knowledge for the purpose of training other economists […]. It is not intended to replace the many colleges or Faculties of Political Sciences existing in Latin American universities, nor to compete with them, but rather to co-operate with these institutions, supplement their task and work hand in hand with their graduates who, having already some experience of Latin American problems and concrete responsibility in economic planning, desire to specialize themselves in problems of development. The seminar courses envisaged would be for postgraduates and by reason of their nature, it is presumed that they would be limited to a relatively small number of persons (ECLA, 1951, pp. 112–113).

In 1955, ECLA published *Analyses and Projections on Economic Development*, part one of which included "An introduction to the technique of programming". The programming technique identified common variables in Keynesian models of macroeconomic growth, but added an emphasis on international economic relations that was consistent with the Commission's concerns. In addition, it distinguished early on the problems of measuring the volume of capital and the use of techniques. Thus, it referred to what was later called the "capital controversy" or the "Cambridge controversy", which aimed to discover inconsistencies in the fundamental propositions of the neoclassical theory of capital in its aggregate form.[10]

From the Commission's perspective, planning had to be focused first on the general, then on the specific. These two phases were called aggregate and sectoral projection, respectively,[11] and the first phase included the variables of the fundamental macroeconomic equation. Starting with aggregate projections answered any questions about the investments required to achieve a specific rate of growth in output. That rate was the target variable and was used to determine what was needed achieve the goal. It was argued that starting with a sectoral planning approach meant the growth rate could not be determined beforehand, and therefore could not serve as the target variable, resulting in the failure to optimize efforts and resources.[12]

The work highlighted the neutrality of the technique, which would make it possible to distinguish between present and future consumption, as well as the share of foreign capital and public spending which, according to the Commission, were ways of financing growth in activity in light of stronger future consumption. It was said that:

[10] This text likely contributed to the debate about the problem of measuring capital, how it was linked to the trend in output and the reversal of techniques from the periphery. See Boianovsky (2013) for more details on the theoretical debate.

[11] Once these first two phases were in place, both the economic policy to be followed and the administrative organization for implementation had to be determined. Both phases fell outside the scope of the document.

[12] Aggregate planning would generate: (i) the trend in income, (ii) the distribution of income between consumption and saving, (iii) the amount of investment needed and financing of this investment and (iv) the capacity to import and substitute. Subsequently, sectoral planning would reveal: (v) future demand of the different goods (consumer, intermediate, capital), (vi) the distribution of required investment, (vii) end demand and imports at the sectoral level, (viii) export possibilities and (ix) information on labour productivity levels.

> The role of the expert is to submit the different alternatives with all objectivity (...). This attitude of impartiality in the technique of programming is not only laudable in defining functions; it is also commendable inasmuch as it strengthens the moral authority and increases the powers of persuasion of those drawing up the programme (ECLA, 1955, p. 9).

Sectoral planning consisted of breaking down the aggregate estimate of demand by sector, estimating sectoral growth by calculating the respective income elasticities of demand —in accordance with projected increases—, studying the possibilities of substituting imports, and then analysing the compatibility of supply-side compliance.

According to Ahumada (1966a), development planning required the training of aggregate programmers, whom he called project planners. Other requirements were coordination personnel with a profile in statistics and management, given their involvement in the different stages of the process, and lastly, sectoral planners, for example agricultural, industrial, transport and mining specialists, among others. Although the economists had to be in charge of aggregate programming, sectoral planners had to have profiles linked more strictly to the activity (for example engineers and agronomists). Ahumada (1966a) recognized that economists in Latin American universities in the mid-1960s were not receiving such training, and supported the idea of institutionalizing the development planning profession.

III. Training and management with the technique of programming

In 1957, FCE-UBA created an advisory committee to develop a new curriculum. In *Revista de Ciencias Económicas*, the committee published two drafts of the reform: one by Enrique Reig and the other by the Curriculum Committee (Reig, 1958). The new School of Economics (which offered a bachelor's degree in Economics and a doctorate) included the Seminar on Economic Development Policy[13] proposed in one of the drafts. Core content included the study of development planning and evaluation of investment projects, economic development financing, sectoral planning and localization, organization of development planning and understanding the economic development problem in Argentina. The programme of the 1963 seminar (UBA, 1963b) included the core content formulated years earlier and was run by Leopoldo Portnoy.[14] Its learning objectives included a focus on modelling, goal and strategy setting, evaluating investment timing and alternatives, project management and calculations. Not only was Ahumada's programme included, but sections were exclusively focused on reviewing the aggregate planning model and examining sectoral planning problems. The seminar bibliography included references to both econometrics (L. Klein, F. Toranzos and R. G. D. Allen) and development planning (J. Ahumada, J. Tinbergen, A. Hirschman, United Nations and H. Chenery) and other authors discussing capital accumulation (R. Nurkse and N. Kaldor). Some contents of the seminar were updated in 1967, including economic development planning, which focused on authors such as Arthur Lewis, Walt W. Rostow and Jan Tinbergen (UBA, 1967). It was not until 1973 that the subject of economic development began to reflect the influence of the dependency theory, far removed from the concerns about measuring development typical of the political and university context (UBA, 1973).

[13] Although some economic development themes were included in parts of the existing curriculum (curriculum D of the Seminar on Economic Development Policy), there was no equivalency between the new curriculum and the old one (CECE, 1962). The programme of the third economics course of 1958 at FCE-UBA (still in curriculum D) expanded the themes of the unit on economic development to include "Development planning", "Short- and long-term planning" and "The balance of payments and foreign investment". The curriculum reform drafts of 1958 included the "Seminar on economic development and contemporary economic structure".

[14] Portnoy (1918–1997) was a public accountant and held a doctorate in Economic Sciences from UBA, where he served as lecturer and dean. He taught the ECLA programme offered at FCE-UBA.

In 1960, the Federal Investment Council of Argentina organized an intensive training course on economic development problems. Héctor Grupe and Oscar Cornblit wrote and published a unit on regional planning that included themes specific to their areas of expertise (transport, location, agglomeration and agrarian studies, among others). Alfredo Eric Calcagno (Arana, 2018) said that he not only took the ECLA course while he was a student at FCE-UBA, but he also travelled to Chile when he was the Secretary-General of the Federal Investment Council to request permission from Raúl Prebisch to teach the course at the Argentine institution. Prebisch agreed, and also offered to collaborate by providing ECLA materials and staff to teach the course. Hence, the intensive course was offered in 1960 by the Department of Graduate Affairs at FCE-UBA.[15] The syllabus included the development of economic development planning instruments, and the main text used was the one written by Jorge Ahumada in 1959 for the UBA course (Cuello and Tandeciarz, 1964). Different planning models were presented for closed and open economies, on the basis of macroeconomic factors, combined with sectoral estimates of national accounts (of the agricultural, industrial and services sectors) and classical growth theory instruments (capital-output ratios, depreciation rates and capital stock). Unconventional modelling elements were also included, such as terms of trade coefficients and profit remittance indicators. Planning consisted of simple requirements regarding the assessment of compiled variables and the setting of probable and desirable targets, followed by the review of the distribution of growth compatible with the components of aggregate demand and production sectors. In this way, programming gave rise to the national budget, which meant, at the aggregate level, what the fiscal budget meant for public sector projections and intentions. The same course was taught within the framework of the Department of Graduate Affairs in 1963 by Carlos A. García Turdero and was continued for at least two more years.[16]

1. Objectivity, neutrality and control

In December 1959, academic status was granted to the Institute for Statistics and Applied Mathematics Research, which had been created two years earlier at FCE-UBA. Some of the most representative examples of the Institute's work are the papers entitled "Modelo de crecimiento económico del tipo lineal-logarítmico con tasa evolutiva", "Metodología para el modelo sectorial de crecimiento para la economía argentina" and "Sobre la cuantificación del progreso tecnológico en un país en desarrollo", along with the seminar Modelos de Expansión Económica Equilibrada. Another sectoral economic planning model was developed by Carlos Eugenio Dieulefait (1958).[17] In his work, he used the contributions of Leontief to develop a mathematical model that integrated all national sectors by using the methodological recommendations of ECLA to save on the costs of use of electronic calculation equipment. Thus, he tried to set end demand targets to find out the intermediate requirements of each sector. The article helped to disseminate modern planning techniques associated with the idea of controlling the production process.

Several mathematical models related to growth and distribution problems were published in *Revista de Ciencias Económicas*, such as the linear model of balanced economic expansion by Fausto Toranzos (1962),[18] which, based on ratios expressed in the Leontief model, highlighted that the problem of development planning was determining the expansion of end demand that would trigger stronger

[15] When Álvaro Alsogaray became the Minister of Economy of Argentina in 1959, Mario Brodershon moved to the province of Buenos Aires, of which Aldo Ferrer was Minister of Economy and Norberto González led the Economic Planning Board. González used the course developed by ECLA and taught economic planning, and Brodershon introduced practical work. Both replicated this model in graduate courses in 1960 at FCE-UBA, where Juan C. Gómez Sabaíni and Raúl Cuello studied (Arana, 2015b).

[16] FCE-UBA produced publications in 1964 on themes such as public accounting and input-output tables prepared by the Department, and the material was reprinted the following year (UBA, 1964 and 1965).

[17] Dieulefait, born in 1901, was the National Director of Statistics and Census Research in Argentina in 1946.

[18] Toranzos was born in 1908, obtained a Doctor of Sciences in Physics and Mathematics and was a member of the Curriculum Committee that created the degree in 1958. He served as lecturer of Statistics at FCE-UBA.

growth in national output subject to the supply conditions of production factors. Thus, the problem with the development process was maximizing national output with available resources, and therefore was a problem of linear programming.

In December 1961, the Association of Economic Science Graduates presented a cycle of conferences on the economic situation of Argentina, with the participation of Carlos Moyano Llerena, Francisco García Olano, Manuel San Miguel, Leopoldo Portnoy, Federico Pinedo and Adalbert Krieger Vasena. San Miguel and others (1961) suggested that structural imbalances would not be solved with stabilization policies. Instead, they pointed out that harmonious and accelerated development through the use of programming techniques would make it possible to accelerate growth, improve productivity, increase basic social capital (transport, communications and energy), improve the organization of businesses and, in so doing, mitigate the propagating effects of inflation (price and wages), thus reversing the depressive effects of the fall in the terms of trade.

The idea of control of the development process was included in almost all the interventions in this conference cycle. At that time, the economists' inventory included linear programming techniques, calculation of technical coefficients and demand elasticities, assessment of the impact on the balance of payments, calculation of the need for external financing and cost estimates for major investment projects. According to San Miguel and others (1961), these were of "an eminently neutral character".

2. The uses of the technique of programming

In 1956, Manuel Balboa and Alberto Fracchia worked on a paper entitled "El capital fijo renovable de la República Argentina en el período 1935–1955",[19] which was to be presented the following year at the fifth General Conference of the International Association of Research in Income and Wealth, in Arnhem, Netherlands, and was published in 1959 in *Desarrollo Económico: Revista de Ciencias Sociales* (Balboa and Fracchia, 1959).[20] Dedicated to the study of social accounting issues, in 1957 Balboa included the study of "general schemes of social accounts and economic models for the whole economy" (Besa García, 1992, p. 3) in his economic statistics classes in Santiago. The following year he published "La utilización del modelo de insumo-producto en las proyecciones de la economía argentina" in *Desarrollo Económico: Revista de Ciencias Sociales* (Balboa, 1958), a work which would be used that same year in one of the most important texts of the time: "El desarrollo económico de la Argentina", published by ECLA (1959a) as part of its series *Análisis y Proyecciones del Desarrollo Económico*, begun in 1955. In fact, its initial volume was precisely "Introducción a la técnica de programación". The work included data on 23 productive sectors and focused on explaining the dynamics of imports and the integration of sectoral plans in aggregate programming (ECLA, 1959a). Balboa's contributions within the framework of ECLA continued throughout the 1960s, aimed at the application of these techniques in various countries and the production of support material for the courses in which he participated (Besa García, 1992). Balboa presented a paper on the promotion of import-substitution policies at the Regional Conference for Income and Wealth Research in Rio de Janeiro, projecting three growth scenarios for the period 1962–1967. The technique of programming, together with the input-output model, served to analyse the intersectoral structure and the consequences of end demand projections (Balboa, 1960).

[19] An English version of this document was published in *The Measurement of National Wealth* (see Balboa and Fracchia, 1959).

[20] In 1952, Balboa was a senior adviser at the then Ministry of Economic Affairs, headed by Alfredo Gómez Morales. In 1955, he participated in the joint group of the Government of Argentina and the United Nations for economic development planning. He prepared the volumes of *Contabilidad social* published by ILPES in 1963 ([online] https://repositorio.cepal.org/handle/11362/33203), which had been used since 1961 in the Joint ECLA/TAA Economic Development Training Programme. Fracchia worked at the Central Bank of Argentina, the Federal Investment Council, CONADE and the National Institute of Statistics and Censuses (INDEC). He was a professor at the University of Buenos Aires (UBA) and participated in the ECLA training programme as a professor of Social Accounting. Both are considered the initiators of national accounts in Argentina.

One year after it was founded in 1962, the Argentine National Development Council (CONADE), together with Ahumada, produced the publication of the development theory and planning course. This was one of the first records of the training provided by the institution, which had been created in 1961 when the government was headed by Arturo Frondizi. CONADE worked with several local and external institutions. The programme of collaboration with ECLA on national accounts was led by Alberto Fracchia, while another on taxation was conducted by Federico Herschel. Manuel San Miguel and Carlos Eugenio Dieulefait, among others, served as advisers in the creation of the institution. San Miguel ensured continuity when the agency was restructured during the government of Arturo Illia, as Roque Carranza became the new Executive Secretary, supported by Bernardo Grinspun (Jáuregui, 2013). They were all linked to FCE-UBA and had participated, in some cases, in the preparation of articles, and in others, in the development planning training carried out a few years earlier. It is not surprising, as Jáuregui (2014) points out, that Roque Carranza wanted to take a technical approach to economic management, which, contrary to the Frondizi approach, was closer to "ideas of balanced growth" (p. 150).

Although there was continuity in terms of the participating officials, De Pablo (1995, p. 147) points out that Carranza made no mention of the use of input-output tables in the aggregate projections of the National Development Plan 1965–1969. He also indicates that the documents produced during San Miguel's tenure were not used either. At CONADE in 1962, the technology used for calculations was based on rectangular spreadsheets and on manual calculators (Facit and Olivetti) and electric calculators (Friden and Olivetti). A simple regression of 30 observations took several hours, with no possibility to verify calculation errors easily. De Pablo remembers that the "terribly impressive" table (the input-output table of 1953) was a huge sheet of paper stuck to the wall, and included calculations of intermediate requirements made by Clementina, the Mercury model computer that had been running at the University of Buenos Aires Faculty of Exact and Natural Sciences since 1961.[21]

At the first annual meeting of the Argentine Association of Political Economy (AAEP), held in the city of Río Tercero in 1964, the members of CONADE, Julio Berlinski, Faustino González, Clemente Panzone and Jacobo Rabinovich,[22] published a document on the projection method followed within the framework of the development plan managed by that institution (Berlinsky and others, 1964). The work showed a planning sequence similar to those of the technique of programming. First, macroeconomic projections were made using a model of 7 equations with 16 variables and parameters, the aim of which was to set the growth rate of output and analyse the investment and external sector requirements that would make it possible to meet the target. Subsequently, the production possibilities of the sectors were analysed by selecting a sample of 11 relevant sectors within industry, transport and energy (the remaining sectors had no systematic information and were difficult to model). The work suggested that the particular attention paid to the external sector and to import substitution was evident in all programming technique documents and therefore did not refer to the intersection of actual estimates with the financial area.[23]

In 1967, the Centre for Economic Research at Argentina's Torcuato Di Tella Institute (ITDT) published its working paper number 39, entitled "Utilización del modelo de insumo-producto como instrumento de proyección en la Argentina" (Brodersohn and Guisarri, 1968), which evaluated the capabilities of four projection techniques for economic activity: techniques based on the input-output table (in its 1953, 1960 and 1963 versions), multiple regression, expansion of gross domestic product and expansion

[21] In order to finish his master's thesis at Harvard, and with the help of staff from the Institute of Calculus and a mathematician, Mario Brodersohn made an appointment to use Clementina and had to wait three months to invert an input-output table comprising 20 rows and 20 columns. Mathematical economists such as Arturo O'Connell and Roberto Frenkel worked at the Institute of Calculus in the 1960s.

[22] They published their work the following year in *Desarrollo Económico: Revista de Ciencias Sociales*. As De Pablo (1995) recalls, Faustino González was in charge of the aggregate programming sector, in which the best professionals of CONADE worked.

[23] Although the intensive courses included modules on monetary policy, the absence of references to capital movements and interest rates in all the literature reviewed is notable.

of end demand. Through this research, it was concluded that the first two techniques achieved much lower predictive margins of error than the last ones. In the case of Argentina, multiple regression had the advantage of generating much lower production costs and achieving better overall estimates. However, paradoxically, the results of the input-output technique were more accurate the longer the projection period. The work was an extension of the CONADE exercise on the sensitivity of the 1960 input-output table coefficients, which had concluded that the use of the technique for projection was reliable despite its weaknesses (Brodersohn and Guisarri, 1968). Like their colleagues, Osvaldo Fernández Balmaceda, Reinaldo Félix Bajraj, Guillermo Calvo and Julio Alberto Piekarz of CONADE presented their research at the first AAEP conference in 1964, and it was published the following year in *Desarrollo Económico: Revista de Ciencias Sociales*.

IV. Concluding remarks

This paper explored the development and importance of the technique of programming for economists and economic development planning institutions during the two decades following its creation in 1952. The main transformations of this technique and its circulation in different institutions in Argentina were studied in a context of great changes in the field of indicative planning and ideologies in the region.

Firstly, we should note the emphasis placed on the achievement of planned, accelerated and stable growth, which introduced the documents discussed into the debates of the late 1950s on balanced and unbalanced growth, led by Ragnar Nurkse and Albert Hirschman, respectively. This approach was also in line with the use of new calculation techniques and technologies. Linear programming, electronic calculators and computers (mainly for use on input-output tables), together with the possibility of exploiting old data with new tools and building other interpretations from them, fed experts' confidence in the ability to conduct the economic process rationally. This rationality was expressed in the use of "neutral" techniques, which ensured the researcher's objectivity, so that it was possible to believe that if the results were well calculated, the identified goals could be met. The expert had to offer various economic paths to meet the social goals selected by the politicians.

Although the technique was initially based only on practice and theories were scarce, as the years went by, the search for conceptual definitions and refinements of the method led, in Ahumada's case, to the outline of a general theory. The ideas of renowned foreign economists such as John M. Keynes and Wassily Leontief frequently appeared in writings on planning: on the one hand, Keynesian theoretical tools, then linked to orthodoxy in English-speaking countries, and, on the other, Leontief's technical instruments, which expanded Keynesian macroeconomics and allowed it to be applied to both central and peripheral countries. When Ahumada tried to extrapolate his planning practice to a general model of Latin American economies, he also made use of Arrow, a general equilibrium theorist and one of the most prominent economists of neoclassical theory (Ahumada, 1977). The overall planning of central macroeconomic controls, the mesoeconomic planning of the input-output table, the selection of investment techniques and projects, and the governance of new equation models helped to refine calculations, sharpen the focus and place greater confidence in the technique. Although Jorge Ahumada, as an ECLA economist, engaged with these central texts of Western political economy and had creative ambitions in that regard, he does not seem to have gained a great deal of recognition in the discourses on modernization through development planning or even in Latin American economic thought. However, the impact he had at the time appears to be significant enough for him to be included in the social research agenda of the economic past.

In addition to highlighting Ahumada's theoretical contributions and references —creative capacity, ideological insertion and technical uses—, the second part of this paper refers to his role in the institutional context. ECLA, through the courses mentioned, sought to complement the training

received by economists in universities and public bodies, encouraged the training of aggregate and sectoral planners, granted scholarships to specialists from decision-making centres and established fluid dialogues with government authorities, universities and experts from all over Latin America.

In the specific case of Argentina, training in planning circulated in courses, subjects and curricula of FCE-UBA, professional associations (AAEP and the Department of Graduate Affairs), publishers (Editorial Universitaria de Buenos Aires (EUDEBA) and ECLA), the national government (CONADE and ministries) the provincial government (the Federal Investment Council) and specialized journals (*Revista de Ciencias Económicas* and *Desarrollo Económico: Revista de Ciencias Sociales*). In this way, they influenced curriculum reforms for economists, while acting as postgraduate training institutions in a region where such specializations were virtually non-existent. In the total absence of development planners, ECLA developed several training courses. All this thematic breadth generated debates, research, publications, jobs and policies. The training of specialists and the contribution to development plans appear to be the two major contributions.

By 1972, the social and political problems associated with planning were already evident, and ILPES itself acknowledged excessive confidence in development plans (ILPES, 2012b). Neither the theory nor the planning technique was questioned, but rather the difficulties imposed by the political processes. From then on, emphasis was placed on adapting planning mechanisms to the particular circumstances of each country, but their importance to the technical-administrative system of the State was maintained. These configurations of techniques, theories and instruments were combined with the circulation of specialists in key institutions for the training of economists and public policy in Argentina, which spread the ideas and practices contained in ECLA texts on development planning in Latin America. This not only broadened the discussion of ideas, but also contributed to obtaining new information for the economic study of the region.

Bibliography

Ahumada, J. (1977), “Notas para una teoría general de la planificación”, *Project Documents, Studies and Research Papers* (INT-0173), Santiago, Latin American and Caribbean Institute for Economic and Social Planning (ILPES).

___(1967), “Teoría y programación del desarrollo económico”, *Cuadernos del ILPES*, vol. 1, No. 1, Santiago, Latin American and Caribbean Institute for Economic and Social Planning (ILPES).

___(1966a), “Necesidades de formación del personal de las instituciones para el desarrollo económico”, *Revista Mexicana de Sociología*, vol. 28, No. 1.

___(1966b), “Notas para una teoría general de la planificación”, *Cuadernos de la Sociedad Venezolana de Planificación*, vol. 4, No. 4–5, Caracas.

___(1962), “Teoría y programación del desarrollo”, Buenos Aires, National Development Council (CONADE).

___(1961), “Investment priorities”, *Economic Development for Latin America*, H. Ellis and H. Wallich (eds.), London, Palgrave Macmillan.

___(1959), “Discurso del doctor Jorge Ahumada en el acto de clausura del Curso Intensivo de Capacitación en Problemas de Desarrollo Económico”, *Revista de Desarrollo Económico*, vol. 2, No. 2.

___(1958), *Teoría y programación del desarrollo económico*, Buenos Aires, University of Buenos Aires (UBA)/ Economic Commission for Latin America (ECLA).

___(1955), “Preparación y evaluación de proyectos de desarrollo económico”, *El Trimestre Económico*, vol. 22, No. 87.

___(1952), “El empleo de la contabilidad del ingreso nacional en la planificación del desarrollo económico”, *Project Documents, Studies and Research Papers* (INT-1749), Santiago, Economic Commission for Latin America (ECLA), November.

___(1951), “Desarrollo económico y estabilidad”, *El Trimestre Económico*, vol. 18, No. 71.

Arana, M. (2018), “Entrevista a Alfredo Eric Calcagno”, October, unpublished.

___(2015a), “En el núcleo de la edad dorada del desarrollo: la Revista de Ciencias Económicas, UBA (1958–1963)”, Master’s thesis on political economy, Buenos Aires, Latin American Faculty of Social Sciences (FLACSO).
___(2015b), “Entrevista a Brodersohn, Mario S.”, May, unpublished.
___(2013), “Entrevista a Arturo O’Connell”, July, unpublished.
Balboa, M. (1963), “Construction and use of input-output tables in Latin American countries”, *Structural Interdependence and Economic Development*, T. Barna (ed.), London, Palgrave Macmillan.
___(1960), “Some applications of the input-output model to the Argentine economy”, *Economic Bulletin for Latin America*, vol. 5, No. 1, Santiago, Economic Commission for Latin America (ECLA).
___(1958), “La utilización del modelo de insumo-producto en las proyecciones de la economía argentina”, *Desarrollo Económico: Revista de Ciencias Sociales*, vol. 1, No. 1.
Balboa, M. and A. Fracchia (1959), “Fixed reproducible capital in Argentina, 1935–55”, *The Measurement of National Wealth*, R. Goldsmith and C. Saunders (eds.), Chicago, Quadrangle Books.
Berlinski, J. and others (1964), “Metodología de las proyecciones del plan de desarrollo” [online] https://aaep.org.ar/anales/works/works1964/Berlinski.pdf.
Besa García, J. (1992), “Escritos de Manuel Balboa 1952–1976: bibliografía existente en la Biblioteca de la CEPAL” [online] https://repositorio.cepal.org/bitstream/handle/11362/3400/FILE%20%28147914%29_es.pdf?sequence=1&isAllowed=y.
Boianovsky, M. (2013), “The Economic Commission for Latin America and the 1950s’ debate on choice of techniques”, *Review of Political Economy*, vol. 25, No. 3.
Brodersohn, M. and A. Guisarri (1968), “Utilización del modelo de insumo-producto como instrumento de proyección en la Argentina”, *El Trimestre Económico*, vol. 35, No. 140.
CECE (Centro de Estudiantes de Ciencias Económicas) (1962), “Guía del estudiante”, Buenos Aires.
Chirom, J. (1985), “La profesión contable: ejercicio, antecedentes, marco legal”, thesis on professional practice, Buenos Aires.
Cuello, R. and C. Tandeciarz (1964), *Programas de desarrollo económico: introducción a su estudio*, Buenos Aires, Editorial Universitaria de Buenos Aires (Eudeba).
Dagnino Pastore, J. and M. Fernández López (1988), “Los economistas en el gobierno argentino”, *Crónicas económicas: Argentina, 1969–1988*, J. Dagnino Pastore (ed.), Buenos Aires, Editorial Crespillo.
De Pablo, J. (1995), *Apuntes a mitad de camino: economía sin corbata*, Buenos Aires, Ediciones Macchi.
Dieulefait, C. (1958), “El modelo de insumo-producto y el problema de inversión”, *Revista de Ciencias Económicas*, vol. 4, No. 3.
ECLA (Economic Commission for Latin America) (1961), *Report on the Joint ECLA/BTAO Economic Development Training Programme* (E/CN.12/588), Santiago, March.
___(1959a), “El desarrollo económico de la Argentina”, *Analyses and Projections on Economic Development*, vol. 5 (E/CN.12/429/Add.3/Rev.1), Mexico City, August.
___(1959b), *Report on the Joint ECLA/TAA Economic Development Training Programme* (E/CN.12/523), Santiago, March.
___(1958), *Manual on Economic Development Projects* (E/CN.12/426/Add.1/Rev.1), New York.
___(1957), *Report on the ECLA/TAA Economic Development Training Programme* (E/CN.12/433), Santiago, April.
___(1955), “An introduction to the technique of programming”, *Analyses and Projections on Economic Development*, vol. 1 (E/CN.12/363), New York, June.
___(1953), *Preliminary Study on the Technique of Programming Economic Development* (E/CN.12/292), Santiago, March.
___(1951), *Theoretical and Practical Problems of Economic Growth* (E/CN.12/221), New York, May.
ECLA/ILPES (Economic Commission for Latin America/Latin American and Caribbean Institute for Economic and Social Planning) (1963), “Progress in planning in Latin America”, *Economic Bulletin for Latin America,* vol. 8, No. 2, Santiago, Economic Commission for Latin America (ECLA), October.
Fernández Balmaceda, R. and others (1965), “Construcción de modelos de insumo-producto en la República Argentina”, *Desarrollo Económico: Revista de Ciencias Sociales*, vol. 5, No. 17/19.
Furtado, C. (1988), *La fantasía organizada*, Buenos Aires, Editorial Universitaria de Buenos Aires (Eudeba).
Grupe, H. and O. Cornblit (1960), *Curso intensivo de capacitación sobre problemas de desarrollo económico*, Mendoza, Federal Investment Council (FIC).

ILPES (Latin American and Caribbean Institute for Economic and Social Planning) (2012a), "Evolución y orientaciones del Instituto Latinoamericano de Planificación Económica y Social: nota del director general", *Los fundamentos de la planificación del desarrollo en América Latina y el Caribe: textos seleccionados del ILPES (1962–1972)*, ECLAC Books, No. 116 (LC/G.2552-P), R. Martner and J. Máttar (comps.), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

___(2012b), "Evolución y perspectivas de los procesos de planificación en América Latina", *Los fundamentos de la planificación del desarrollo en América Latina y el Caribe: textos seleccionados del ILPES (1962–1972*), ECLAC Books, No. 116 (LC/G.2552-P), R. Martner and J. Máttar (comps.), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Jáuregui, A. (2014), "La planificación en la Argentina del desarrollo (1955–1973)", *Temas de historia argentina y americana*, No. 22.

___(2013), "La planificación en la Argentina: el CONADE y el PND (1960–1966)", *Anuario del Centro de Estudios Históricos "Prof. Carlos S. A. Segreti"*, No. 13.

Leontief, W. (1951), *The Structure of American Economy, 1919–1939: An Empirical Application of Equilibrium Analysis*, New York, Oxford University Press.

Reig, E. (1958), "Notas universitarias: reforma del plan de estudios. La enseñanza universitaria en EE.UU.", *Revista de Ciencias Económicas*, vol. 4, No. 2.

San Miguel, M. and others (1961), "Examen crítico de la actual situación económica del país en el aspecto relacionado con la estabilidad monetaria y la producción", *Revista de Ciencias Económicas*, vol. 49, No. 16.

Sunkel, O. (2000), "La labor de la CEPAL en sus primeros dos decenios", *La CEPAL en sus 50 años: notas de un seminario conmemorativo*, ECLAC Books, No. 54 (LC/G.2103-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), July.

Toranzos, F. (1962), "Modelo lineal de expansión económica equilibrada", *Revista de Ciencias Económicas*, No. 18.

UBA (University of Buenos Aires) (1975), "Programa de la materia 315, 'Desarrollo Económico'" [online] http://biblio.econ.uba.ar/cgi-bin/koha/opac-detail.pl?biblionumber=192679&query_desc=ti%2Cwrdl%3A%20programa%20desarrollo%20econ%C3%B3mico.

___(1973), "Programa de la materia 315, 'Desarrollo Económico'" [online] http://biblio.econ.uba.ar/cgi-bin/koha/opac-detail.pl?biblionumber=192678&query_desc=ti%2Cwrdl%3A%20programa%20desarrollo%20econ%C3%B3mico.

___(1967), "Programa Seminario sobre política del desarrollo económico", Buenos Aires, Faculty of Economic Sciences.

___(1965), "Curso intensivo de capacitación sobre problemas del desarrollo económico", Buenos Aires, Faculty of Economic Sciences.

___(1964), "Curso intensivo de capacitación sobre problemas del desarrollo económico: elementos de contabilidad general, contabilidad nacional", Buenos Aires, Faculty of Economic Sciences.

___(1963a), "Curso intensivo de capacitación sobre problemas del desarrollo económico", Buenos Aires, Faculty of Economic Sciences.

___(1963b), "Programa Seminario sobre política del desarrollo económico", Buenos Aires, Faculty of Economic Sciences.

Indicator of the efficiency of value added tax and income tax collection in Ecuador[1]

José Ramírez-Álvarez and Paul Carrillo-Maldonado

Abstract

This paper outlines a methodology to measure the efficiency of revenue collection by tax administrations. The proposed methodology is aimed in particular at developing countries that do not have enough disaggregated information to measure tax gaps (registration, filing, veracity and payment) using traditional methods. The proposed indices are based on estimations of the structural balances of public finances, and rises in the indices can be interpreted as a comprehensive narrowing of tax gaps. The methodology is applied to Ecuador's value added tax (VAT) and income tax, producing results that show that a more efficient tax administration leads to revenue growth.

Keywords

Income tax, value added tax, tax collection, tax evasion, tax administration, evaluation, Ecuador

JEL classification

H21, H26, H83

Authors

José Ramírez-Álvarez holds a PhD in Economics and is a Professor in the Department of Quantitative Economics at the National Polytechnic School, Ecuador. Email: jose.ramirez@epn.edu.ec.

Paul Carrillo-Maldonado is an Economic Analyst at the Inter-American Development Bank and a PhD candidate in the Doctoral Programme of the Facultad Latinoamericana de Ciencias Sociales (FLACSO). Email: paulcar@iadb.org.

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I. Introduction

Tax management is a crucial administrative function for the State, since it helps to ensure that enough public resources are available for expenditure and investment, and safeguards equity and redistribution in a country's fiscal structure. Tax administrations are responsible for this, which basically comprises tax collection, inspection and payment (Jorratt, 1996).

In essence, tax management covers the management and monitoring of four gaps: registration, filing, veracity and payment. The first of these gaps is the difference between the number of registered taxpayers and the potential population (usually the economically active population in employment). The second gap is the difference between the total number of tax returns that registered, economically active taxpayers should submit and the number of returns actually filed. The payment gap is the difference between the tax paid on time and the amount voluntarily declared by taxpayers. The veracity gap is the difference between the declared amount and that determined by the tax administration following an inspection (Pecho, Sánchez and Peláez, 2012).

A coordinated reduction in these gaps is one of the key goals when formulating strategies for tax administrations and measuring their performance as tax collection entities. The literature on this subject has examined different methods for estimating each gap. Pecho, Sánchez and Peláez (2012) describe these methodologies and present their results for Latin America between 2000 and 2010. However, they also show that the technical feasibility of the methodologies depends on the availability and quality of information from outside the tax administration, potentially preventing comprehensive monitoring of tax management. Alm and Duncan (2014) propose using input-output methodologies (data envelopment analysis) and stochastic frontier analysis to measure the efficiency of the tax administration and its agencies. However, this approach is difficult to apply in emerging economies because of the limited information available on the cost of administrative processes, foreign-source taxpayer transactions and the budget at the administrative-geographical level, among other factors.

This paper proposes a methodology for constructing collection efficiency indices, drawing on macroeconomic information. The methodology is based on estimations of a structural balance of public finances (see Fedelino, Ivanova and Horton, 2009), considering only the tax revenue side; that is to say, eliminating the effects of any economic conditions or tax reforms. The indicator reflects the comprehensive narrowing of the aforementioned tax gaps. This proposal has been applied to the Internal Revenue Service (SRI) of Ecuador and specifically to value added tax (VAT) and income tax in the country. Ecuador is a particularly interesting case because it is a developing country that has achieved substantial increases in revenue in recent years, in clear contrast with previous periods (Almeida and others, 2012).

The results of the exercise show that the efficiency of the SRI has increased since 2006. They also indicate an improvement in VAT collection efficiency from 2007 onward and significant changes between 2006 and 2010 in income tax collection efficiency. Lastly, the results suggest that the behaviour of the SRI can be adapted to possible decreases in revenue caused by factors that are beyond its control.

This paper is divided into sections: the economic theory related to the determinants of tax revenue is presented in section II; the methodology used to construct the efficiency indicators is described in section III; some background on tax collection in Ecuador is provided in section IV; the results obtained for Ecuador are described in section V; and the conclusions are set out in section VI.

II. Efficiency and tax collection: theoretical guidelines

According to Jorratt (1996), there are two main means of increasing tax revenue: establishing new taxes or collecting existing ones with greater efficiency. In a tax context, efficiency is the narrowing or closing of tax gaps through inspections and management strategies that increase taxpayers' risk perception and improve their behaviour. In addition, the Tax Administration Department of Uruguay (2006) and Ricciardi (2007) both state that, in order to measure the efficiency of tax administration, it is necessary to distinguish between three factors that influence tax revenue: economic activity, tax policy and compliance with tax obligations.

Economic activity and tax policy are key elements in the design and structure of any tax system. Economic activity —as a driver of resource generation, usage and transformation— provides an initial estimate of an economic agent's ability to assume a tax burden. Tax policy, meanwhile, establishes how the tax is calculated; that is to say, it determines the taxable event, the taxable person or entity, the tax rate, any exemptions and deductions, and payment of the tax (Martín, 2009).

Great importance is attached to compliance with tax obligations when formulating tax administration strategies and control measures. Control and management actions, whether universal or focused, are designed according to the tax collected, the tax gap, the tax risk and the body of taxpayers that shows signs of undesirable behaviour.[2]

There are several factors that determine tax compliance and hence affect tax collection efficiency. Authors such as Allingham and Sandmo (1972), Andreoni, Erard and Feinstein (1998), Myles (2000), Slemrod and Yitzhaki (2002), Sandmo (2005) and Torgler (2007) analyse several of them from a theoretical point of view. The main factors include risk aversion, the perception of tax controls, the institutional strength of the tax administration, the administrative costs of tax returns, the interaction between taxpayers and tax administrations, the complexity of tax legislation, tax fairness, tax morale and social dynamics.

In practice, these characteristics are difficult to measure because of their social and institutional nature. Regular surveys are often needed to garner public opinion on these issues. However, to do so tax administrations must make use of valuable resources. In addition, field research may be needed, using impact assessments to determine how these characteristics affect tax compliance.[3]

Of the aforementioned factors, risk aversion is key to understanding taxpayer behaviour. Allingham and Sandmo's (1972) model, which has served as the basis for the various theoretical analyses of tax evasion, holds that evasion will increase as the probability of detection, severity of penalties, tax rate and taxpayer risk aversion decrease and income rises (Cowell, 2004). In particular, the last two factors link tax compliance in a different way with taxpayer's characteristics, such as perception and economic activity. There is evidence that risk aversion varies over time and is procyclical (Sancak, Velloso and Xing, 2010). In other words, taxpayers evade less when the economy is booming, since at that point in the business cycle it is less attractive for them to risk engaging in profit-seeking behaviour that would result in a penalty; conversely, taxpayers evade more in recessions, since the scarcity of resources forces them to take the risk and commit fraud. In addition, tax compliance is positively correlated with stronger institutional underpinnings of countries, and negatively correlated with the overall tax burden in the economy (Sancak, Velloso and Xing, 2010).

[2] Tax risk refers to the probability that the tax administration will incur losses, or that some unfavourable event will occur, as a result of taxpayers' unusual behaviour.

[3] The literature on tax evasion has grown rapidly in recent years thanks to impact assessments and particularly field experiments. These assessments generally focus on compliance with income tax and VAT, as well as variables used for filing related returns and for balance sheets (income, sales, deductions and expenses). As part of these assessments, letters, questionnaires or booklets are sent to a group of taxpayers before they fulfil their tax obligations. The information provided usually focuses on deterrence, taxpayer assistance, public services, social standards and morality. Walsh (2012) and Hallsworth (2014) give concise descriptions of several of these assessments. For developing countries, some of the most important experiments may be found in Ortega and Sanguinetti (2013), Pomeranz (2015) and Carrillo, Pomeranz and Singhal (2017).

III. Methodological strategy

Constructing the structural balance of public finances to evaluate discretionary fiscal policy measures has been widely discussed in the economic literature. The Organization for Economic Cooperation and Development (OECD) and the International Monetary Fund (IMF) have established similar methodologies for these indicators: both organizations propose econometric estimation of the elasticity of the components of tax revenue and public expenditure with respect to gross domestic product (GDP), in order to purge the effect of the business cycle and use the difference to determine the effect of policy on the overall result of public finances.[4] The Tax Administration Department of Uruguay uses this methodology to ascertain the efficiency of VAT management in the country, owing to its close relationship with other taxes (Tax Administration Department, 2006).

From a tax perspective, both IMF (see Ebrill and others (2001) or Keen (2013)) and OECD (2008) have proposed assessing VAT-related tax policies using the C-efficiency methodology. C-efficiency is the ratio of VAT revenue to the product of the standard rate and consumption, in nominal pre-tax terms (Keen, 2013). C-efficiency is also used to compare VAT among different countries, as OECD does in its reports (see OECD, 2008).

The VAT and income tax management indices proposed in this document are based on the methodologies of OECD (2008), IMF (Ebrill and others, 2001) and the Tax Administration Department of Uruguay (Tax Administration Department, 2006). The IMF and OECD methodology is used to estimate tax elasticities relative to GDP (or their tax bases) and then the effect of the business cycle is removed. The impact of tax reforms is also estimated, to subtract it from the amount of each tax collected. The remaining component of this process is used to measure the combined efficiency of the tax administration, in accordance with the theoretical guidelines set out above.

There are essentially three stages to estimating the index: (i) seasonal adjustment; (ii) estimation of the long-term elasticities of tax revenue with respect to GDP; and (iii) adjustment of revenue by business cycle. These steps enable estimation of the comprehensive management of the tax administration in the collection of tax revenues. The first step excludes the seasonal effects from the tax variables that are typical of the taxation or economic system, and which may have adverse effects on the econometric estimation. The second step captures the economic activity involved in generating the tax base. The third extracts the cyclical fluctuations in the tax base using the elasticities. This final step adjusts tax revenue by economic cycle and corrects for taxpayer risk aversion in different growth phases. The Tax Administration Department of Uruguay carries out this same process, but its estimate of elasticity suffers from endogeneity between the tax base and the collected amount. In the method proposed in this paper, this problem is corrected by using the dynamic ordinary least squares estimator.

This methodological process enables construction of indicators of the tax administration's collection efficiency, based on identification of the taxes to be studied (VAT or income tax), their macroeconomic tax bases (GDP or consumption) and the reforms that affect the amounts collected. For this proposal, no information is required on commodities, production or imports, among other variables at the industry level, as in the methods reviewed by Pecho, Sánchez and Peláez (2012); nor is it necessary to quantify the processes, their inputs or their level of technology to establish efficiency (see Alm and Duncan, 2014), which is difficult in developing economies.

[4] In short, the structural balance methodology comprises three steps: estimating the elasticity of the components of total revenues and primary expenditure in relation to GDP (or the tax base); adjusting revenues and expenditures for the business cycle, and; subtracting adjusted primary expenditure and interest payments from adjusted revenues. For further details, see Fedelino, Ivanova and Horton (2009).

To implement this methodology in Ecuador, we used quarterly data covering the period 1993–2014 on VAT collected on domestic transactions,[5] income tax revenue, GDP and consumption, in current (or nominal) dollars. The tax series are lagged by one period to make the collection date match the tax period in which the tax base was generated. In addition, the X11-ARIMA method is used to seasonally adjust the variables.

1. Tax elasticities

The long-term elasticities of VAT and income tax are estimated separately using two econometric models. These models explain the macroeconomic patterns in tax revenue as functions of the tax base (a variable directly associated with economic activity). In the case of VAT, final consumption is used as a proxy for the tax base, while in the case of income tax, GDP is used (see Sevilla, 2004):

$$Tax_t = \alpha + \beta_{TB}^{Tax} \cdot TB_t + \delta \cdot D_t + u_t \quad (1)$$

Where Tax_t is the logarithm of VAT or income tax revenue, TB_t is the logarithm of the tax base for each tax (consumption or GDP), α is a constant, β_{TB}^{Tax} is the elasticity of the tax with respect to its tax base, D_t is a vector of dummy variables that control for reforms or structural changes, δ is the coefficient associated with the dummy variables and u_t is the residual.

As previously explained, economic agents may seek to adjust their declared tax base to pay less tax, depending on their level of risk aversion and the penalty they expect if the tax administration detects fraud (Allingham and Sandmo, 1972). This generates endogeneity problems in the estimation of elasticity using ordinary least squares (OLS). Moreover, according to the national accounts manuals, GDP and consumption are already constructed to include the taxes that are generated.

To eliminate this problem, the dynamic ordinary least squares (DOLS) method is used, which modifies the OLS estimate by including lags and advances of the first difference of the independent variables, without affecting the rest of the Gauss-Markov assumptions. Furthermore, this technique is asymptotically equivalent to Johansen's maximum likelihood estimator, with better efficiency and performance on small samples. This method should only be used when there is previous evidence of cointegrating relations among the variables (Stock and Watson, 1993).

Statistical validation of the cointegrating relations was performed in accordance with the methodology of Engle and Granger (1987). In the case of integrated series of order 1, this methodology focuses on verifying that the series in levels contain a unit root, the series in the first difference do not contain a unit root and the linear combination of the series in level does not contain a unit root. The existence of unit roots was evaluated through the Dickey-Fuller and Phillips and Perron tests (see Baum, 2005). Because there could be structural breaks in the economic series due to the 1999 financial crisis in Ecuador and the impact of the 2008 international financial crisis, the Clemente, Montañés and Reyes test (1998) was also used. The results of this process are set out in annex A1.

Structural breaks in the model were identified by means of the cumulative sum of squares test (CUSUMSQ), which allows the periods of greatest instability in the model residuals to be determined (Hansen, 1992; Krämer, Ploberger and Alt, 1988). In addition, the Chow test was used recursively to find the most likely date of the structural break in the variables (Greene, 2007). Based on these tests, it was found that VAT has a structural break in both the mean and slope in the second quarter of 1999. No break was detected in the income tax model (see annex A2).

[5] VAT on domestic transactions is used because SRI manages this tax revenue. Ecuador's national customs service is responsible for collecting VAT on imports.

Equation (1) also includes dummy variables to isolate the legal changes that affected the structure of the tax system. How to demonstrate the impact of these legal changes (narrative method) has been the subject of extensive discussion in the fiscal policy literature. The most noteworthy proposals include insertion of dummy variables in the prevailing period of the reform, as Edelberg, Eichenbaum and Fisher (1999) did, and the use of ex ante estimates of tax reforms from official records as per Romer and Romer (2010). The latter methodology has been criticized for assuming a certain pattern in reforms, probably conditioned by the information, the duration of the reforms, the time lapse between their announcement and implementation, and economic agents' expectations (Leeper, Walker and Yang, 2008; Perotti, 2007).

Tax reforms have been implemented in Ecuador for economic or institutional reasons and in response to exogenous shocks. Arias and others (2008), Paz and Miño Cepeda (2015) and Carvajal, Carrasco and Álvarez (2012) all provide a history of the country's tax system, presenting the economic and political context of the key tax-related events in Ecuador. For the purpose of this model, dummy variables are included in the period of the legal reforms that modified the tax base and/or the tax rate permanently. In the case of income tax, six reforms were taken into account: (i) between December 1998 and December 1999, income tax was replaced by the financial transactions tax (ICC), with a rate of 1% on all movements of money or capital pursuant to the Economic Reorganization of Taxation and Finance Act,[6] with the aim of simplifying procedures and improving tax efficiency; (ii) in January 2000, income tax was reinstated and the financial transactions tax was converted into an advance on the personal income tax at a rate of 0.8% until November 2000, when it was completely eliminated,[7] as IMF did not agree with the measure; (iii) in April 2007, the income tax withholding rate was increased from 1% to 2% for companies acquiring real estate or entering into a service contract, as part of President Rafael Correa's first round of reforms;[8] (iv) in January 2008, personal income tax was modified through a new tax table, deductions of personal expenses and a new calculation of income tax advances, with the aim of making the tax more progressive;[9] (v) in December 2009, advances were established as a minimum and non-refundable tax under the Act to amend the Domestic Tax Regime Act and the Reform Act for Tax Equity in Ecuador, amendments that were made through the adoption of the 2008 Constitution;[10] and (vi) in December 2010, the Production, Commerce and Investment Code (COPCI) was adopted, a legal framework that established some deductions and exemptions for investment in certain sectors and assets. The Code also established a reduction of 1 percentage point in the corporate income tax rate each year until it reached 22% in 2013.[11]

In the case of VAT, five reforms were considered, which changed both the tax rate and the tax base. The first reform entered into force in December 1997 and modified the list of VAT-exempt products.[12] The second reform increased the rate from 10% to 12%, as part of the measures to counteract the economic crisis the country experienced in the late 1990s. The third was the temporary increase in the VAT rate from 12% to 14%.[13] This measure was withdrawn because it did not have enough political support to maintain it. The fourth reform comprises the changes made by the Reform Act for Tax Equity in Ecuador with respect to VAT, which entered into force in January 2008, exempting public sector purchases from VAT and establishing tax rebates for exporters, among other measures.[14] The latest reform considered is the elimination of VAT exemptions on purchases by State-owned enterprises.[15]

[6] Economic Reorganization of Taxation and Finance Act (Law No. 98–17), published in official gazette No. 78 of 1 December 1998.

[7] Public Finance Reform Act (Law No. 99–24), published in official gazette No. 181 of 30 April 1999.

[8] Official gazette No. 98, 5 June 2007.

[9] Reform Act for Tax Equity in Ecuador, published in the third supplement to official gazette No. 242, 29 December 2007.

[10] Act to amend the Domestic Tax Regime Act and the Reform Act for Tax Equity in Ecuador, published in the supplement to official gazette No. 94 of 23 December 2009.

[11] Production, Commerce and Investment Code, published in the first supplement to official gazette No. 351, 29 December 2010.

[12] Law No. 41, published in official gazette No. 206 of 2 December 1997.

[13] Supplement to official gazette No. 390 of 15 August 2001.

[14] Reform Act for Tax Equity in Ecuador, published in the third supplement to official gazette No. 242, 29 December 2007.

[15] State-owned Enterprises Act, published in the first supplement to official gazette No. 48 of 16 October 2009.

2. Construction of the efficiency indices

The estimation from equation (1) allows the variation in tax revenues derived from developments in economic activity to be captured. According to the IMF (Ebrill and others, 2001) and OECD (2008) manuals, VAT revenue is adjusted according to the business cycle using the following expression:

$$Tax_t^A = Tax_t \left(\frac{TB_t^T}{TB_t} \right)^{\beta_{TB}^{Tax}} \quad (2)$$

Where Tax_t^A is adjusted VAT or income tax revenue per cycle, TB_t^T is the consumption trend or GDP and β_{TB}^{Tax} is the long-term elasticity of the tax with respect to its base. This adjustment allows the procyclical relationship to be extracted from taxpayers' risk aversion, as explained above. If the elasticity is greater than 1, equation (2) establishes that a tax base greater (smaller) than its trend generates an adjusted revenue that is less (greater) than the observed revenue, meaning that:

$$TB_t > TB_t^T \Rightarrow Tax_t^A < Tax_t$$

$$TB_t < TB_t^T \Rightarrow Tax_t^A > Tax_t$$

In other words, tax revenues are undermined in boom periods and compensated in periods of recession. This makes it possible to extract the variations that are characteristic of the economic cycle and correct the underlying bias that introduces less (more) appetite for risk in phases of economic expansion (contraction). Lastly, in order to obtain a measurement of the tax burden resulting from the management of the tax administration, the adjusted revenue is expressed in terms relative to the actual long-term tax base, taking a base year. For the purposes of this paper, 2000 was the reference year.

IV. Tax structure in Ecuador

Ecuador is a developing Latin American country with a small, open economy. Its production system is primarily export-based, and has been to a greater extent since the first oil boom in the 1970s. According to Díaz (2018), average annual economic growth was 4% between 1972 and 2015; Díaz also mentions that per capita GDP increased annually by 1.7% over the same period. These figures are below those for the overall economic development of the region. In addition, the country is dependent on international trade, with the price of oil as a transmission channel.

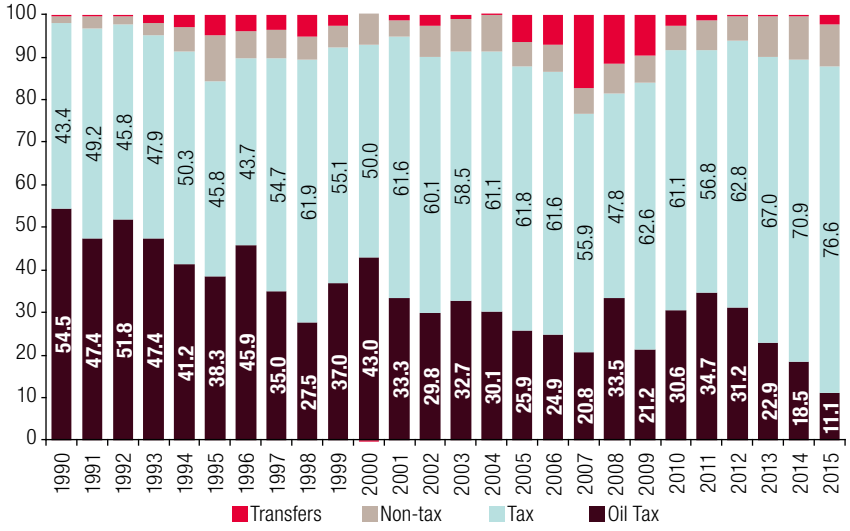
Different political, economic and natural events drove the country into a crisis in 1999, characterized by persistent inflation (the average between 1990 and 1999 was 39.8%), mistrust of the monetary system and more than 50% of the population living in poverty. The authorities made a policy decision to dollarize the Ecuadorian economy. This measure produced results a few years later, with a single-digit inflation rate (for the first time since 2003) and real GDP growth of 4.3% between 2000 and 2006. Since 2007, the country has experienced economic growth of 3.9%, thanks in particular to the commodity boom that took place throughout Latin America (Díaz, 2018).

One disadvantage of dollarization has been the elimination of traditional monetary and exchange rate policy instruments, leaving fiscal policy solely responsible for maintaining macroeconomic stability. In fact, fiscal policy has evolved the most since 2007, on both the revenue and expenditure sides. The Government of Ecuador increased current and capital expenditure in an effort to accelerate the country's development. The performance of fiscal revenues —especially tax revenues— is presented below in the context of the methodology proposed in the document.[16]

[16] For a more detailed review of fiscal policy in Ecuador, see Carrillo (2017), Cueva, Mosquera and Ortiz (2018) and Almeida and others (2012).

Since the 1990s, oil and tax revenues have been the main source of funding (above the line) for public spending. In the 1990s, those two revenues combined represented more than 90% of the total: on average, their share was 43% and 50%, respectively. With the creation of the SRI in 1997, tax revenues strengthened and reached an average share of 59% by 2006. Following the reforms and reorganization of tax management that have taken place since 2007, the contribution of taxes has continued to increase, reaching an average of 62% of total revenues in the period 2007–2015 (see figure 1).

Figure 1
Central government revenue share, 1990–2015
(Percentages)

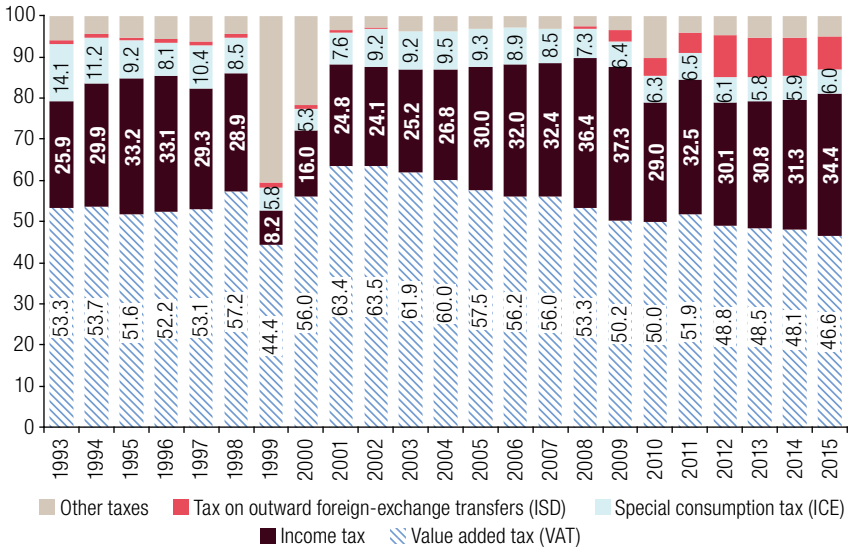


Source: Prepared by the authors, on the basis of data from the Central Bank of Ecuador.
Note: From 2010 onward, the data correspond to the General State Budget (PGE) and are not comparable with previous data, because data from the autonomous entities are included.

Article 300 of the Constitution of the Republic of Ecuador stipulates that the tax system must be governed by the principles of generality, progressiveness, efficiency, administrative simplicity, non-retroactivity, equity, transparency and revenue adequacy (Ecuador, 2008). In addition, the National Plan for Good Living mentions the need to increase State revenue, mainly tax revenues, by increasing the number of taxpayers and controls and penalties for evasion (SENPLADES, 2009). In this regard, the SRI has followed a strategy of downward pressure that includes measures such as facilitating tax return processes for taxpayers who are willing to comply, providing assistance in filing returns, detection as a deterrent for taxpayers who comply if pressured, and using the full force of the law against those who decide not to comply (Carvajal, Carrasco and Álvarez, 2012; Andino, Carrasco and Arteaga, 2012).

The most representative taxes in Ecuador have been VAT and income tax. From 1993 to 2015, these two taxes accounted for more than 80% of effective revenues, VAT being the most important of the two. Since the 2008 Constitution entered into force, however, income tax has been strengthened with a more progressive tax table, higher withholdings and advances, targeted incentives and benefits, and stricter tax controls, among other measures. As a result, income tax accounted for an average of 32% of effective revenues between 2009 and 2015 (see figure 2).

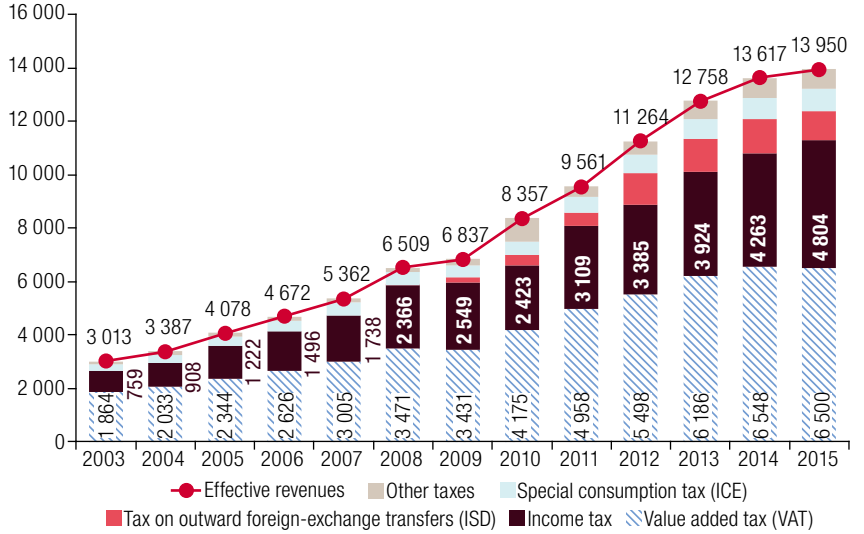
Figure 2
Share of taxes in effective revenues, 1993–2015
(Percentages)



Source: Prepared by the authors, on the basis of data from the Internal Revenue Service of Ecuador.
Note: In 1999 and 2000, income tax was replaced by the financial transactions tax (ICC). The collected amount of tax on outward foreign-exchange transfers for the years prior to 2008 is that levied at airports upon departure from the country.

In recent years, there has been a strong and sustained increase in revenue from these taxes (see figure 3). Some of this growth is likely the result of improved fiscal management by the SRI. However, there are other factors, such as economic activity or recent tax reforms, which may influence tax growth. These factors make it impossible to determine the extent to which increases in revenue are a result of tax administration action, or of reform processes or of the performance of the economy. This is where the proposed efficiency indicators will help measure the effect of tax management.

Figure 3
Tax revenues, 2003–2015
(Millions of nominal dollars)



Source: Prepared by the authors, on the basis of data from the Internal Revenue Service of Ecuador.

V. Efficiency of the tax administration

This section outlines the results of applying the described methodology to Ecuador. First, the estimate of the elasticity of the taxes is presented and the result is compared with those obtained in other studies that have estimated the same coefficients in the region. Secondly, the indices are shown on an annual basis for the dollarization period. The quarterly indices are set out in annex A3.

For Ecuador, the elasticity of VAT with respect to consumption is 1.9505, with a significance of 99%. As mentioned above, a structural break was detected in the second quarter of 1999, which shows lower elasticity: 0.4856 (1.9505 - 1.4649). In other words, VAT was less elastic in relation to consumption before the break. Income tax has an elasticity of 2.6669 with respect to GDP, with a significance of 99% (see table 1).

Table 1
Ecuador: estimation of the long-term elasticities of VAT and income tax using the dynamic ordinary least squares method (DOLS)

Variable	Coefficient	P-value	Variable	Coefficient	P-value
Constant	-18.5125***	0.0000	Constante	-30.9628***	0.0000
VAT-Consumption elasticity	1.9505***	0.0000	Income tax-GDP elasticity	2.6669***	0.0000
Break in the mean	22.6490**	0.0175			
Break in the slope	-1.4649**	0.0160			

Source: Prepared by the authors.
Note: *** p<0.01; ** p<0.05, * p<0.1.

Tax elasticities have been widely calculated in the economic literature. Latin America has been no exception. Table 2 shows the long-term elasticities of VAT and income tax in Latin American countries, as estimated by Ardanaz and others (2015). The results for Ecuador show elasticities of 2.0 and 2.3 for VAT and income tax, respectively, close to the estimates made in this paper, which confirms the country's position above the regional average, with taxes that show greater elasticity.

Through the estimation of elasticity, the tax series were adjusted for the business cycle using equation (2). This same procedure also adjusts taxpayers' risk aversion regarding tax evasion, since, if the cycle is above its trend (boom), agents evade less as more economic resources are generated, while taxpayers evade more in phases of recession because their income is reduced.

The VAT indicator allows three distinct periods to be identified (see figure 4). During the first period, 2000 to 2002, the SRI behaved passively regarding collection of VAT. In the second period, 2003 to 2006, there was a decrease in the indicator below the level for the base year. Andino and Parra (2007) show that VAT evasion rose from 30.1% to 31.8% between 2003 and 2005. This could be linked to President Lucio Gutiérrez being removed from office and the ensuing political and institutional crisis in the country.

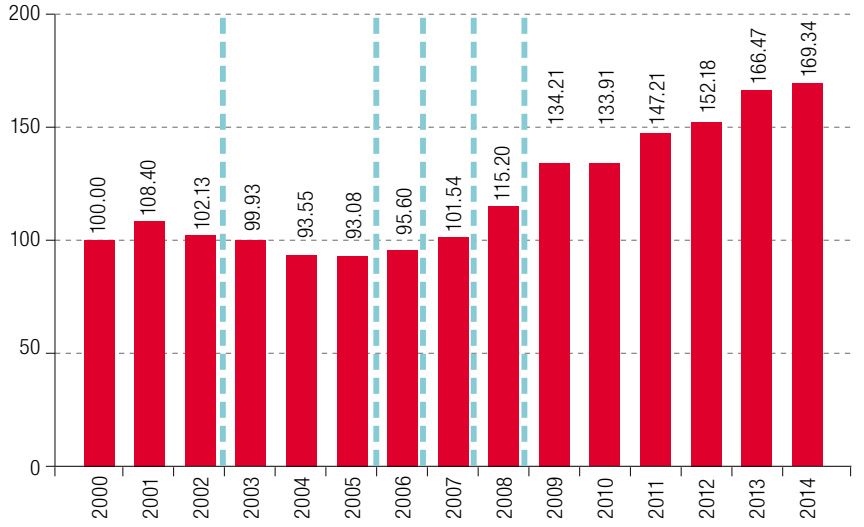
In the third period, which began in 2007, the SRI made several administrative and operational improvements (annexes and cross-checking of information, training and education (see Carvajal, Carrasco and Álvarez, 2012; Andino, Carrasco and Arteaga, 2012)) which made it possible to increase progressively the efficiency of VAT collection. In 2010, there was only a small drop in efficiency (see figure 4), probably in anticipation of the legal reforms to the Production, Commerce and Investment Code adopted at the end of that year, which established various exemptions and deductions for the production sector. It can be argued that the constant growth that has occurred since 2007 is the result of improvements in complementary information, such as the personal expenses schedule and the tax lottery, among others, which may have affected the tax culture among taxpayers.

Table 2
Latin America (20 countries): long-term elasticities of VAT and income tax

Country	Income tax	Indirect taxes
Argentina	3.0	1.1
Barbados	1.9	1.7
Bolivia (Plurinational State of)	3.0	1.5
Brazil	2.3	1.0
Chile	1.2	1.4
Colombia	1.3	1.8
Costa Rica	2.0	0.8
Dominican Republic	1.8	1.4
Ecuador	2.3	2.0
El Salvador	3.0	2.1
Guatemala	2.2	2.0
Guyana	1.6	1.8
Honduras	1.4	3.1
Mexico	1.3	1.8
Panama	1.3	0.7
Paraguay	0.5	2.1
Peru	2.0	1.8
Trinidad and Tobago	0.6	0.7
Uruguay	2.5	3.8
Venezuela (Bolivarian Republic of)	3.3	2.6
Latin America (average)	1.9	1.8

Source: Ardanaz, M. and others, "Structural fiscal balances in Latin America and the Caribbean: new dataset and estimations", *IDB Working Paper*, No. 579, Washington, D.C., Inter-American Development Bank (IDB), June 2015.
Note: The elasticity of income tax is a simple average of the elasticity of corporate income tax and personal income tax. Indirect taxes are the sum of VAT and excise duties.

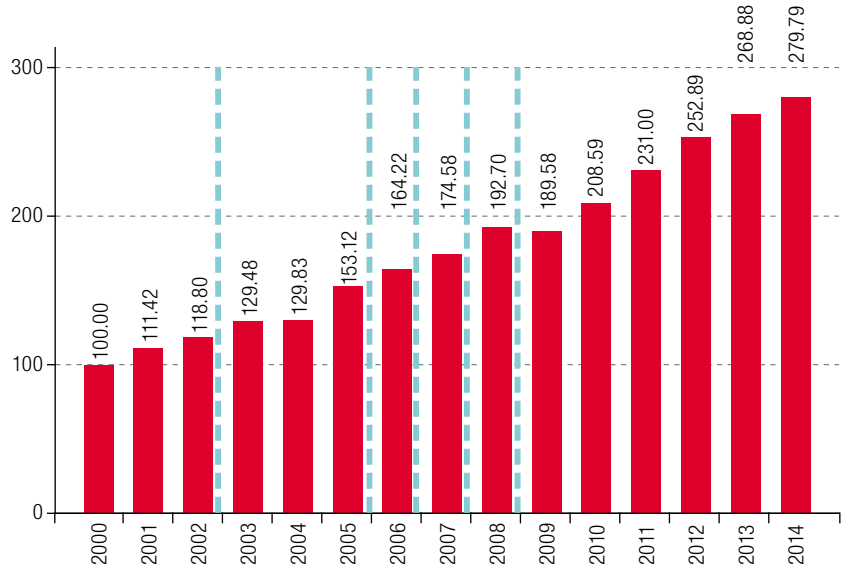
Figure 4
Annual average for the VAT efficiency indicator, 2000–2014
(Index, base year 2000 = 100)



Source: Prepared by the authors.
Note: The dotted lines represent the institutional reforms to the General Operating Regulations of the Internal Revenue Service of Ecuador applied in October 2002, June 2005, June 2006, November 2006, April 2007 and January 2008 (Carvajal, Carrasco and Álvarez, 2012).

The income tax collection efficiency index is presented in figure 5. This indicator shows moderate growth in the first five years of dollarization (29.8 points). In 2001, the indicator shows a significant improvement in management by SRI, mainly due to the reintroduction and control of income tax, and the elimination of the financial transactions tax (ICC). When estimating the index, controls were included for the reforms that replaced income tax with the financial transactions tax, but the reintroduction of income tax is likely to have had an indirect effect on tax control that would not be the result of the legal changes.

Figure 5
Annual average for the income tax efficiency indicator, 2000–2014
(Index, base year 2000 = 100)



Source: Prepared by the authors.
Note: The dotted lines represent the institutional reforms to the General Operating Regulations of the Internal Revenue Service of Ecuador applied in October 2002, June 2005, June 2006, November 2006, April 2007 and January 2008 (Carvajal, Carrasco and Álvarez, 2012).

The index shows a marked acceleration in growth (59.8 points) between 2004 and 2009, possibly owing to innovation in control and service processes. The tax administration incorporated new technology to strengthen tax control, such as online services and electronic invoicing (Carvajal, Carrasco and Álvarez, 2012; Andino, Carrasco and Arteaga, 2012). In addition, the new management staff of SRI maintained the same policy line on direct taxation, as established by the Constitution of Ecuador (Carrasco, 2012).

In 2009 there is a decrease in income tax collection efficiency, probably because the tax administration anticipated possible tax evasion by taxpayers, as their income would decrease as a result of the global financial crisis. From that point onward, the collection efficiency of the SRI rebounded and the proposed index increases from 208.6 points in 2010 to 279.8 points in 2014.

In short, the collection efficiency indices used in this paper show three different patterns of behaviour from the tax administration. The first is passive behaviour: in the case of VAT, such behaviour was observed between 2000 and 2006, while in the case of income tax it was observed between 2000 and 2004. The second is a pattern of increasing efficiency, which had an effect on revenue following implementation of administrative reforms within the SRI: for VAT this period begins in 2007 and for income tax in 2005. The last pattern of behaviour is of occasional falls in efficiency of the tax administration, which may be rooted in phenomena that are exogenous to the administration itself, such as international shocks or the indirect effects of legal reforms, which reduce the tax base and, by extension, tax revenue.

In addition, the reforms that sought to strengthen the institutional framework of the SRI (except for that of 2002) clearly succeeded in improving its tax management. The income tax and VAT indices patently show this effect, with increases of 48% and 43%, respectively, between 2004 and 2008.

VI. Conclusions

In taxation, greater efficiency is sought by closing tax gaps through tax administration actions to improve tax collection. Increased tax efficiency is crucial, since it allows sufficient resources to be generated in a timely manner, to sustain public expenditure in the long term.

Although the tax administration has its own information to measure certain gaps, external information is required to continuously evaluate its management and effectiveness. This paper proposes the construction of a collection efficiency indicator from easily accessible macroeconomic information. Based on the structural balance of public finances methodology, this indicator is estimated for Ecuador's VAT and income tax between 1993 and 2014. This indicator is intended as an instrument for monitoring the collection and control activity of the SRI for the comprehensive closing of tax gaps. The main idea behind the construction of the index is the filtering out of the impact of tax reforms, business cycle fluctuations and risk aversion that affect the collection of the main taxes in the country.

The results show that the SRI management has improved the efficiency of VAT and income tax collection over the last decade. In addition, there has been a recovery in the efficiency of VAT collection since 2007, while the efficiency of income tax collection has shown sustained growth over almost all of the period studied, with significant variations between 2005 and 2010. Lastly, the behaviour of the tax administration can be said to be somewhat adaptive to possible decreases in revenue for different reasons (external shocks or legal reforms that extend deductions or exemptions).

Bibliography

Allingham, M. and A. Sandmo (1972), "Income tax evasion: a theoretical analysis", *Journal of Public Economics*, vol. 1, No. 3–4, November.

Alm, J. and D. Duncan (2014), "Estimating tax agency efficiency", *Public Budgeting & Finance*, vol. 34, No. 3.

Almeida, M. and others (2012), "Ingresos y gasto público en democracia: de la rigidez fiscal al pago de la deuda social", *Una nueva política fiscal para el buen vivir: la equidad como soporte del pacto fiscal*, Internal Revenue Service, Quito, Ediciones Abya-Yala.

Andino, M. and J. Parra (2007), "Estimación de la brecha de recaudación del IVA e impuesto a la renta de las sociedades por industria", *Revista Fiscalidad*, No. 1, Quito, Internal Revenue Service.

Andino, M., C. Carrasco and L. Arteaga (2012), "Servicio de Rentas Internas: repensando el nuevo modelo organizacional y de gestión", *Una nueva política fiscal para el buen vivir: la equidad como soporte del pacto fiscal*, Internal Revenue Service, Quito, Ediciones Abya-Yala.

Andreoni, J., B. Erard and J. Feinstein (1998), "Tax compliance", *Journal of Economic Literature*, vol. 36, No. 2, June.

Ardanaz, M. and others (2015), "Structural fiscal balances in Latin America and the Caribbean: new dataset and estimations", *IDB Working Paper*, No. 579, Washington, D.C., Inter-American Development Bank (IDB), June.

Arias, D. and others (2008), "Historia del sistema tributario ecuatoriano 1950–1999", *Revista Fiscalidad*, No. 2, Quito, Internal Revenue Service.

Baum, C. (2005), "Stata: the language of choice for time series analysis?", *The Stata Journal*, vol. 5, No. 1.

Carrasco, C. (2012), "Introducción", *Una nueva política fiscal para el buen vivir: la equidad como soporte del pacto fiscal*, Internal Revenue Service, Quito, Ediciones Abya-Yala.

Carrillo, P. (2017), "El efecto de la política fiscal en expansión y recesión para Ecuador: un modelo MSVAR", *Cuadernos de Economía*, vol. 36, No. 71, Bogotá, National University of Colombia.
Carrillo, P., D. Pomeranz and M. Singhal (2017), "Dodging the taxman: firm misreporting and limits to tax enforcement", *American Economic Journal: Applied Economics*, vol. 9, No. 2, April.
Carvajal, D., C. Carrasco and J. Álvarez (2012), "Historia de la tributación en Ecuador: cambios sociales y organizacionales", *Una nueva política fiscal para el buen vivir: la equidad como soporte del pacto fiscal*, Internal Revenue Service, Quito, Ediciones Abya-Yala.
Clemente, J., A. Montañés and M. Reyes (1998), "Testing for a unit root in variables with a double change in the mean", *Economics Letters*, vol. 59, No. 2, May.
Cowell, F. (2004), "Carrots and sticks in enforcement", *The Crisis in Tax Administration*, H. Aaron and J. Slemrod (eds.), Washington, D.C., Brookings Institution Press.
Cueva, S., R. Mosquera and M. Ortiz (2018), "Ciclicalidad de la política fiscal ecuatoriana desde la dolarización", *Reformas y desarrollo en el Ecuador contemporáneo*, J. Díaz-Cassou and M. Ruiz Arranz (eds.), Washington, D.C., Inter-American Development Bank (IDB).
Díaz, J. (2018), "La historia económica contemporánea de Ecuador, 1972–2015", *Reformas y desarrollo en el Ecuador contemporáneo*, J. Díaz-Cassou and M. Ruiz Arranz (eds.), Washington, D.C., Inter-American Development Bank (IDB).
Ebrill, L. and others (eds.) (2001), *The Modern VAT*, Washington, D.C., International Monetary Fund (IMF).
Ecuador (2008), *Constitution of the Republic of Ecuador* [online] http://pdba.georgetown.edu/Constitutions/Ecuador/english08.html.
Edelberg, W., M. Eichenbaum and J. Fisher (1999), "Understanding the effects of a shock to government purchases", *Review of Economic Dynamics*, vol. 2, No. 1.
Engle, R. and C. Granger (1987), "Co-integration and error correction: representation, estimation, and testing", *Econometrica*, vol. 55, No. 2, March.
Fedelino, A., A. Ivanova and M. Horton (2009), "Computing cyclically adjusted balances and automatic stabilizers", *Technical Notes and Manuals*, vol. 9, No. 5, Washington, D.C., International Monetary Fund (IMF), November.
Greene, W. (2007), *Econometric Analysis*, 6th edition, Boston, Prentice Hall.
Hallsworth, M. (2014), "The use of field experiments to increase tax compliance", *Oxford Review of Economic Policy*, vol. 30, No. 4.
Hansen, B. (1992), "Testing for parameter instability in linear models", *Journal of Policy Modeling*, vol. 14, No. 4, August.
Jorratt, M. (1996), "Evaluation of the Collection Capability of the Tax System and of Tax Evasion", paper presented at the Technical Conference of the Inter-American Center of Tax Administrations (CIAT), Viterbo, October.
Keen, M. (2013), "The anatomy of the VAT", *National Tax Journal*, vol. 66, No. 2, June.
Krämer, W., W. Ploberger and R. Alt (1988), "Testing for structural change in dynamic models", *Econometrica*, vol. 56, No. 6.
Leeper, E., T. Walker and S. Yang (2008), "Fiscal foresight: analytics and econometrics", *NBER Working Paper*, No. 14028, Cambridge, National Bureau of Economic Research (NBER), May.
Martín, F. (2009), "La economía de los ingresos tributarios: un manual de estimaciones tributarias", *Manual Series*, No. 62 (LC/L.3047-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), August.
Myles, G. (2000), "Taxation and economic growth", *Fiscal Studies*, vol. 21, No. 1, March.
OECD (Organization for Economic Cooperation and Development) (2008), *Consumption Tax Trends 2008: VAT/GST and Excise Rates, Trends and Administration Issues*, Paris.
Ortega, D. and P. Sanguinetti (2013), "Deterrence and reciprocity effects on tax compliance: experimental evidence from Venezuela", *CAF Working Papers*, No. 2013/08, Caracas, Development Bank of Latin America (CAF), December.
Paz y Miño Cepeda, J. (2015), *Historia de los impuestos en Ecuador: visión sobre el régimen impositivo en la historia económica nacional*, Quito, Internal Revenue Service.
Pecho, M., J. Sánchez and F. Peláez (2012), "Estimating Tax Noncompliance in Latin America: 2000-2010", *Working Papers*, No. 3, Panama, Inter-American Center of Tax Administrations (CIAT), September.
Perotti, R. (2007), "In search of the transmission mechanism of fiscal policy", *NBER Working Paper*, No. 13143, Cambridge, National Bureau of Economic Research (NBER), June.

Pomeranz, D. (2015), "No taxation without information: deterrence and self-enforcement in the value added tax", *American Economic Review*, vol. 105, No. 8, August.
Ricciardi, M. (2007), "Análisis de eficiencia en el IVA y una propuesta para eliminar los impuestos distorsivos", document prepared for second Congreso Metropolitano de Ciencias Económicas, Buenos Aires, November.
Romer, C. and D. Romer (2010), "The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks", *American Economic Review*, vol. 100, No. 3, June.
Sancak, C., R. Velloso and J. Xing (2010), "Tax revenue response to the business cycle", *IMF Working Paper*, No. WP/10/71, Washington, D.C., International Monetary Fund (IMF), March.
Sandmo, A. (2005), "The theory of tax evasion: a retrospective view", *National Tax Journal*, vol. 58, No. 4.
SENPLADES (National Secretary of Planning and Development) (2009), *Plan Nacional para el Buen Vivir: 2009–2013: construyendo un Estado plurinacional e intercultural*, Quito.
Sevilla, J. (2004), *Política y técnica tributarias*, Manuales de la Escuela de la Hacienda Pública, Madrid, Institute of Fiscal Studies.
Slemrod, J. and S. Yitzhaki (2002), "Tax avoidance, evasion, and administration", *Handbook of Public Economics*, vol. 3, A. Auerbach, M. Feldstein and E. Saez (eds.), Elsevier.
Stock, J. and M. Watson (1993), "A simple estimator of cointegrating vectors in higher order integrated systems", *Econometrica*, vol. 61, No. 4, July.
Tax Administration Department (2006), "Eficiencia de la Administración Tributaria en la recaudación: ¿Contribuye la gestión de la DGI a incrementar la recaudación impositiva?", *Documento de trabajo*, No. 4, July.
Torgler, B. (2007), *Tax Compliance and Tax Morale: a Theoretical and Empirical Analysis*, Cheltenham, Edward Elgar Publishing.
Walsh, K. (2012), "Understanding taxpayer behaviour – new opportunities for tax administration", *The Economic and Social Review*, vol. 43, No. 3.

Annex A1

Table A1.1
Clemente-Montañés-Reyes unit root tests for series in levels, series in differences and model disturbances

Series in levels
H0: The series have a unit root

Variable	T-statistic	Critical values		
		1%	5%	10%
VAT	-3.52	-5.96	-5.49	-5.24
Consumption	-3.17	-5.96	-5.49	-5.24
Income tax	-5.73	-5.96	-5.49	-5.24
GDP	-2.39	-5.96	-5.49	-5.24

Series in differences
H0: The series have a unit root

Variable	T-statistic	Critical values		
		1%	5%	10%
VAT	-6.40	-5.96	-5.49	-5.24
Consumption	-8.38	-5.96	-5.49	-5.24
Income tax	-7.56	-5.96	-5.49	-5.24
GDP	-7.56	-5.96	-5.49	-5.24

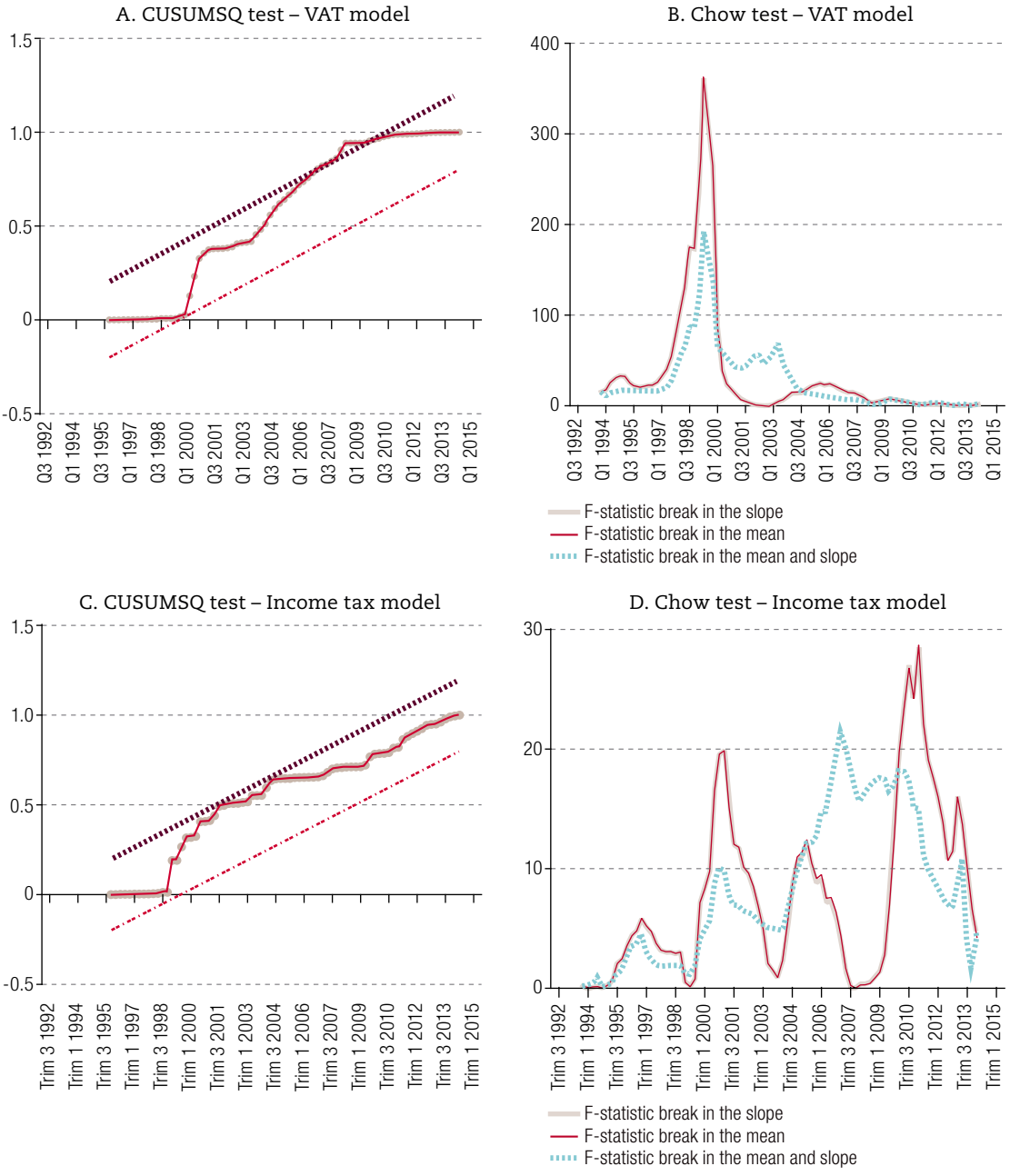
Disturbances
H0: The series have a unit root

Variable	T-statistic	Critical values		
		1%	5%	10%
VAT error	-14.56	-5.96	-5.49	-5.24
Income tax error	-10.42	-5.96	-5.49	-5.24

Source: Prepared by the authors.
Note: If the t-statistic is less than a critical value, then the null hypothesis is accepted with the margin of error corresponding to that critical value.

Annex A2

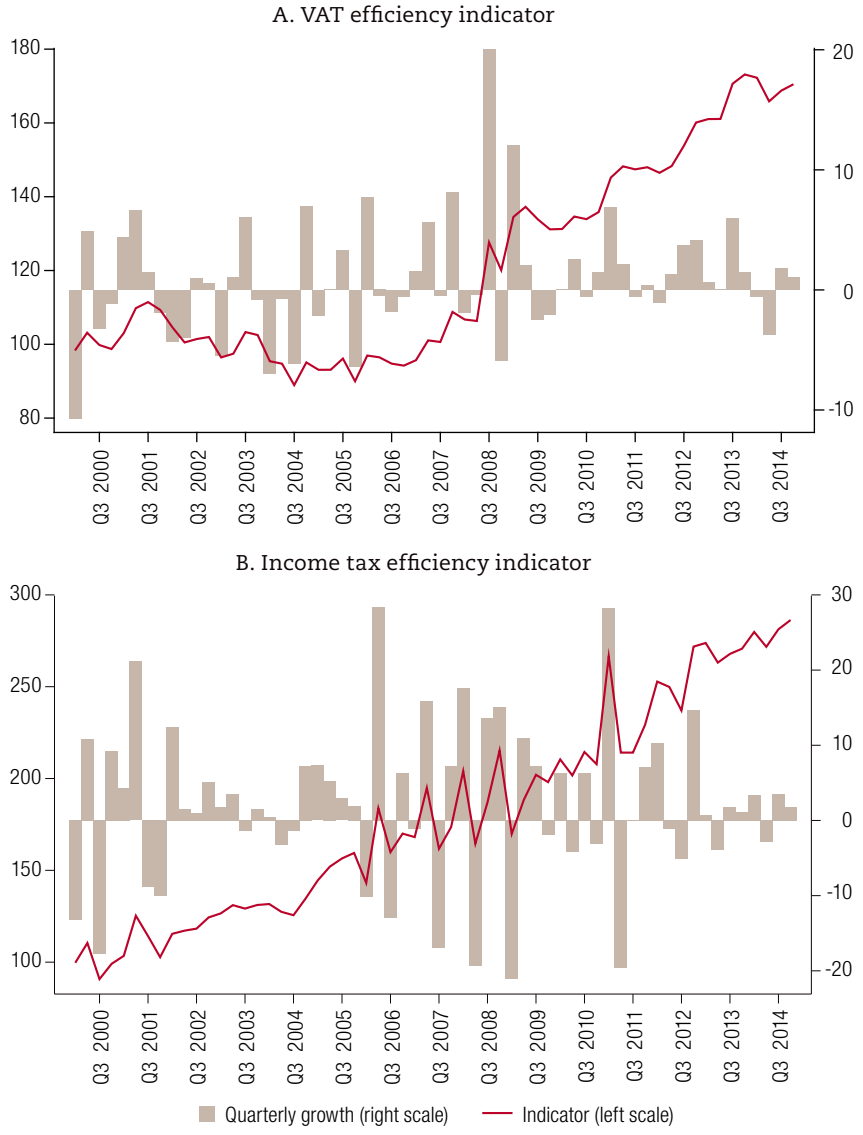
Figure A2.1
Cumulative sum of squares test (CUSUMSQ) and Chow test



Source: Prepared by the authors.

Annex A3

Figure A3.1
Quarterly VAT and income tax efficiency indices and quarterly growth rates
(Index, base year 2000 = 100 and percentages)



Source: Prepared by the authors.

Growth and heterogeneity of human capital: effects of the expansion of higher education on the income increase in Brazilian municipalities

Leonardo Andrade Rocha, Napiê Galvê Araújo Silva, Carlos Alano Soares de Almeida, Denison Murilo de Oliveira and Kaio César Fernandes

Abstract

This study analyses the effects of the expansion of the highly skilled labour force (higher education) on the per capita income increase in Brazilian municipalities. The results show that a larger highly educated labour force translates into stronger growth in the most developed municipalities with fewer opportunity costs, measured by wage differences. The reduction of regional inequalities fostered by the expansion of higher education over the past 15 years will become sustainable if the increase in the skill supply is accompanied by a rise in demand, so the opportunity costs between factors are reduced and the skill premium grows.

Keywords

Human resources, labour force, skilled workers, municipal government, income, regional inequalities, economic growth, Brazil

JEL classification

E24, O43, Q55, R11

Authors

Leonardo Andrade Rocha holds a doctorate in economic development and is a lecturer at the Centre for Applied Social and Human Sciences (CCSAH) of Universidad Federal Rural do Semi-Árido (UFERSA), Brazil. Email: leonardo.rocha@ufersa.edu.br.

Napiê Galvê Araújo Silva holds a doctorate in social sciences and is a lecturer at the Centre for Applied Social and Human Sciences (CCSAH) at Universidad Federal Rural do Semi-Árido (UFERSA), Brazil. Email: pie@ufersa.edu.br.

Carlos Alano Soares de Almeida holds a doctorate in administration and is a lecturer at the Centre for Applied Social and Human Sciences (CCSAH) at Universidad Federal Rural do Semi-Árido (UFERSA), Brazil. Email: alano@ufersa.edu.br.

Denison Murilo de Oliveira holds a doctorate in administration and is a lecturer at the Centre for Applied Social and Human Sciences (CCSAH) at Universidad Federal Rural do Semi-Árido (UFERSA), Brazil. Email: denison@ufersa.edu.br.

Kaio César Fernandes holds a doctorate in social sciences and is a lecturer at the Centre for Applied Social and Human Sciences (CCSAH) at Universidad Federal Rural do Semi-Árido (UFERSA), Brazil. Email: kaio@ufersa.edu.br.

I. Introduction

The importance of human capital for development and the reduction of economic inequalities has been highlighted in numerous studies (Barro, 2001; Barro and Sala-i-Martin, 1992; Becker and Woessmann, 2009; Becker, Hornung and Woessmann, 2011; Benhabib and Spiegel, 1994). It derives from the need for the knowledge acquired by individuals as the economy develops. Knowledge is important both to absorb existing production techniques and to create a new generation of technologies (Benhabib and Spiegel, 2005). Human capital accumulation is historical and has been associated with significant economic divergence in the world (Acemoglu, Gallego and Robinson, 2014).

While these studies have described the importance of human capital in development, some recent research has outlined the heterogeneous nature of this capital (Vandenbussche, Aghion and Meghir, 2006; Ang, Madsen and Islam, 2011; Ott and Soretz, 2011; Basu and Mehra, 2014; Madsen, 2014). Different types of human capital complement the prevailing technological pattern of an economy (Caselli and Coleman, 2006), and are allocated to different activities so economic divergences may be related to differences in human capital composition across economies (Basu and Mehra, 2014).

In Brazil, higher education has expanded significantly over the past 15 years, giving rise to a skilled labour force to meet demand requirements amid the country's ongoing economic transformations. These changes were driven internally, through policies to reduce regional inequalities, and externally, owing to increasing international competition (Mancebo, Vale and Martins, 2015).

According to data from the Higher Education Census (INEP, 2016), registration in higher education institutions in Brazil increased from 2,694,245 in 2000 to 8,027,297 in 2015.[1] This represents growth of approximately 198% in that period, which reflects an important strategy of the national education policy.

However, that increase did not always seek to match the growth in the supply of skilled labour with demand. This point is reflected in recent research, especially Cury (2014), Mancebo, Vale and Martins (2015), Lima (2012) and Costa, Costa and Barbosa (2013). According to Cury (2014), there have been major changes in Brazil's higher education system in the last 20 years, particularly its expansion through "partnership" between public and private institutions. However, this expansion has been driven mainly by major mechanisms of financialization and creation of oligopolies within the sector, which regulated part of the process and compromised its quality considerably. The private sector played a greater role in the expansion than the public sector (Mancebo, Vale and Martins, 2015), driving significant transfers of Brazil's public resources over the past few years (Lima, 2012; Costa, Costa and Barbosa, 2013). This process also brought to light some social aspects regarding access to new opportunities as a result of higher education expansion, which ensured greater equity in terms of opportunities and more equality in access to the labour market, serving as a key element of social integration (Felicetti, Cabrera and Costa-Morosini, 2014, p. 36).

This is relevant to the macroeconomic scenario, as the policy aims to obtain the maximum well-being of society through the allocation of limited resources. From a budgetary perspective, economic policy planning in every country involves decisions targeting the efficient allocation of resources in order to bring social returns closer into line with private returns.

As in the works of Vandenbussche, Aghion and Meghir (2006), Aghion (2008) and Aghion and others (2009), this study includes a Schumpeterian growth model in which productivity growth is influenced by two important types of activity: (i) imitation, based on the activity of low-skilled workers implementing existing technologies transferred from the technological frontier; and (ii) innovation, which involves the recruitment of highly skilled labour assigned to research departments. The equilibrium conditions of the innovative business show that the weight of demand for skilled and unskilled labour differs depending on the proximity to the technological frontier, which determines the skill premium and the rate of technological progress.

[1] See [online] http://portal.inep.gov.br/web/guest/sinopses-estatisticas-da-educacao-superior.

Unlike other works, this study uses wage differences to measure the effect of the distance from the frontier, as this variable directly affects factor allocation incentives and is conditioned by fluctuations in proximity to the frontier. In labour market intervention policies, income monitoring becomes more intuitive and therefore more consistent in measuring the regional reality of each municipality.

Using data from the Atlas of Human Development in Brazil (UNDP/IPEA/FJP, 2013) based on the smallest political and administrative dimension, we estimated a linear regression model linking the skilled labour and the per capita GDP of municipalities. On the basis of the controlled model and the generalized method of moments, estimates indicate that the increase in workers with higher education translates into stronger growth in the most developed municipalities with fewer opportunity costs, measured by wage differences.

The debate about the composition of human capital and its effects on economic growth is still recent, so only a few internal and regional studies have been carried out. These include the contributions from Zhang and Zhuang (2011), Gennaioli and others (2013) and Korpi and Clark (2015).

II. Economic environment

Based on Aghion and Howitt (1998; 2009), the model consists of an economy with a finite number of sectors, each composed of intermediary business owners and a population of workers who offer their labour in a competitive market. The workers are endowed with heterogeneous human capital resources so that, at the aggregate level, the economy is divided into S units of highly skilled labour and U units of low-skilled labour, offered exogenously and at a constant rate over time. With a competitive market and elastically defined labour supply, we have $(s = \widetilde{S},\ u = \widetilde{U}) \in \Re_+^2$, where $\widetilde{S}$ and $\widetilde{U}$ correspond, respectively, to the equilibrium levels of skilled and unskilled labour in the labour market.

The companies adopt strategies of imitation (implementing the innovations of the most advanced companies or sectors) and of innovation. Each business owner decides to use a balanced combination of the two strategies, with a view to obtaining the benefits of the temporary monopoly of the sector. The decision to adopt more innovative or imitative practices depends on the potential distance from sector leaders (companies with benchmark technology).

Time is discrete (not continuous) and the final economic output is obtained using a continuous flow of intermediate inputs in accordance with the Cobb-Douglas production function:

$$Y_t = \int_0^1 A_t(i)^{1-\alpha} x_t(i)^{\alpha} di \therefore \alpha \in (0,1) \quad (1)$$

According to equation (1), $x_t(i)$ corresponds to the flow of intermediate inputs of sector i in time t. The productivity of the sector is given by the technology parameter $A_t(i)$, which is defined by the lagged level $A_{t-1}(i)$ plus a "strategic sector component". The definition of this component will be addressed in the next section. The intermediate input sector is monopolized by the leading company, which benefits from the monopoly for a short period of time.

Assuming that the final output sector is competitive, each producer of intermediate inputs faces an inverse demand curve that defines the price of the intermediate input:

$$p_t(i) = \frac{\partial Y_t}{\partial x_t(i)} = \alpha A_t(i)^{1-\alpha} x_t(i)^{\alpha-1} \quad (2)$$

In each intermediate sector, only one intermediate producer can produce output i with the productivity of sector $A_t(i)$ using the final output as capital. This process will be carried out by means of a one-for-one technology, following the specificity $A_t(i): \Im \rightarrow \Omega \ \therefore Y_t \in \Im;\ y_t(i) \in \Omega$.

The monopolist of sector i chooses $x_t(i)$, which solves the maximization problem:

$$\max_{x_t(i)} \{p_t(i)x_t(i) - x_t(i)\} \tag{3}$$

Solving the maximization problem (3) generates an equilibrium demand function:

$$\widehat{x}_t(i) = \alpha^{\frac{2}{1-\alpha}} A_t(i) \tag{4}$$

By replacing (4) in (3), we obtain the equilibrium benefits of the sector monopolist:

$$\widehat{\pi}_t(i) = (p_t(i)-1)\widehat{x}_t(i) = \pi A_t(i); \pi \equiv \left(\frac{1-\alpha}{\alpha}\right)\alpha^{\frac{2}{1-\alpha}} \tag{5}$$

The sources of productivity growth and their link to the technological frontier are defined below.

1. Sources of productivity growth

The dynamics of technology in sector i can be captured by a positive and growing function, $\Phi(\cdot)$, in the following arguments:

$$A_t(i) = A_{t-1}(i) + \underbrace{\Phi(\overline{A}_{t-1}(i) - A_{t-1}(i), A_{t-1}(i), u_t(i), s_t(i))}_{STRATEGIC\ COMPONENT} \tag{6}$$

where $\overline{A}_{t-1}(i), A_{t-1}(i), s_t(i), u_t(i)$ correspond, respectively, to the technological frontier of sector i at the end of period $t-1$, the productivity of sector i at the end of period $t-1$, and the units of skilled and unskilled labour of sector i at the end of period t. The function $\Phi(\cdot)$ is linear in the imitation and innovation components and non-linear in human resources. Specifically, we then have:

$$A_t(i) = A_{t-1}(i) + [s_t(i)^{\Phi}(\gamma - 1)A_{t-1}(i) + u_t(i)^{\beta}{}_{\eta}(\overline{A}_t(i) - A_{t-1}(i))]^{\sigma} \tag{7}$$

where the parameters γ, η correspond to the innovative and imitative skills adopted by companies in each sector i, satisfying the following inequalities: $\gamma > 1$ (one step forward) and $\eta \leq 1$ (one step back). The parameter σ reflects the elasticity of the strategic component, which for simplicity is assumed to be $\sigma = 1$. The technological frontier grows at a constant rate $\overline{g}$, $\overline{A}_t(i) = (1 + \overline{g})\overline{A}_{t-1}(i)$, and the technological stage of each sector is limited to the level of the frontier; thus, $\overline{A}_t(i) \leq \overline{A}_t(i)$. The parameters Φ, β represent the coefficients of elasticity of each production factor.

2. The monopolist's decision and equilibrium conditions

The monopolist business owner decides to invest in hiring skilled and unskilled labour based on their position and the best rate of return on investment. If they are relatively far from the technological frontier, allocating resources to the recruitment of unskilled labour may generate a bigger improvement than hiring skilled labour, i.e., $\Delta u_t(i)^{\beta}\eta(\overline{A}_t(i) - A_{t-1}(i) > \Delta s_t(i)^{\Phi}(\gamma - 1)A_{t-1}(i)$.

The decision of the monopolist depends on the optimization of the expected benefits and the cost of the investment, in this case represented by the total cost of hiring labour. Thus, the utility function of the monopolist can be expressed as follows:

$$U_t(i) = E(c) - W_t \tag{8}$$

where, $c = \begin{cases} \widehat{\pi}_t(i) = \pi A_t(i), \text{ with probability } \lambda \\ 0, \text{ with probability } (1 - \lambda) \end{cases}$, and w_t is the total cost of hiring skilled and unskilled

labour. Workers' wages are expressed as $w^u A_{t-1}(i)$ (unskilled) and $w^s A_{t-1}(i)$ (skilled).[2] By definition, $w^i \therefore i \in (s, u)$ corresponds to the wage rate. As a result:

$$W_t = w^u A_{t-1}(i) u_t(i) + w^s A_{t-1}(i) s_t(i) = (w^u u_t(i) + w^s s_t(i)) A_{t-1}(i)$$

The problem of maximizing the business owner's profit is defined as:

$$\max_{u_t(i), s_t(i)} U, \max_{u_t(i), s_t(i)} \{\lambda \pi A_t - (w^u u_t(i) + w^s s_t(i)) A_{t-1}(i)\}$$

The first-order condition with respect to the arguments $u_t(i)$, $s_t(i)$ generates the following equilibrium equations:

$$\frac{\partial U}{\partial s_t(i)} = \lambda \pi \Phi s_t(i)^{\Phi-1} (\gamma - 1) A_{t-1}(i) - w^s A_{t-1}(i) \equiv 0 \qquad \text{U.1}$$

$$\frac{\partial U}{\partial u_t(i)} = \lambda \pi \beta u_t(i)^{\beta-1} \eta (\bar{A}_{t-1}(i) - A_{t-1}(i)) - w^u A_{t-1}(i) \equiv 0 \qquad \text{U.2}$$

The demand functions of the monopolist in relation to skilled and unskilled labour are obtained by reorganizing equations U.1 and U.2. These functions are strictly negative with respect to the wage rate and positive with respect to the other function arguments. The demand functions are detailed below:

$$\widehat{s_t}(i) = \left(\frac{\lambda \pi \Phi (\gamma - 1)}{w^s} \right)^{\frac{1}{1-\Phi}} \qquad \text{E.1}$$

$$\widehat{u_t}(i) = \left(\frac{\lambda \pi \beta \eta (d_{t-1}(i) - 1)}{w^u} \right)^{\frac{1}{1-\beta}} \therefore d_{t-1} = \frac{\bar{A}_{t-1}(i)}{A_{t-1}(i)} = (a_{t-1})^{-1} \qquad \text{E.2}$$

where, "a_{t-1}" represents the indicator of proximity to the frontier and its opposite, the distance from the frontier.

With a competitive labour market in equilibrium, the demand for labour is matched by supply, which is given exogenously as $\widehat{u_t}(i) = \tilde{U}$; $\widehat{s_t}(i) = \tilde{S}$. The interpretation of equation E.1 shows that the demand for skilled labour depends positively on the probability of success λ of the innovating company, the profit equilibrium parameter π and the incremental size of the innovation strategy $(\gamma - 1)$.

The second equation E.2 reveals that the business owner's demand for unskilled labour is a positive function of the technological distance $d_{t-1}(i)$ of sector i. The low level of training reveals short-term interest focused on imitation strategies. Companies' significant lag leads business owners to assign a proportion of unskilled workers to less innovation-intensive activities. As the sector approaches the frontier, the monopolistic business owner will demand more and more labour focused on research and development (R&D) activities.

There are also important considerations about demand functions: it is not isolated growth that conditions the business owner's factor demand, but rather growth accompanied by the narrowing of the technological gap between economies. As the economy grows and closes the gap, structural changes "condition" business demand, which in turn has an impact on growth and gives rise to new demand.[3]

[2] Wages are proportional to productivity because technological advances increase the returns on the labour involved in activities. In this sense also, $w^s >> w^u$, showing that the skill premium is higher for the most skilled labour. See Vandenbussche, Aghion and Meghir (2006) and Aghion and others (2009) for more details.

[3] According to Dosi, Fagiolo and Roventini (2010), growth as well as demand factors lead to technological changes in the long run. Is the long-term growth just driven by changes in the technological "fundamentals"? Or, can variations in aggregate demand influence future dynamics? And, ultimately, can one identify multiple growth paths whose selection depends on demand and institutional conditions[...]? (Dosi, Fagiolo and Roventini, 2010, p. 1748).

3. Skill premium

According to Acemoglu (1998), the skill premium represents the wage differentials between skilled and unskilled labour that generate opportunity costs among production factors. Thus, a low premium implies high opportunity costs in skilled labour, which can be explained by low pay linked to insufficient demand, resulting from the low level of development prevailing in the economy. As in business theory, the business owner seeks a factor level where marginal cost equals marginal value. The definition of marginal value is associated with the concept of marginal factor productivity, which is proportional to a company's level of technology. Higher productivity levels allow for an increase in the production factor output, increasing its skill premium.

In this study, the skill premium function can be expressed by the relationship between equilibrium spending for each production factor:

$$w_t(i) \equiv \frac{w^s A_{t-1}(i)\hat{s}_t(i)}{w^u A_{t-1}(i)\hat{u}_t(i)} = (\lambda\pi)^{\frac{\varphi\cdot\beta}{(1-\varphi)(1-\beta)}} \cdot \left[\frac{(\varphi(\Upsilon-1))^{\frac{1}{1-\varphi}}}{(\beta\eta(d_{t-1}(i)-1))^{\frac{1}{1-\beta}}}\right] \cdot \frac{(w^u)^{\frac{1}{1-\beta}}}{(w^s)^{\frac{1}{1-\varphi}}} \qquad \text{W.1}$$

According to equation W.1, the skill premium is inversely determined by the distance from the frontier. A low level of productivity in the sector means weaker demand for skilled labour, so the output of this factor is reduced and the skill premium decreases. An increase in innovation activities γ raises the skill premium, in the same way that an increase in imitation strategies η requires a less skilled factor and reduces the skill premium.

In this case, the larger wage differences imply higher costs for the most skilled factor, reducing its contribution to productivity growth. On the contrary, productivity patterns close to the frontier imply a higher output of the factor most responsible for the company's proximity, increasing the skill premium. Therefore, fluctuations in proximity to the frontier lead to fluctuations in the skill premium.

4. Growth and production factor demand

Based on the demand functions E.1 and E.2, the rate of technological progress can be reformulated as follows:

$$A_t(i) = A_{t-1}(i) + s_t(i)^{\phi}(\gamma - 1)A_{t-1}(i) + u_t(i)^{\beta}\eta(\bar{A}_t(i) - A_{t-1}(i))\ \sigma=1$$

$$g_t(i) = \frac{A_t(i)-A_{t-1}(i)}{A_{t-1}(i)} = \hat{s}_t(i)^{\Phi}(\gamma-1) + \hat{u}_t(i)^{\beta}\eta(d_{t-1}(i)-1) \qquad \text{G.1}$$

The rate of technical progress is a function of the demand curves, which establish the equilibrium conditions of the parameters of imitation, innovation and distance from the frontier. By replacing E.1 and E.2 in G.1, we obtain:

$$g_t(i) = (\gamma - 1)^{\frac{1}{1-\Phi}}\left(\frac{\lambda\pi\Phi}{w^s}\right)^{\frac{\Phi}{1-\Phi}} + \eta^{\frac{1}{1-\beta}}\left(\frac{\lambda\pi\beta}{w^u}\right)^{\frac{\beta}{1-\beta}}(d_{t-1}(i)-1)^{\frac{1}{1-\beta}} \qquad \text{G.2}$$

Equation G.2 presents an important conclusion of the study:

- **Proposition 1**: The sectors furthest from the technological frontier reflect a different demand for resources than the most advanced sectors. In the economies furthest from the frontier there is a deficit in demand for skilled labour that reduces the skill premium and its contribution to productivity growth. In other words, $d_{t-1}(i) \geq 1 \Rightarrow \hat{u}_t(i) \geq 0$.

Proposition 1 shows that distance from the frontier directly affects productivity growth, which is determined by the demand for each production factor. This conclusion can be presented through the partial second-order derivative with the growth function.

- **Test**: by rewriting equation G.2, we have:

$$\frac{\partial^2 g_t(i)}{\partial d_{t-1}(i)\partial \eta} = \left(\frac{\beta}{1-\beta}\right)^2 \left(\frac{\lambda \pi \beta \eta (d_{t-1}(i)-1}{w^u}\right)^{\frac{\beta}{1-\beta}} \geq 0 \Rightarrow d_{t-1}(i) \geq 1 \qquad \text{G.3}$$

Equation G.3 shows that the rate of change in technical progress depends positively on the distance from the frontier. If there is a potential lag $d_{t-1}(i) > 1$, training through intensive imitation practices and unskilled labour demand can provide viable technological opportunities that reinforce short-term growth. Therefore, a low skill premium is caused by a deficit in skilled labour demand, which limits the contribution to productivity growth.

III. Empirical methodology

1. Definition of the sample and operationalization of the variables

The data used in this study were taken from the Atlas of Human Development in Brazil (UNDP/IPEA/FJP, 2013), which includes more than 200 indicators of demographics, education, income, work, housing and vulnerability of Brazilian municipalities from the 1991, 2000 and 2010 demographic censuses (IBGE, n/da).

In order to analyse the most recent information, the decision was taken to define the total of 5,565 municipalities based on the year 2010. In addition, some important variables used in the study —such as the average income of employed persons— are only available in this database for 2010.[4] Given the aim to employ a sample with as much data as possible and without too much loss of generality, the cross section did not imply serious limitations for the data sample, as the 5,565 municipalities selected are sufficient for a suitable inference for the model.

The variables used in the research are described in table 1.

Table 1
Description of the variables used

Acronym	Definition
RDPC	Per capita income
RENOCUP	Average income of employed persons aged 18 years and over
P_{SUPER}	Percentage of employed persons aged 18 years and over having completed higher education
PRENTRAB	Percentage of labour income
$T_{FBSUPER}$	Gross attendance rate, higher education
P_{MED}	Percentage of employed persons aged 18 years and over having completed secondary education
TRABCC	Percentage of employees aged 18 years and over with an employment contract
P_{TRANSF}	Percentage of persons aged 18 years and over employed in the processing industry
REN_0	Percentage of employed persons aged 18 years and over without income
$E_{ANOSESTUDO}$	Expectation of years of study at age 18
T_{MED18M}	Percentage of the population aged 18–20 years having completed secondary education
T_{FBMED}	Gross attendance rate, secondary education
$T_{SUPER25M}$	Percentage of the population aged 25 years and over having completed higher education

Source: United Nations Development Programme (UNDP)/Institute of Applied Economic Research (IPEA)/João Pinheiro Foundation (FJP), "Atlas of Human Development in Brazil", 2013 [online database] http://www.atlasbrasil.org.br/2013/en/consulta/.

[4] While the highlights of the 2010 data are based on the Atlas of Human Development in Brazil (UNDP/IPEA/FJP, 2013), it should be emphasized that other important databases may guide the continuity of this research: the National Household Sample Survey (PNAD) (IBGE, n/db) and the microdata of the 2010 Population Census (IBGE, n/da). These databases include more detailed information that, in principle, correlates with the data presented in the Atlas.

The next section describes the linear regression model that seeks to analyse the relationships between the variables according to the description of the theoretical model.

2. Linear regression model

The set of equations to be estimated consists of:

Reg.1

$$log(RDPC_{ij}) = \alpha + \beta_1 \cdot P_{SUPER_{ij}} + \beta_2 \cdot \left[P_{SUPER_{ij}} * w_{relat_{ij}}\right] + \beta_3 \cdot P_{TRANSF_{ij}} + \beta_4 \cdot REN_{0ij} + \beta_5 \cdot E_{ANOSESTUDO_{ij}} + \beta_6 \cdot T_{MED18M_{ij}} + \beta_7 \cdot T_{FBMED_{ij}} + \beta_8 \cdot T_{SUPER25M_{ij}} + \delta_j \cdot \varepsilon_{ij}$$

Reg.2

$$P_{SUPER_{ij}} = \alpha' + \beta'_1 PRENTRAB_{ij} + \beta'_2 \cdot T_{FBSUPER_{ij}} + \beta'_3 \cdot P_{MED_{ij}} + \beta'_4 \cdot TRABCC_{ij} + \gamma \cdot x + \delta'_j + \varepsilon'_{ij}$$

Reg.3

$$P_{SUPER_{ij}} * w_{relat_{ij}} = \alpha'' + \beta''_1 PRENTRAB_{ij} + \beta''_2 \cdot T_{FBSUPER_{ij}} + \beta''_3 \cdot P_{MED_{ij}} + \beta''_4 \cdot TRABCC_{ij} + \theta \cdot x + \delta''_j + \varepsilon''_{ij}$$

Equation Reg.1 is the main equation of the study. It analyses the contribution of skilled labour assigned to productive activities, to the extent that the oscillations in relative wages across municipalities capture the opportunity cost among production factors.

These relative wages are represented by the variable "w_{relat}" which corresponds to the relationship between the average income of employed persons (RENOCUP) of the municipality and the maximum value observed in the corresponding state. Thus, regional differences do not influence the calculation of the relative measure, and the variable ranges between $0 \leq w_{relat} \leq 1$ for each state. Values close to 1 represent municipalities that are close to the highest average wages within the state, indicating higher earnings in the regional sample and, therefore, relatively lower opportunity costs of labour and vice versa. This relative measure indirectly captures the degree of proximity to the frontier, according to equation W.1. The vector X included in equations Reg.2 and Reg.3 represents the other regressors of equation Reg.1.

The vectors δ_j, δ'_j, δ''_j represent the set of fixed effects relating to the specific characteristics of each state. These characteristics, duly included in the model, capture different patterns of development, policies, demographics and other aspects that influence the relationships between variables. In this case, their exclusion would imply a serious specification error in the model, which would lead to inconsistencies in parameter estimates (Greene, 2012).

The variables ε_{ij}, ε'_{ij}, ε''_{ij} represent the measure of error or ignorance and therefore capture the other factors irrelevant to the model.

3. Estimation method

Equations Reg.1–3 present an endogeneity relationship that needs to be adequately addressed in the estimation of parameters. Neglecting it implies serious errors in specification and method, which cause biases and inconsistencies in the technique. One of the most popular approaches to solving this methodological problem is the instrumental variables estimator (Galvao and Montes-Rojas, 2015).

In turn, the method must meet the following validity conditions in order to ensure unbiased and consistent parameter estimates (Hsiao and Zhang, 2015): the instruments (variables exogenous to the model) must be (i) valid, and therefore not correlated with the stochastic disturbance; and (ii) relevant, so that they capture important information on endogenous regressors.

To test the described hypotheses, two important test statistics were implemented to evaluate the suitability of the selected instruments. These statistics are described in table 2.

Table 2
Summary of model test statistics

Test	Summary of statistics	
Hansen's J test (Hayashi, 2000)	Null hypothesis (H_0)	Alternative hypothesis (H_a)
	Valid instruments not correlated with the error term	Invalid instruments correlated with the error term
Kleibergen and Paap (2006)	Null hypothesis (H_0)	Alternative hypothesis (H_a)
	Irrelevant instruments with weak or no correlation with endogenous regressors	Relevant instruments strongly correlated with endogenous regressors

Source: Prepared by the authors.

While the results of the statistics indicate a suitable selection of instruments, the instrumental variables method is subject to the loss of efficiency of the estimates when there are heterogeneity problems in the estimated model. This violation of the statistical hypothesis results in a bias in the estimates in table 2, so they must be corrected to reach a suitable conclusion on the instruments and the outcome of the model (Hayashi, 2000; Baum, Schaffer and Stillman, 2003).

To verify the presence of heteroscedasticity, the model incorporated the Pagan and Hall test (1983) adapted to the instrumental variables method (Baum, Schaffer and Stillman, 2003). Once its presence was detected, the issue was corrected by generating residual series using the states as a group model (cluster). This process leads to efficient estimates, allowing subsequent testing of the suitability of the most reliable and consistent instruments.

Finally, to ensure estimation alternatives and greater precision, the generalized method of moments was applied to the model, in reference to the contributions of Hansen (1982). In the presence of heteroscedasticity, the generalized method of moments reflects efficiency gains in estimates compared to traditional instrumental variables estimators (Baum, Schaffer and Stillman, 2003). These results were also recently shown in Cameron and Trivedi (2005) and Hsiao and Zhang (2015).

Table 3 describes the variables used in the model.

Table 3
Description of variables in the estimation method

Variables used	Instruments included	Instruments excluded
P_{SUPER}	P_{TRANSF}	PRENTRAB
$[P_{SUPER}*W_{relat}]$	REN_0	$T_{FBSUPER}$
	$E_{ANOSESTUDO}$	TRABCC
	T_{MED18M}	P_{MED}
	T_{FBMED}	
	$T_{SUPER25M}$	

Source: Prepared by the authors.

4. Selection of instruments

To capture the determinants of human capital stock and labour market differences, some recent studies —especially Philippon and Reshef (2012) and Gennaioli and others (2013)— have pointed out that

differences in human capital are important sources of regional inequality and persist over time in several regions of the world. Like all capital, it must be accumulated through effort, with output being produced through the skills acquired (Lucas, 2009). In this case, labour income serves as an available resource to finance the expansion of skills, which translates into new sources of asymmetry in wage distribution.

Gennaioli and others (2013) found that wages are relatively higher in the most productive and developed regions and that this difference intensifies the migration effect from the least developed regions. Skilled workers living in the least productive regions are encouraged to migrate because of the high opportunity cost among factors. Thus, the most skilled workers have a bigger incentive to pay the migration cost because the benefits received are much greater. This further expands the pool of skills, increasing the demand for new training courses as a result of local dynamics. The increased demand for new types of skill increases enrolment in training courses, which tends to be relatively higher in the most developed regions. This fosters a reallocation of skills in the labour market, where more weight is given to highly skilled labour than to low-skilled labour (Schiopu, 2015).

Recently, Bastgen and Holzner (2017) showed an important relationship between development, innovation and employment protection. According to the authors, formal employment and its protection by legislation mean that companies keep workers employed even in low productivity periods. As a result, companies increase their innovation initiatives to offset this process. Technological advances offset the decline in productivity and further stimulate training of skilled workers. This process alters local economic activity, generating more development and strengthening the relationship between labour market protection and innovation. Thus, legislation that protects the labour market stimulates innovation and new firm creation, so many countries with strict labour laws tend to encourage and specialize in improving existing products and processes (Acharya, Baghai and Subramanian, 2014; Koeniger, 2005).

IV. Analysis of the results

1. Descriptive analysis of the sample

Table 4 presents the main descriptive statistics of the data sample.

Table 4
Descriptive analysis of the sample

Variable	Average	Standard deviation	Minimum	Maximum
RDPC	493.61	243.27	96.25	2 043.74
RENOCUP	780.11	341.68	136.42	3 177.26
P_{SUPER}	7.04	3.61	0.32	37.53
PRENTRAB	68.48	10.80	27.43	95.24
$T_{FBSUPER}$	19.10	10.38	0.96	76.78
P_{MED}	30.42	9.84	4.16	73.65
TRABCC	30.25	18.05	0.90	83.21
P_{TRANSF}	9.61	8.92	0.00	65.11
REN_0	13.42	11.98	0.00	73.93
$E_{ANOSESTUDO}$	9.46	1.10	4.34	12.83
T_{MED18M}	24.75	8.68	3.04	66.23
T_{FBMED}	65.85	14.97	0.00	168.64
$T_{SUPER25M}$	5.50	3.26	0.28	33.68

Source: Prepared by the authors.

The average per capita income of the municipalities was 493.61 reais, between a minimum value of 96.25 reais and a maximum value of 2,043.74 reais. Considering the income of employed persons, the average value increases to 780.11 reais (a variation corresponding to 58.04%), with a minimum of 136.42 reais and a maximum of 3,177.26 reais.

The average percentage of employed people having completed higher education in the municipalities was around 7%, with a minimum of 0.32% and a maximum of 37.53%. With regard to labour income, the highest value is 95.24% (in this municipality, 95.24% of total income derives from work), while the average corresponds to 68.48%.

The percentage of employed persons having completed secondary education was significantly higher than that of employed persons having completed higher education, at 30.42%. The lowest percentage recorded was approximately 4%, while the highest value was over 70%.

The percentage of workers with an employment contract partly captures the level of formality in the local economy. In defining this share of formality in terms of workers with an employment contract, the public sector is not taken into account.[5] According to some recent research, especially Mattos (2011 and 2015), public employment accounts for about 10.7% of employed persons in Brazil (in the broadest sense, which includes direct, indirect and state administration of all kinds). This low percentage will not result in large losses of asymptotic quality for the model, as the instruments will be tested prior to validation (Greene, 2012).

Municipal data show a low proportion of workers with an employment contract, as the average is approximately 30.25% of employed persons in the reference age group. The maximum percentage is 83.21%, so only 16.79% of employed workers would not have an employment contract in that municipality.

Another important piece of information concerning the labour market is employment in the processing industry. The average percentage of workers employed in this sector was approximately 9.6%, with a maximum value of 65.11%.

An analysis of the percentage of employed workers without income reveals an average percentage of 13.42%. This variable reflected a minimum value of zero and a maximum value of 73.93%. This indicates that inequality related to the lack of wages prevails in some municipalities in the sample.

An important dimension of municipal development is the expectation of education, which projects the expectation of years of study for future generations. The average expectation was 9.46 years of study, and the maximum value was 12.83.

The proportion of the population having completed secondary education stood at a low average of 24.75%. In the municipality with the highest value, 66.23% of the population had completed secondary education. The proportion of the population aged 25 years and over having completed higher education was also relatively low, averaging 5.5%, with a maximum of 33.68% (lower than the proportions of employed persons).

Table 5 shows the correlation between the variables used in the model. The variable log(RDPC) reflected a significant correlation with all the selected variables (significant at 1%). The strongest correlation with log(RDPC) corresponded to the variable REN_0, which represents the percentage of employed workers without income (ρ = -0.737), followed by the proportion of persons having completed secondary education (ρ = 0.736).

Only one variable reflected a weak correlation coefficient, the gross secondary school attendance rate (ρ = 0.271, although significant at 1%). All other variables reflected correlation coefficients greater than ρ = 0.50, showing medium and strong correlations.

[5] This variable excludes military personnel in the army, navy, aeronautics, military police and the fire brigade, and employees included in the legal regime of civil servants, as well as employers and own-account workers contributing to a public social security agency, as these categories present a different dynamic in the labour market.

Table 5
Correlation between variables

	log(RDPC)	P_{SUPER}	PRENTRAB	$T_{FBSUPER}$	P_{MED}	TRABCC	P_{TRANSF}	REN_0	$E_{ANOSESTUDO}$	T_{MED18M}	T_{FBMED}	$T_{SUPER25M}$
log(RDPC)	1.000											
p value	-											
P_{SUPER}	0.658	1.000										
valor *p*	0.000	-										
PRENTRAB	0.689	0.385	1.000									
p value	0.000	0.000	-									
$T_{FBSUPER}$	0.724	0.710	0.399	1.000								
p value	0.000	0.000	0.000	-								
P_{MED}	0.674	0.807	0.459	0.649	1.000							
p value	0.000	0.000	0.000	0.000	-							
TRABCC	0.700	0.544	0.567	0.452	0.709	1.000						
p value	0.000	0.000	0.000	0.000	0.000	-						
P_{TRANSF}	0.514	0.271	0.421	0.314	0.423	0.693	1.000					
p value	0.000	0.000	0.000	0.000	0.000	0.000	-					
REN_0	-0.737	-0.515	-0.708	-0.459	-0.638	-0.726	-0.511	1.000				
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-				
$E_{ANOSESTUDO}$	0.544	0.392	0.252	0.519	0.475	0.366	0.296	-0.347	1.000			
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-			
T_{MED18M}	0.736	0.802	0.513	0.693	0.972	0.707	0.432	-0.637	0.490	1.000		
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-		
T_{FBMED}	0.271	0.275	0.099	0.325	0.365	0.187	0.110	-0.167	0.534	0.373	1.000	
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	
$T_{SUPER25M}$	0.725	0.967	0.444	0.735	0.800	0.580	0.320	-0.536	0.394	0.838	0.268	1.000
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-

Source: Prepared by the authors.
Note: The *p* value associated with the correlation measure corresponds to the hypothesis test for H_0: $\rho = 0$.

2. Regression model analysis

The results of the model estimated according to the ordinary least squares technique, including the fixed effects for each state, are detailed in table 6.

Table 6
Econometric model results

Variables	(1) Ordinary least squares Fixed effects	(2) Ordinary least squares Fixed effects
P_{SUPER}	-0.0252**	-0.0653***
	(0.00940)	(0.00771)
P_{SUPER}*W_{relat}	0.115***	0.0646***
	(0.0153)	(0.0102)
P_{TRANSF}		0.00311***
		(0.000495)
REN_0		-0.00949***
		(0.00127)
$E_{ANOSESTUDO}$		0.0316***
		(0.00573)
T_{MED18M}		0.00679***
		(0.00141)
T_{FBMED}		0.000383
		(0.000407)
$T_{SUPER25M}$		0.0603***
		(0.00797)
Constant	5.477***	5.371***
	(0.0287)	(0.0512)
Fixed effects	-	-
- State	Yes	Yes
Heteroscedasticity test	-	-
- $\chi 2$	734.65	98.44
- p value	0.0000	0.0000
R^2	0.846	0.906
Adjusted R^2	0.845	0.906
F statistic	1 082.87	1 573.29
F statistic (p value)	0.0000	0.0000

Source: Prepared by the authors.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.
Confirmation in heteroscedasticity tests involved recalculating the covariance of parameters following the residual series technique using the states as a group model (clusters).

According to the results detailed in the table, the parameter linked to the proportion of employed persons having completed higher education showed a negative value in both columns (significant at 1%). The parameter represents semi-elasticity of the variable in the per capita income of municipalities. Thus, excluding the influence of wage differences on the demand for skilled labour, an increase of one unit in the proportion of employed persons contributes to an average reduction of 2.6% (column (1)) and of 6.7% (column (2)) [(e^{β} – 1)*100]. However, this average effect is not consistent with the literature presented, suggesting that the sign linked to the estimated parameter is influenced by wage differences based on the model presented. In this case, the parameter associated with the cross-effect is presented as positive, which indicates that the final effect of the relationship depends on the proximity of the maximum levels of income for each state.

This empirical evidence suggests that the differences between incomes indicate the existence of opportunity costs among factors. Thus, on average, the most developed municipalities provide greater benefits, reducing opportunity costs among the factors (see figure 1).

Figure 1
Relationship between average income of employed persons and per capita income
(In reais)

Source: Prepared by the authors.

The parameter corresponding to the percentage of employed persons without income reflected the expected negative sign and was significant at 1%. Thus, on average, an increase of one unit tends to reduce per capita income by 0.95%. The expectation of years of study reflected the expected positive relationship. On average, a further increase in the expectation of years of study contributes to a 3.21% increase in per capita income.

When comparing the proportion of the population having completed secondary education with that having completed higher education, both parameters showed the expected positive signs and statistical significance (level of 1%). However, an increase in the proportion of the population having completed secondary education contributes to a rise of approximately 0.68% in per capita income, compared to an increase of 6.22% in the case of a rise in the proportion of the population having completed higher education.

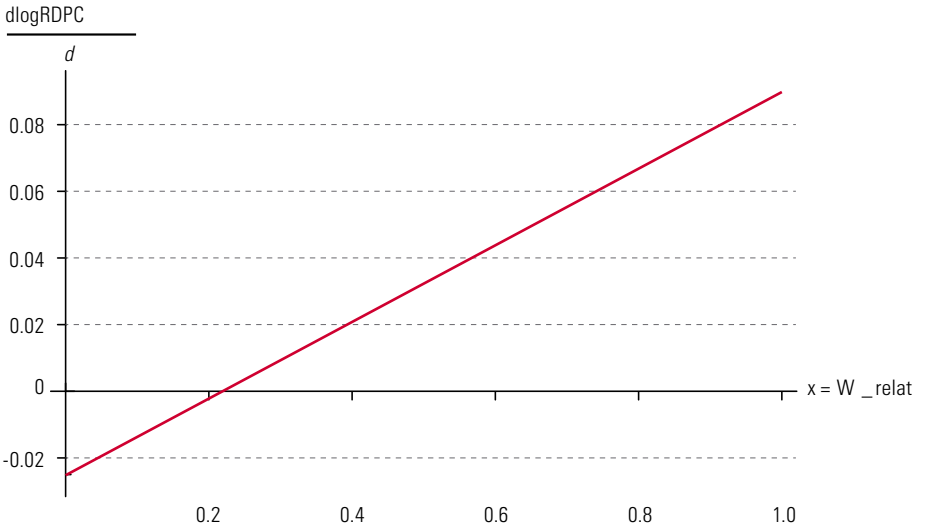
Heteroscedasticity tests showed a rejection of the null hypothesis at 1% homoscedastic variance. The variance-covariance matrix was recalculated so that the standard error estimates would be consistent (efficient parameters). The explanatory power of the model reflected a high value in columns (1) and (2), in addition to adjusted R^2 measures close to the explanatory power. The models reflected overall significance based on high F statistics values and corresponding p values (significant at 1%).

Figure 2 shows that the proximity of income to the maximum value in each state increases the impact of highly qualified human capital on the per capita income of the municipalities.

As shown in figure 2, the final effect of highly skilled labour is conditioned by wage differences. The figure shows that the positive effect is estimated based on a difference of 0.22 or 22%. Thus, in municipalities where average income ranges from more than 22% to the maximum observed in the state, the expansion of the workforce with higher education leads to a positive relationship with the increase in per capita income.

This analysis indicates that the relationship between human capital and its impact on wealth generation reflects heterogeneous results that are not always suitably addressed in the analysis. Some factors relating to different opportunity costs among factors may condition these effects, leading to a bias in the relationship between the variables, which increases as these regional differences become more significant.

Figure 2
Simulation based on the results of the estimated model



Source: Prepared by the authors.
Note: Simulation based on the results of table 6, column (1).

Table 7 presents the results according to the instrumental variables method and the generalized method of moments.

Columns (1) and (3) present the results of the simplified model, which indicate the same conclusion as table 6. The parameter associated with the proportion of employed persons having completed higher education reflects a negative effect (significant at 1% in the two columns). The parameter associated with the cross-effect is presented as positive, indicating that the final effect of the relationship depends on the wage differences that reflect different opportunity costs among municipalities (parameters significant at 1%). While the differences in parameters (instrumental variables and generalized method of moments) are relatively small, there are larger discrepancies in F statistics, indicating efficiency gains in the generalized method of moments.

Considering columns (2) and (4), the inclusion of the other variables influences the estimation of the main parameters of the model, so their exclusion results in overestimation. The additional increase in the proportion of employed persons having completed higher education in the municipality with the highest average income of employed persons contributes to an increase in the per capita income of the municipalities of approximately 12.98% (column (2)) and 15.84% (column (4)), compared to 20.80% (column (1)) and 18.77% (column (3)). On the basis of the results of table 6, the magnitude of this effect represents an average value of 9.40% for the same municipality.

The dividing line between the positive and negative effects of the increase in employed persons having completed higher education on per capita income $\left(\frac{\partial log(RDPC)}{\partial P_{SUPER}} = \hat{\beta}_1 + \hat{\beta}_2 \cdot W_{relat} \geq 0\right)$ represents different results across the models. Controlling for the endogeneity of regressors, the relative values of the average income of employed persons above 46% (see table 7) show a positive relationship between the variables. Without taking endogeneity into account (see table 6), the magnitude of relative value is 22%, demonstrating a downward bias of almost 50% with respect to the instrumental variables method and the generalized method of moments. This result is shown in figure 3, which simulates the relationship between per capita income and the proportion of employed persons with higher education, according to different relative values of income across municipalities.

Table 7
Results of the econometric model according to the instrumental variables method and the generalized method of moments

Variables	(1) Instrumental variables Fixed effects	(2) Instrumental variables Fixed effects	(3) Generalized method of moments Fixed effects	(4) Generalized method of moments Fixed effects
P_{SUPER}	-0.177***	-0.138***	-0.168***	-0.125***
	(0.0244)	(0.0161)	(0.0235)	(0.0144)
P_{SUPER}*W_{relat}	0.366***	0.260***	0.340***	0.272***
	(0.0437)	(0.0403)	(0.0359)	(0.0387)
P_{TRANSF}		0.00403***		0.00503***
		(0.00130)		(0.000860)
REN_0		-0.00613***		-0.00658***
		(0.00105)		(0.000852)
$E_{ANOSESTUDO}$		0.0717***		0.0747***
		(0.0121)		(0.0104)
T_{MED18M}		0.00528***		0.00539***
		(0.00170)		(0.00152)
T_{FBMED}		9.81e-05		-0.000242
		(0.000439)		(0.000370)
$T_{SUPER25M}$		-0.00624		-0.0280
		(0.0224)		(0.0186)
Constant	6.134***	5.508***	6.190***	5.487***
	(0.118)	(0.155)	(0.0992)	(0.133)
Fixed effects	-	-	-	-
- Status	Yes	Yes	Yes	Yes
Heteroscedasticity test	-	-	-	-
- χ^2	212.550	75.498	212.550	75.498
- p value	0.0000	0.0000	0.0000	0.0000
F statistic	52.97	89.57	82.30	104.3
F statistic (p value)	0.0000	0.0000	0.0000	0.0000
LM Kleibergen-Paap statistic (χ^2)	14.02	16.87	14.02	16.87
LM Kleibergen-Paap statistic (χ^2)	0.00288	0.000751	0.00288	0.000751
Hansen's J-statistic (χ^2)	2.015	3.056	2.015	3.056
Hansen's J-statistic (p value)	0.365	0.217	0.365	0.217

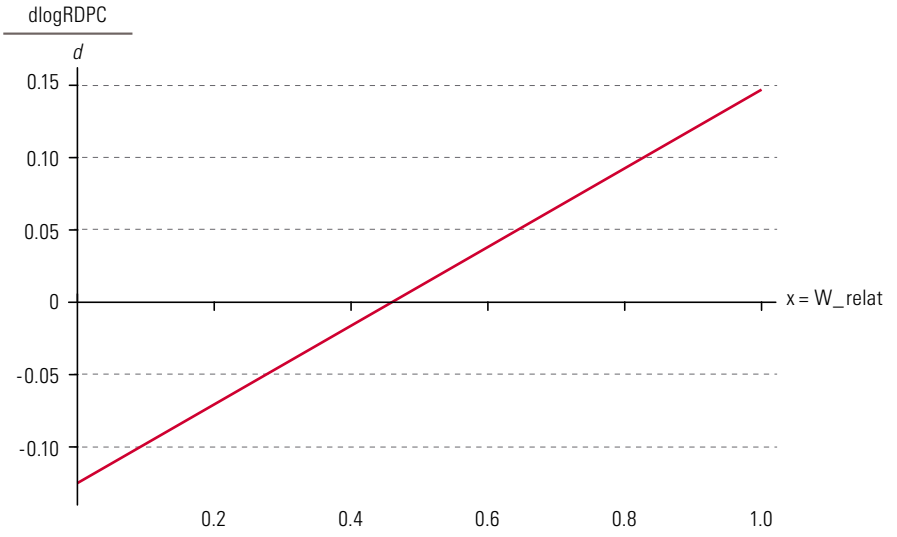
Source: Prepared by the authors.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.
Confirmation in heteroscedasticity tests involved recalculating the covariance of parameters following the residual series technique using the states as a group model (clusters).

The gross secondary education attendance rate and percentage of the population aged 25 years and over having completed tertiary education showed negative signs and lacked statistical significance, contrary to the results in table 6. The impact of the expectation of years of study on per capita income accumulation nearly doubled when controlling for relative endogeneity problems in the model (0.0717 and 0.0747 in columns (2) and (4) of table 7, respectively, compared to 0.0316 in column (2) of table 6), parameters significant at 1%.

Heteroscedasticity tests revealed a significant presence in all columns (rejection of the null hypothesis at 1%). This demonstrates the need for the generalized method of moments to increase efficiency.

In all columns of table 7, instrument validity and relevance tests showed that there was no significant correlation with stochastic disturbance (high p value in Hansen's J tests), and that there was a strong correlation between the instruments and endogenous regressors.

Figure 3
Simulation based on the results of the estimated model



Source: Prepared by the authors.
Note: Simulation based on the results of table 7, column (4).

3. Analysis of results

The results indicate that the increase in the proportion of employed persons having completed higher education tends to contribute to greater accumulation of per capita income in municipalities where factor opportunity costs are relatively lower. In this case, the most developed municipalities, with higher levels of per capita income and wage income, offer better incentives for a more skilled workforce. This shows that the contribution of human capital to the increase in wealth reflects heterogeneous results, which are conditioned by the different regional realities. Other regional studies have supported these results, including Aghion and others (2009) and Zhang and Zhuang (2011).

In a study on the composition of investment in education in the United States, Aghion and others (2009) found evidence that investment in higher education stimulated stronger growth in states with higher levels of technological development and therefore closer to the technological frontier. In states at the technological frontier, a US$ 1,000 increase in per capita investment in higher education research contributes to an average increase of about 0.04 percentage points in the growth rate. The final result of the investment depends on the coefficient of proximity to the frontier, generating positive or even negative results for the states further from the frontier.

Zhang and Zhuang (2011) assessed the effects of human capital composition on China's growth, distinguishing three education levels: tertiary, secondary and primary. According to the authors, human capital composition plays an important role in regional growth and is influenced by development disparities within the country. The benefits of labour with tertiary level education are greater in the more developed provinces than in the less developed ones. As a result, tertiary education had a positive and significant effect on growth in the more developed provinces, unlike primary and secondary education, for which results were not significant or negative. In this regard, while higher education in China has been responsible for significant progress in economic growth, the reduction of regional disparities is conditioned by investment at all levels, especially in the improvement of primary and secondary education.

Other studies indicate similar results. These include the contributions from Vandenbussche, Aghion and Meghir (2006), Aghion (2008), Ang, Madsen and Islam (2011), Ott and Soretz (2011), Basu and Mehra (2014) and Madsen (2014).

Gennaioli and others (2013) studied the impact of human capital on development in a sample of over 1,500 regions in 110 countries around the world. The sample covered 74% of the earth's surface and represented 97% of global GDP. The results of the study indicated that regional disparities are largely influenced by differences in human capital, but that these differences are more susceptible to different types and levels of education. These differences are reflected in quality and are determined by the composition (quality) of human capital.

From this perspective, countries need a specific type of highly qualified human capital to sustain economic convergence, so that this process can be accelerated in countries where the participation of high-performing students in schools and universities is significant. These advances depend on policies that internalize different compositions in the allocation of resources, which are designed to boost education indicators at different levels (Hanushek and Woessmann, 2012; Ang, Madsen and Islam, 2014).

While this composition is clearly reflected in the different growth rates across the countries, some important aspects such as labour migration can be explained by fluctuations in proximity to the frontier. According to Di Maria and Lazarova (2012), many studies on migration highlight its effects on the level of human capital accumulated, but do not take into account its influence on the composition of human capital. This derives from differences between wages and the employability of the labour force, which affect incentives and are conditioned by the degree of technological development. Economies at the technological frontier have a significant influence on the economic rationality of talent migrating from developing economies. This effect of distribution of highly skilled human capital across different economies has a clear impact on the levels and composition of human capital, reducing the rate of productivity growth in the countries and regions of origin and increasing it in the destination economies (Di Maria and Stryszowski, 2009).

These results may explain how the expansion of skilled labour in the least developed regions contributes proportionally less to income accumulation. This indicates the absence of institutional restrictions on labour migration between municipalities and states, contrary to the regulation observed between countries (Hendricks, 2002).

In this vein, Korpi and Clark (2015) analysed data from a sample of 982,179 persons, including 126,233 internal migrants, in microdata from Sweden.[6] The results indicated that the most skilled workers captured the largest share of the significant income increases as they migrated to the most developed metropolises. This suggests that human capital reflects a selective pattern in internal migration between regions, attributing different weights in composition according to different income distributions.

V. Limitations of the study and suggestions for future research

Although the results of the empirical exercise align with the assumptions presented in the theoretical model, it is necessary to properly outline some important aspects highlighted in the study.

In the Brazilian labour market, the public sector exerts a notable influence, increasing the skill premium of the labour force and competing with major segments of the private sector, especially in lower income municipalities. This made it possible to partly sustain the expansion of the welfare state through public employment (Mattos, 2015 and 2011). In addition, some inconsistencies in the concept of workers' skills associated with the level of schooling in Brazil have given rise to differences in many empirical tests, indicating new ways of perceiving workers' skills. This is because some important results indicate the absorption of skilled workers in occupations requiring a lower level of education. Data from the National

[6] Statistics Sweden's Microdata Online Access (MONA) database [online] https://www.scb.se/en/services/guidance-for-researchers-and-universities/mona--a-system-for-delivering-microdata/.

Household Sample Survey (PNAD) from 1981 to 2001 indicate a trend towards the increasing precarity of skills associated with the underutilization of workers with higher education levels in Brazil. In this case, a possible surplus of highly skilled workers ends up being "forced" into activities that require lower skill levels, possibly owing to the lack of options in the labour market (Machado, Oliveira and Carvalho, 2004).

However, some recent research indicates that the average wage ratio of workers having completed secondary education has varied between 2.65 and 2.9 times since the 2000s, indicating a considerable increase in the demand for higher education over the period (Insper, 2016; Rocha and others, 2017). Some estimates made from 2000 to 2010 at the municipal level indicate that a 1 percentage point change in the proportion of adults with higher education is associated with a 0.4 percentage point increase in the employment rate and growth of 0.9% in wages and 1.3% in household per capita income (Rocha and others, 2017, p. 66).

Although these results are consistent with the economic realities of different periods, no peaceful consensus has been reached on the impact of human capital on Brazil's development. "Peaceful consensus" is highlighted here, based on heterogeneous results which must be refined in future research to more accurately capture possible divergence between demand and supply in the labour market and the consequences for growth in Brazilian municipalities.

This research indicates, in the theoretical model, the existence of different activities that require differentiated production factors. From a Schumpeterian perspective, different activities require factors that complement the prevailing technological model. Consequently, it is not reasonable to treat different employment categories with a single measure, as is clear from relevant national research (Machado, Oliveira and Carvalho, 2004; Insper, 2016; Rocha and others, 2017) and international research (Ang, Madsen and Islam, 2011; Ott and Soretz, 2011; Basu and Mehra, 2014; Madsen, 2014).

Also, regression analysis and other techniques based on the average of the conditional distribution of the model may not capture these imperfections in the labour market, over- or underestimating the relationships between variables. In the technique proposed in this study, the differences in income between the municipalities are adopted to capture possible differences in demand across the regions. These differences can significantly influence the impact of workers with higher education on the per capita income of municipalities. Furthermore, if there are no controls for endogeneity, the estimated parameters may reflect erroneous relationships that should be interpreted with due caution (Imbens, 2014; Fan and Liao, 2014; Ackerberg and others, 2014; Lenkei, Mustafa and Vecchi, 2018; Chaudhuri and Guilkey, 2016).

In addition to these highlighted issues, the problems arising from the use of an aggregate database should be underscored. In this case, depending on the level of aggregation, much information about the variables can "smooth out" the relationships in the model, potentially limiting the results. However, the above-mentioned potential costs are minimized to the extent that the theoretical model set forth differentiates the empirical exercise from the studies presented. While not avoiding the relevance of such restrictions, we emphasize that the alternative approach proposed here mitigates their costs, and the results are consistent with international research such as that of Vandenbussche, Aghion and Meghir (2006), Ang, Madsen and Islam (2011), Basu and Mehra (2014) and Madsen (2014).

VI. Concluding remarks

This study analysed the contribution of the increase in workers with higher education to per capita income in Brazilian municipalities, to the extent that the different incomes among employed persons affects the magnitude of this contribution. Using a Schumpeterian growth model based on the approaches of Aghion and Howitt (2009 and 1998), the decision of the monopolistic firm to maximize its profits depends on two components of human capital: (i) highly skilled workers engaged in innovation activities and (ii) low-skilled workers carrying out imitation and technology transfer activities.

Under optimized conditions, companies' demand for low-skilled labour depends positively on the degree of proximity to the technological frontier. Based on the results of the model, final demand for low-skilled workers is greatest among the companies furthest from the technological leader (frontier) of the sector. As companies move closer to the technological frontier, total demand reflects a larger share of workers dedicated to innovation activities and, therefore, with higher skill levels. In wage differences among factors, the distance from the frontier increases the opportunity costs of skilled labour reducing the skill premium, as the results of the empirical model suggest.

The empirical results based on municipal data from the 2010 census indicate that the contribution of the increase in employed persons with higher education tends to be greater in municipalities with smaller income differences compared to the highest value recorded in each state. The increase in income differences raises factor opportunity costs, contributing to a possible migration effect in higher income regions. The results also suggest that municipalities with low per capita income offer fewer opportunities and therefore fewer benefits associated with curbed demand.

Municipalities with incomes above 46% of the maximum income recorded in the state reflect a positive relationship between the increase in employed persons with higher education and per capita income. These results indicate that the final effect of the expansion of the skilled labour force in the country depends on significant labour market characteristics that increase the demand for the skills acquired through higher education. The neglect of public policies targeting both supply (higher education training) and demand (employment in income-generating activities for this type of factor) may contribute to the increase in regional inequalities.

While these results indicate better coordination of policies (especially education and industrial), the limitations of the study point to future lines of research: different types of higher education training, quality of training, differences between public and private education, and differences between investments by level (primary, secondary and higher), among other relevant factors that were not included in the scope of this research.

Furthermore, the adherence of empirical results to the theoretical model requires an interpretation that has yet to be made, with due caution. In this case, part of the increase in income in municipalities may be influenced by activities that employ skilled workers when, in fact, less skilled workers are needed. Therefore, this study indicates the need for different types of human capital for different activities, which may have an impact on differentiated growth patterns across economies.

While this differentiated growth across economies may explain some of the inequalities, further research is needed, especially in the different labour markets, to understand how and what types of human resources are most needed based on municipalities' characteristics. Finally, the results presented indicate that the concept of human capital, based on aggregate metrics, may limit the way in which education contributes to development.

Bibliography

Acemoglu, D. (1998), "Why do new technologies complement skills? Directed technical change and wage inequality", *The Quarterly Journal of Economics*, vol. 113, No. 4, November.

Acemoglu, D., F. Gallego and J. Robinson (2014), "Institutions, human capital and development", *Annual Review of Economics*, vol. 6.

Acharya, V., R. Baghai and K. Subramanian (2014), "Wrongful discharge laws and innovation", *The Review of Financial Studies*, vol. 27, No. 1, January.

Ackerberg, D. and others (2014), "Asymptotic efficiency of semiparametric two-step GMM", *The Review of Economic Studies*, vol. 81, No. 3, July.

Aghion, P. (2008), "Higher education and innovation", *Perspektiven der Wirtschaftspolitik*, vol. 9, No. S1, May.

Aghion, P. and P. Howitt (2009), *The Economics of Growth*, Cambridge, The MIT Press.
___(1998), *Endogenous Growth Theory*, Cambridge, The MIT Press.
Aghion, P. and others (2009), "The causal impact of education on economic growth: evidence from the United States", *Brookings Papers on Economic Activity*, spring, Washington, D.C., Brookings Institution Press.
Ang, J., J. Madsen and M. Islam (2014), "Quality-adjusted human capital and productivity growth", *Economic Inquiry*, vol. 52, No. 2, April.
___(2011), "The effects of human capital composition on technological convergence", *Journal of Macroeconomics*, vol. 33, No. 3.
Barro, R. (2001), "Human capital and growth", *The American Economic Review*, vol. 91, No. 2.
Barro, R. and X. Sala-i-Martin (1992), "Convergence", *Journal of Political Economy*, vol. 100, No. 2.
Bastgen, A. and C. Holzner (2017), "Employment protection and the market for innovations", *Labour Economics*, vol. 46, June.
Basu, S. and M. Mehra (2014), "Endogenous human capital formation, distance to frontier and growth", *Research in Economics*, vol. 68, No. 2, June.
Baum, C., M. Schaffer and S. Stillman (2003), "Instrumental variables and GMM: estimation and testing", *The Stata Journal*, vol. 3, No. 1, Texas, Stata Corporation.
Becker, S., E. Hornung and L. Woessmann (2011), "Education and catch-up in the industrial revolution", *American Economic Journal: Macroeconomics*, vol. 3, No. 3, July.
Becker, S. and L. Woessmann (2009), "Was Weber wrong? A human capital theory of protestant economic history", *The Quarterly Journal of Economics*, vol. 124, No. 2, May.
Benhabib, J. and M. Spiegel (2005), "Human capital and technology diffusion", *Handbook of Economic Growth,* vol. 1A, P. Aghion and S. Durlauf (eds.), Amsterdam, North-Holland.
___(1994), "The role of human capital in economic development: evidence from aggregate cross-country data", *Journal of Monetary Economics*, vol. 34, No. 2, October.
Bond, S., A. Hoeffler and J. Temple (2001), "GMM estimation of empirical growth models", *Economics Discussion Papers*, No. 2001-W21, Oxford, University of Oxford.
Cameron, A. and P. Trivedi (2005), *Microeconometrics: Methods and Applications*, New York, Cambridge University Press.
Caselli, F. and W. Coleman (2006), "The world technology frontier", *The American Economic Review*, vol. 96, No. 3, June.
Chaudhuri, S. and D. Guilkey (2016), "GMM with multiple missing variables", *Journal of Applied Econometrics*, vol. 31, No. 4.
Costa, D., A. Costa and F. Barbosa (2013), "Financiamento público e expansão da educação superior federal no Brasil: o REUNI e as perspectivas para o REUNI 2", *Revista Gestão Universitária na América Latina*, vol. 6, No. 1, January.
Cury, C. (2014), "Formação e conhecimento: perspectivas filosóficas e sociológicas", *Avaliação: Revista da Avaliação da Educação Superior*, vol. 19, No. 3.
Di Maria, C. and E. Lazarova (2012), "Migration, human capital formation, and growth: an empirical investigation", *World Development*, vol. 40, No. 5, May.
Di Maria, C. and P. Stryszowski (2009), "Migration, human capital accumulation and economic development", *Journal of Development Economics*, vol. 90, No. 2, November.
Dosi, G., G. Fagiolo and A. Roventini (2010), "Schumpeter meeting Keynes: a policy-friendly model of endogenous growth and business cycles", *Journal of Economic Dynamics and Control*, vol. 34, No. 9.
Durlauf, S., P. Johnson and J. Temple (2005), "Growth econometrics", *Handbook of Economic Growth*, vol. 1A, P. Aghion and S. Durlauf (eds.), Amsterdam, North-Holland.
Fan, J. and Y. Liao (2014), "Endogeneity in high dimensions", *The Annals of Statistics*, vol. 42, No. 3, June.
Felicetti, V., A. Cabrera and M. Costa-Morosini (2014), "Aluno ProUni: impacto na instituição de educação superior e na sociedade", *Revista Iberoamericana de Educación Superior*, vol. 5, No. 13.
Galvao, A. and G. Montes-Rojas (2015), "On the equivalence of instrumental variables estimators for linear models", *Economics Letters*, vol. 134, September.
Gennaioli, N. and others (2013), "Human capital and regional development", *The Quarterly Journal of Economics*, vol. 128, No. 1, Oxford, Oxford University Press.
Greene, W. (2012), *Econometric Analysis, 7th Edition*, Boston, Prentice Hall.
Hansen, L. (1982), "Large sample properties of generalized method of moments estimators", *Econometrica*, vol. 50, No. 4, July.

Hanushek, E. and L. Woessmann (2012), "Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation", *Journal of Economic Growth*, vol. 17, No. 4, December.
Hayashi, F. (2000), *Econometrics*, Princeton, Princeton University Press.
Hendricks, L. (2002), "How important is human capital for development? Evidence from immigrant earnings", *The American Economic Review*, vol. 92, No. 1, March.
Hsiao, C. and J. Zhang (2015), "IV, GMM or likelihood approach to estimate dynamic panel models when either *N* or *T* or both are large", *Journal of Econometrics*, vol. 187, No. 1, July.
IBGE (Brazilian Institute of Geography and Statistics) (n/da), "Censo demográfico" [online] https://www.ibge.gov.br/estatisticas/sociais/populacao/9662-censo-demografico-2010.html?edicao=9673&t=downloads.
___(n/db), "Pesquisa Nacional por Amostra de Domicílios - PNAD" [online] https://www.ibge.gov.br/estatisticas/sociais/populacao/9127-pesquisa-nacional-por-amostra-de-domicilios.html?=&t=downloads.
Imbens, G. (2014), "Instrumental variables: an econometrician's perspective", *Statistical Science*, vol. 29, No. 3, August.
INEP (National Institute for Educational Studies and Research Anísio Teixeira) (2016), "Sinopse Estatística da Educação Superior 2015" [online database] http://portal.inep.gov.br/web/guest/sinopses-estatisticas-da-educacao-superior.
Insper (2016), "Panorama do mercado de trabalho" [online] https://www.insper.edu.br/wp-content/uploads/2018/09/Panorama-do-Mercado-de-Trabalho-CPP-2016.pdf.
Kleibergen, F. and R. Paap (2006), "Generalized reduced rank tests using the singular value decomposition", *Journal of Econometrics*, vol. 133, No. 1.
Koeniger, W. (2005), "Dismissal costs and innovation", *Economics Letters*, vol. 88, No. 1, July.
Korpi, M. and W. Clark (2015), "Internal migration and human capital theory: to what extent is it selective?", *Economics Letters*, vol. 136, November.
Lenkei, B., G. Mustafa and M. Vecchi (2018), "Growth in emerging economies: is there a role for education?", *Economic Modelling*, vol. 73, June.
Lima, K. (2012), "Expansão e reestruturação das universidades federais e intensificação do trabalho docente: o Programa REUNI", *Revista de Políticas Públicas*, vol. 16, October.
Lucas, R. (2009), "Ideas and growth", *Economica*, vol. 76, No. 301, February.
Machado, A., A. Oliveira and N. Carvalho (2004), "Tipologia de qualificação da força de trabalho: uma proposta a partir da noção de incompatibilidade entre ocupação e escolaridade", *Nova Economia*, vol. 14, No. 2.
Madsen, J. (2014), "Human capital and the world technology frontier", *The Review of Economics and Statistics*, vol. 96, No. 4, October.
Mancebo, D., A. Vale and T. Martins (2015), "Políticas de expansão da educação superior no Brasil 1995–2010", *Revista Brasileira de Educação*, vol. 20, No. 60.
Mattos, F. (2015), "Trajetória do emprego público no Brasil desde o início do século XX", *Ensaios FEE*, vol. 36, No. 1, Porto Alegre, Foundation for Economics and Statistics.
___(2011), "Emprego público nos países desenvolvidos: evolução histórica e diferenças nos perfis", *Texto para Discussão*, No. 1578, Brasilia, Institute of Applied Economic Research (IPEA).
Ott, I. and S. Soretz (2011), "Public policies and convergence", *Journal of Economic Dynamics and Control*, vol. 35, No. 9.
Philippon, T. and A. Reshef (2012), "Wages and human capital in the U.S. finance industry: 1909–2006", *The Quarterly Journal of Economics*, vol. 127, No. 4, November.
Rocha, R. and others (2017), "A relação entre o ensino superior público e privado e a renda e emprego nos municípios brasileiros", *Pesquisa e Planejamento Econômico*, vol. 47, No. 3, December.
Schiopu, I. (2015), "Technology adoption, human capital formation and income differences", *Journal of Macroeconomics*, vol. 45, September.
UNDP/IPEA/FJP (United Nations Development Programme/Institute of Applied Economic Research/João Pinheiro Foundation) (2013), "Atlas of Human Development in Brazil" [online database] http://www.atlasbrasil.org.br/2013/en/consulta/.
Vandenbussche, J., P. Aghion and C. Meghir (2006), "Growth, distance to frontier and composition of human capital", *Journal of Economic Growth*, vol. 11, No. 2, June.
Zhang, C. and L. Zhuang (2011), "The composition of human capital and economic growth: evidence from China using dynamic panel data analysis", *China Economic Review*, vol. 22, No. 1, March.

Macroeconomic stability and economic growth: myths and realities[1]

Guillermo Le Fort Varela, Bastián Gallardo and Felipe Bustamante

Abstract

In this paper, we explore empirical relationships between sustained GDP growth and macroeconomic volatility, using World Economic Outlook data for the period 1980–2015, both in descriptive statistics and in fixed-effect panel regressions (IMF, 2016). The results debunk certain myths, such as those that maintain that more inflation generates more growth, that stabilization carries real costs, or that large inflows of foreign capital stimulate growth. We show that inflation has a tangible negative impact on growth and that there are "inflation thresholds", beyond which that impact increases. Higher inflation is associated with greater nominal and real volatility, defined as cyclical output volatility. Furthermore, current account volatility contributes significantly to real volatility. Lastly, we show that real volatility has a negative impact on trend GDP growth and that macroeconomic volatility does not contribute to growth or well-being.

Keywords

Gross domestic product, macroeconomics, economic stabilization, inflation, balance of payments, econometric models, economic growth

JEL classification

E31, F32, O40

Authors

Guillermo Le Fort Varela has a PhD in Economics from the University of California, Los Angeles (UCLA), is a senior partner of Le Fort Economía y Finanzas and a Professor with the Faculty of Economics and Business of the University of Chile. Email: glefortv@leyf.cl.

Bastián Gallardo is an analyst with the Regulatory Impact Analysis Department of the Financial Market Commission. Email: bgallardo@svs.cl.

Felipe Bustamante has a Master's degree in Economic Analysis from the University of Chile. Email: fbustamant@fen.uchile.cl.

[1] A preliminary and shorter version of this paper was presented at the twenty-fifth Economic Seminar of the Central Bank of Guatemala, in Guatemala City on 6 and 7 June 2016. This was later published as a working paper by the Faculty of Economics and Business of the University of Chile (Le Fort, Gallardo and Bustamante, 2017). We appreciate the many comments received, including from an anonymous reviewer.

I. Introduction

In this paper we will seek empirical answers to some of the issues surrounding the relationship between macroeconomic stability and GDP growth, using annual data from the World Economic Outlook (WEO) database of the International Monetary Fund (IMF) for the period 1980–2015 (IMF, 2016). Both statistics of a more descriptive nature and inferences obtained from econometric estimates are presented, using a data panel for 189 countries, 4 of which presented missing data and had to be discarded, leaving 185 in the sample, and 35 years of information. The purpose is to contrast some myths that seem to be deeply rooted in conventional wisdom, even among specialists, with the objective facts about the subject in question.

Macroeconomic stability in today's globalized world is a complex issue, but one that can be broken down into three dimensions. A first, nominal dimension refers to price stability and what happens in its absence , which is excessive inflation or, worse, hyperinflation and, in a small number of cases, deflation. A second dimension is real stability, which refers to the stability of economic activity and employment; its loss produces cyclical volatility and, in worst case scenarios, recessions or depressions. The third dimension is external stability, namely the sustainability of balance-of-payments accounts, and its loss can be evidenced by reversals of the balance-of-payments current account balance after reaching unsustainable levels. The causes and effects of each of these dimensions of instability manifest themselves in the financial system and are highly complex and important, but examining them is beyond the scope of this paper, so it is preferable to leave the discussion of financial stability for another occasion.

Macroeconomic stability, in its various dimensions, is in itself desirable because it implies less uncertainty for risk-averse economic agents. Risk aversion is related to a positive, but decreasing, marginal utility of income, so that for the same average income level, greater volatility reduces well-being. Nominal instability creates uncertainty in the price level and also in relative prices because inflation does not affect all goods and services equally or at the same time. Meanwhile, real instability generates variability and consumption uncertainty because there are no perfect capital markets that allow unlimited use of savings and dissavings to even out consumption in the face of income fluctuations. Lastly, external instability generates uncertainty regarding a country's payment capacity, contributing to the shortcomings of international capital markets, sudden-stops in external financing and eventually leads to balance-of-payments crises that have significant real effects. Thus, macroeconomic instability will only be efficient in terms of social well-being if it allows for significantly higher GDP growth that sufficiently compensates for the uncertainty generated by volatility. The burden of proof in favour of instability lies in demonstrating that it generates significantly higher GDP growth.

This article will explore the correlation between GDP growth and the different dimensions of macroeconomic stability —price, real and external stability—, based on more descriptive statistical relationships and a review of the literature on this issue. In addition, more sophisticated methodologies will be used to try to prove statistical significance and causality in the relationships identified, by performing different regressions for the data panel that is available for 185 countries and spanning 35 years. The aggregate data have limitations and do not allow us to estimate a structural model that explains inflation, growth or the current account, so we will limit ourselves to identifying general results, putting forward some hypotheses on more detailed causal effects.

II. The relationship between macroeconomic stability and growth

Macroeconomic stability can be defined and measured in different dimensions, including real, nominal and external stability, which we will use in this paper. Real stability is related to sustained and stable growth in economic activity and employment, and is measured by business cycle indicators, such as the unemployment rate or the output gap. For the sake of convenience we will use the output gap, which is measured as the logarithmic difference between actual or short-term GDP and trend or medium-term GDP. The gap converges to an average of zero in the long term, so in order to measure stability the gap's volatility it the variable used to represent the volatility of the economic cycle or real instability. Complete stability is achieved when volatility is zero, which indicates a non-cyclical economy following trend GDP growth.

$$Vol\ gap(GDP_{i,t}(5))=Vol(ln(GDP_{i,t}(5)) - ln(GDP_{i,t}(5))^{T})$$

We measure real volatility as the standard deviation of the output gap over a five-year rolling window $Vol\ gap(GDP_{i,t}(5))$. Overzealous demand policies that force subsequent corrective or "stop-and-go" actions escalate nominal, real and external macroeconomic instability, increasing, among other things, output gap volatility. Conversely, well-designed policies that are defined as countercyclical contribute to real stability.

1. Volatility and growth

Real instability is not harmless; we know that it affects well-being because it makes it difficult for risk-averse agents to smooth consumption over time. No available data demonstrate that real macroeconomic instability boosts GDP growth; on the contrary, there is some information in the literature that growth is negatively affected by volatility, but only in certain periods and for a certain duration. In particular, Zarnowitz and Moore (1986), when analysing the period between 1903 and 1981, find that output growth tends to be lower in periods of high volatility. With more recent information, Blanchard and Simon (2001) argue that the two largest expansions of the United States economy coincided with a large underlying decline in output volatility.

Fact No. 1: Real volatility does not accelerate GDP growth; on the contrary, in the medium-term and for certain periods, it slows it down

When observing aggregate data from the base period, it can be seen that trend GDP growth is negatively correlated with output gap volatility. But in the long term (1980–2015), the effect of output gap volatility on trend growth is less and the R-squared is low, barely more than 0.02. For every percentage point increase in the volatility of the output gap, the GDP growth rate falls by 0.1% (see figure 1). But the effect is different in shorter periods; for example, in the first years of the twenty-first century (2001–2015), the response of GDP growth to ouput gap volatility becomes somewhat more marked, with a 0.25% drop in annual growth for each additional percentage point of output gap volatility. Moreover, the R-squared of this ratio is higher in this shorter period, reaching a level above 0.09 (see figure 2).

Figure 1
Output gap volatility and trend GDP growth, 1980–2015
(Percentages)

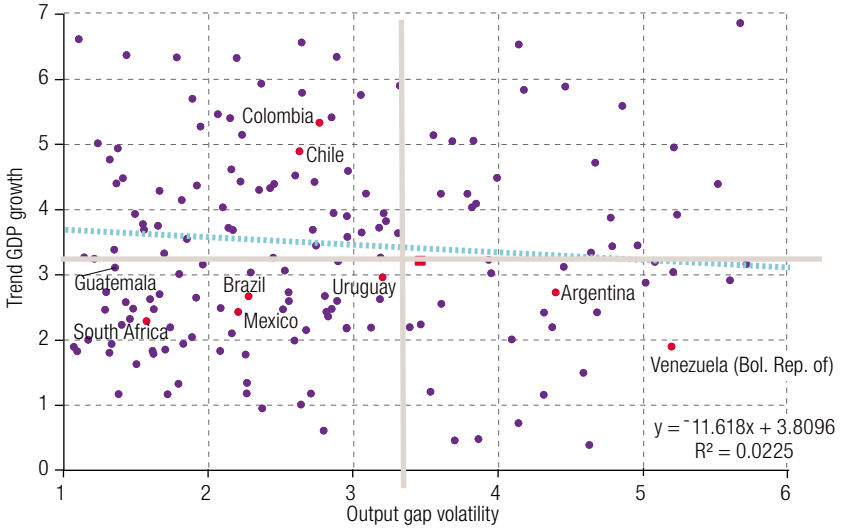


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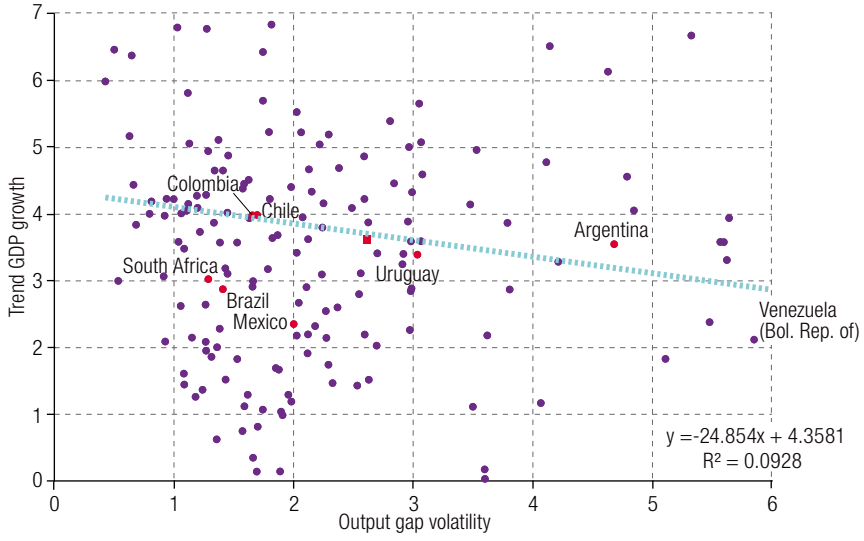
Figure 2
Output gap volatility and trend GDP growth, 2001–2015
(Percentages)



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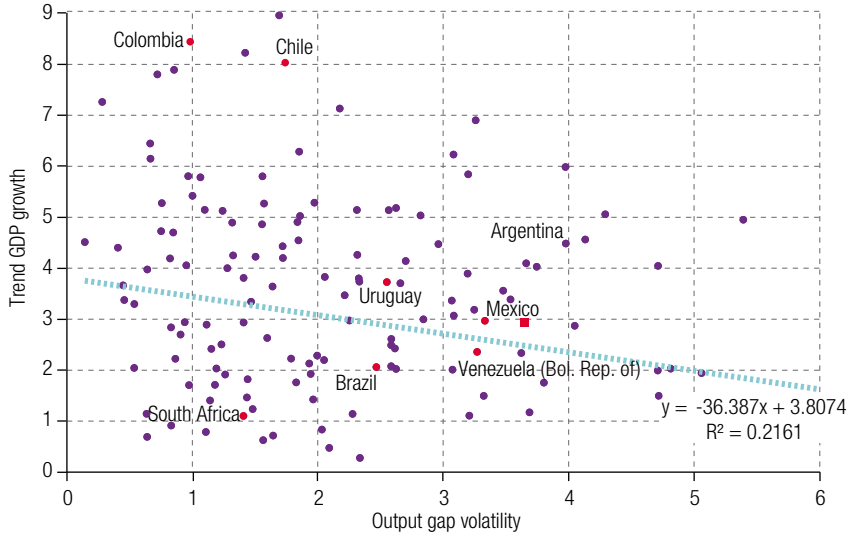
Of the countries identified as belonging to the comparison group, Colombia and Chile have the highest trend GDP growth rate in the 2001–2015 period, with expansion rates of around 4% per year, between 0.5 and 1.0 percentage points above the rest of the group. Their growth rates exceed those of countries whose real volatility is four times greater, such as the Bolivarian Republic of Venezuela; three times greater, such as Argentina; two times greater, such as Uruguay and Mexico; or is similar or less, such as Brazil and South Africa.

Lastly, in the 1991–1995 period, when some countries such as Colombia and Chile registered high growth rates, the negative correlation between output gap volatility and GDP growth rate becomes even stronger (see figure 3). An increase of 1 percentage point in the volatility of the output gap reduces the trend GDP growth rate by 0.36 percentage points, and in addition the R-squared of the ratio rises to 0.22.[2]

Figure 3
Output gap volatility and trend GDP growth, 1991–1995
(Percentages)



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2. Inflation and growth

A second definition of macroeconomic instability is nominal instability. In practice, inflation is the best synonym for nominal macroeconomic instability, as deflation or negative inflation occurs rarely and for limited time periods. Japan's economy has been the global deflation model in recent years; yet its long-term average inflation rate (1980–2015) was 0.85%, while its average inflation in the first years of this century (2001–2015) was 0.06% per year, virtually zero, but under no circumstances deflation.

Downward price rigidity justifies a favourable role for a certain positive inflation rate, which can grease the wheels of the economy by facilitating relative price adjustments, increased resource utilization and, thus, higher economic growth. The problem is that the effect of a certain rate of inflation is extrapolated to any rate of inflation, and so in some situations, some people will call for "a little more inflation to encourage more growth", regardless of the initial rate of inflation.

Myth No. 1: A little more inflation boosts growth

Cross-sectional and long-term data (1980–2015) for a wide range of countries do not support such a positive relationship between growth and inflation.[3] Rather, the aggregate data seem to support

[2] The greatest effect of gap volatility on trend growth occurred in the early 1990s. However, these are very preliminary estimates for all countries and for a particular period. These should be confirmed or reviewed by performing panel econometric modelling using the data from the individual countries and for the whole period analysed, which will be attempted in section III.

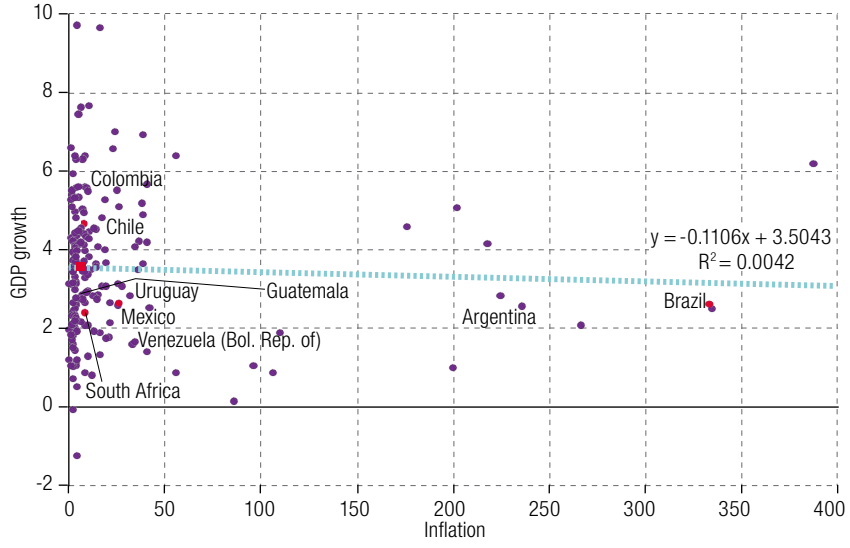
[3] Inflation is calculated as the annual percentage change in the annual average consumer price index (CPI) obtained from the International Financial Statistics of the International Monetary Fund (IMF, 2020). Growth is the percentage change in real GDP and is obtained from the IMF World Economic Outlook database (IMF, 2016).

the hypothesis of the superneutrality of money, which indicates that there is no correlation between GDP growth and inflation in the long term, a result that was presented by Sidrauski (1967) more than half a century ago and has been reaffirmed by various authors. Barro (1995) seeks to put forward a counterproposal to this result, by analysing empirically the effect of inflation on growth. He concludes that, by controlling for a wide range of characteristics, an increase in average inflation of 10 percentage points per year leads to a reduction in the growth rate of real per capita GDP by 0.2–0.3 percentage points per year. This is a small effect, which only appears when high inflation observations are included in the sample, but it would still have a significant cumulative effect in the long term.

For shorter periods and in studies with refined methodologies, a negative correlation between inflation and growth prevails, at least above certain thresholds. The negative relationship between inflation and growth is only present with high frequency data and extreme inflation: growth falls sharply during high inflation crises, then recovers rapidly after inflation falls, as established by Bruno and Easterly (1998), among others. Meanwhile, Faria and Carneiro (2001) find that, in an economy facing persistent high inflation, like Brazil, inflation does not impact real output in the long run, but in the short run there exists a negative effect from inflation on output. Lastly, in an interesting paper, Khan and Senhadji (2001) find a threshold level of inflation above which inflation significantly slows growth. This relationship is robust with respect to the estimation method and alternative specifications. For developing countries, the inflation threshold above which growth begins to be negatively affected is 11–12% per year.

In practice, the relationship between average inflation and growth rates with long-term data for 185 countries confirms the superneutrality hypothesis. There seems to be no correlation between growth and inflation; the estimated parameters have no statistical significance. Figure 4 shows that some Latin American economies stand out from the point cloud because of their high long-term average inflation (1980–2015), particularly Brazil and, to a lesser extent, Argentina. For more recent periods (2001–2015), the high average inflation in the Bolivarian Republic of Venezuela is notable.

Figure 4
GDP growth and inflation rate, country averages, 1980–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.
Note: The red square indicates the average for the variable.

In reality, it seems that sustained growth is the result of cumulative factors, physical, human and working capital, and the resulting increased productivity, but this has no relation to price inflation, which is due to the excessive expansion in the means of payment. But the correlation between inflation and growth may also be a matter of timing and thresholds: above a certain positive inflation rate, a negative correlation between inflation and growth appears. What is clear is that there is no empirical basis for claiming that higher inflation will led to greater GDP growth, at least not from any initial rate of inflation. The situation would be different if the initial inflation rate was zero or negative.

3. Disinflation and its real costs

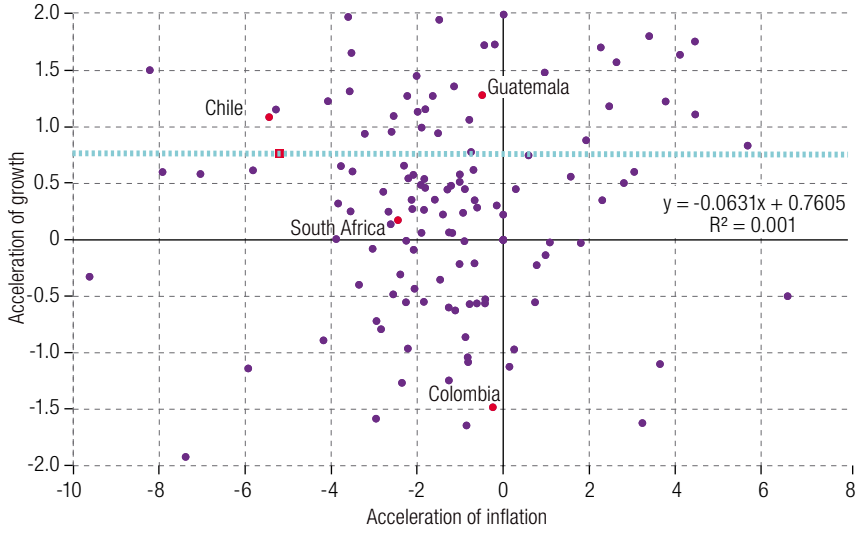
Nominal instability or high inflation can have immense costs in the form of distorted resource allocation and income distribution, which depend on the magnitude of the inflation rate and the value of the transfers that can be generated by it. However, when given the option of stabilizing an inflationary economy, there are often those who would point out the possible real costs of this process and, therefore, how inconvenient it would be to implement.

Myth No. 2: Stabilization necessarily generates significant real costs

Even if the direct benefits of stabilization —overcoming the costs and problems caused by inflation— are ignored, there is no clear evidence that the real costs of stabilization, in terms of the impact on output, will persist in the medium term, much less the long term.

For 15-year periods, the relationship between inflation and growth acceleration is tenuous, barely negative in the period 1986–2000 (see figure 5) and somewhat more negative in the period 2001–2015 (see figure 6); in both cases, the relationship is significantly different from zero. The available data also show that disinflation has been possible for many countries with high average GDP growth rates or without any further slowdown in growth.

Figure 5
Acceleration of inflation and growth, 1986–2000
(Percentages)



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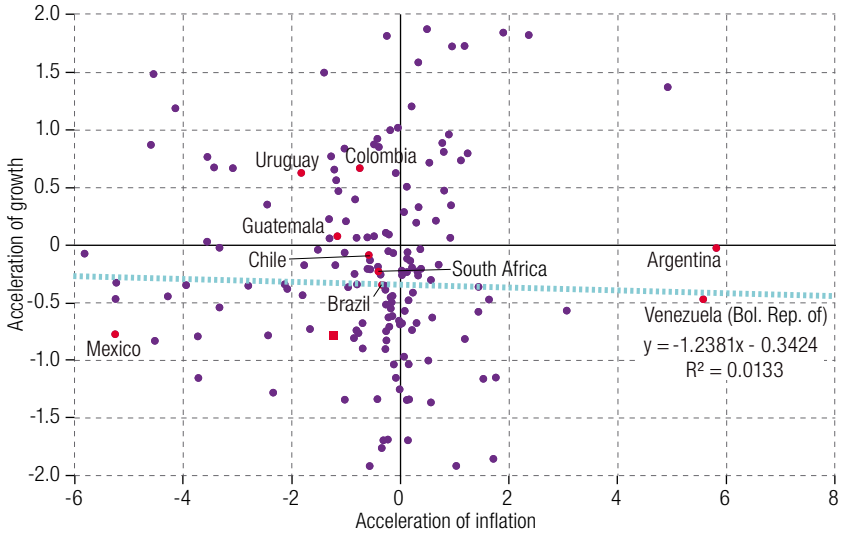
Note: The red square indicates the average for the variable.

Figure 6
Acceleration of inflation and growth, 2001–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.
Note: The red square indicates the average for the variable.

The available empirical information indicates that it is perfectly possible to achieve nominal stability without affecting the growth of real activity, although higher costs may be paid in the short term, which could be avoided by means of an appropriate stabilization strategy; that is, by regulating the pace of disinflation and adopting exchange rate flexibility and, possibly, inflation targets; however, there is no broad agreement in the literature on this matter. While Christoffersen and Doyle (1998) indicate that rapid disinflation has been associated with output losses only in the presence of pegged exchange rates, Calvo, Celasun and Kumhof (2003) note that inflation inertia means that the costs of disinflation would be significant for a small open economy with a flexible exchange rate. Meanwhile, Végh (1992) and Calvo and Végh (1999) point out that disinflation will have real costs regardless of the exchange rate; however, the time frame in which these costs become apparent will depend on the type of nominal anchor chosen.

More importantly, as Ghosh and Steven (1998) state, the short-term costs of disinflation are only relevant for the most rapid and severe disinflations, or when the initial inflation rate is low or well within the single-digit range, that is less than 10% per year. Loungani and Sheets (1997) show that the type of disinflation matters, and that greater central bank independence is associated with lower rates of inflation, beyond what can be explained by the initial conditions, fiscal reform and other structural reforms. But they also find that in the 26 countries that transitioned from a command economy to a market-based economy there was a strong and robust negative relationship between inflation and growth. The adverse effect of inflation on investment appears to be the channel through which this relationship is established and transmitted.

4. Nominal and real volatility

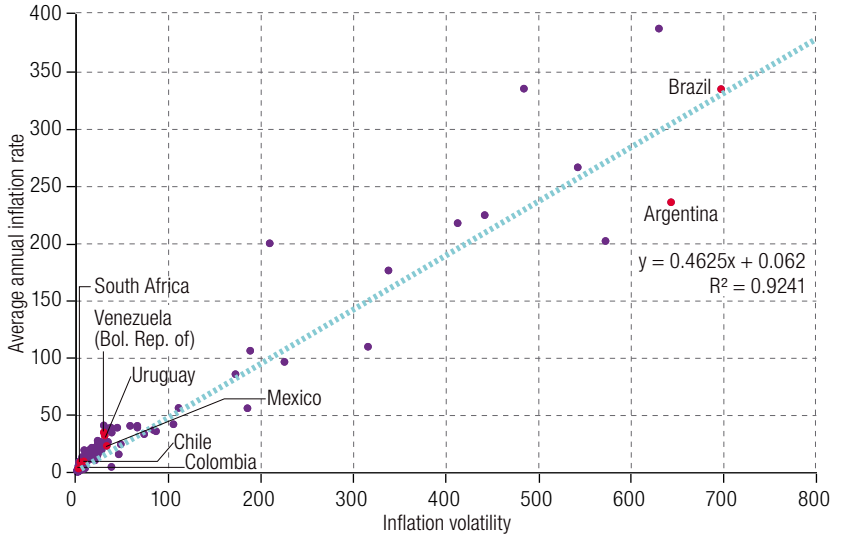
The myths are contradicted by the fact that higher inflation generates greater volatility. Thus, a "little bit more inflation" creates more nominal and real volatility instead of more GDP growth.[4]

[4] Nominal volatility is measured as the standard deviation of annual inflation during a specific period.

Fact No. 2: A little more inflation generates more nominal volatility

The relationship between the average rate of inflation and inflation volatility is clearly positive and quite strong in the long term. This correlation is also evident in all the subperiods considered. Most Latin American countries had long-term average inflation rates well below 100% between 1980 and 2015. The exceptions were Argentina and Brazil, which had average inflation rates of between 600% and 700%, which are largely associated with the hyperinflation that these countries experienced towards the end of the twentieth century (see figure 7).

Figure 7
Average rate of inflation and inflation volatility, 1980–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.

Between 2001 and 2015, most Latin American economies had average inflation rates of less than 10% (see figure 8). The exceptions are the Bolivarian Republic of Venezuela, with average annual inflation of almost 35% and high volatility, and Argentina, with an average annual inflation rate of just over 10%. Nevertheless, Argentina has an average rate of inflation and inflation volatility that are twice that of Brazil, Chile and Colombia, while the inflation rate and inflation volatility of the Bolivarian Republic of Venezuela are more than seven times that average. Uruguay and Brazil appear to have relatively low inflation volatility in relation to their average inflation rate. In contrast, Chile and Colombia have much lower inflation rates, but their volatility is relatively similar to the aforementioned countries. The Bolivarian Republic of Venezuela and Argentina have average inflation rates as well as clearly higher volatility, which separate them from the cohort, as well as from the rest of the Latin American countries.

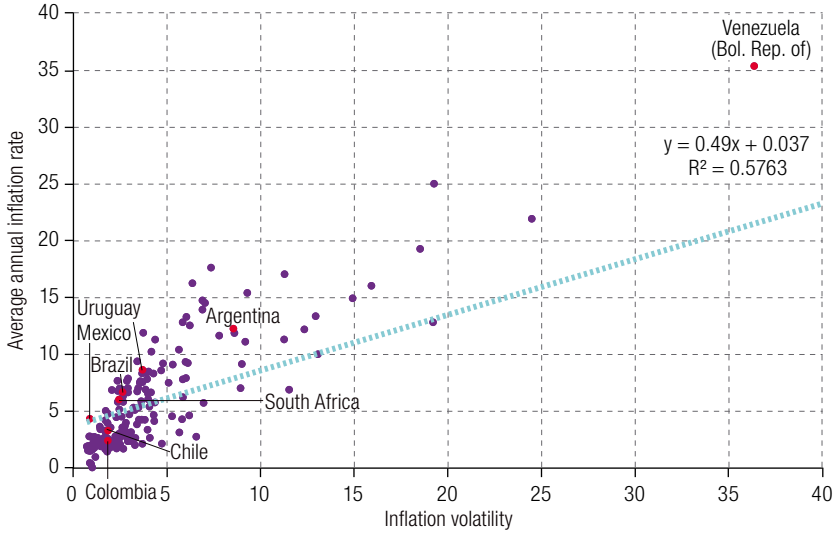
Fact No. 3: Higher nominal volatility in general is associated with greater real volatility

Another interesting fact is that inflation volatility is not merely a harmless or inconsequential nominal volatility. It is also related to real volatility or output gap volatility. It is not as strong a relationship as that between inflation volatility and the average inflation rate; in fact, the relationship between inflation volatility and output gap volatility is nonlinear and real volatility decreases when levels of nominal volatility are high.[5]

[5] Real volatility is calculated as the standard deviation of the output gap. Trend GDP is a seven-year average, centered on the fourth year.

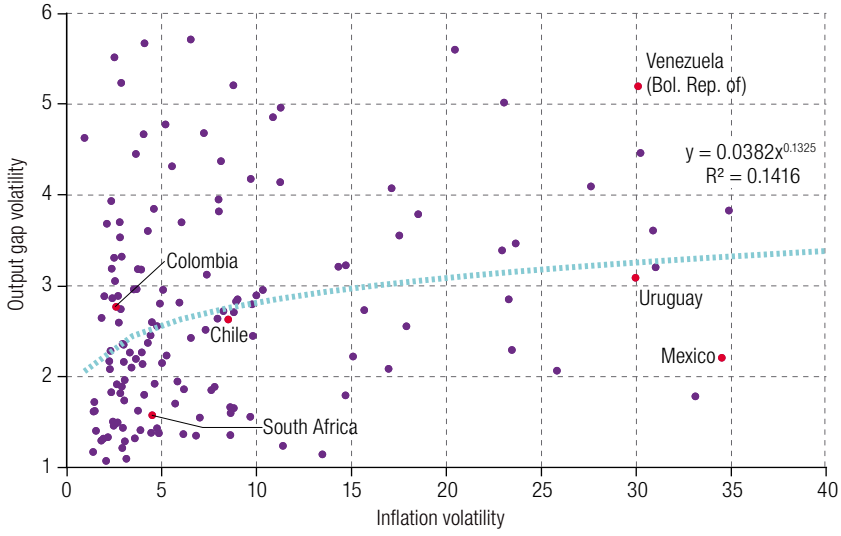
In other words, the relationship becomes flatter when levels of nominal volatility are high (see figure 9). In any case, for intermediate nominal volatility levels, an increase in those levels is associated with higher real volatility, with an R-squared of between 0.13 and 0.14, depending on the period under analysis.

Figure 8
Average rate of inflation and inflation volatility, 2001–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.

Figure 9
Inflation volatility and output gap volatility, 1980–2015
(Percentages)



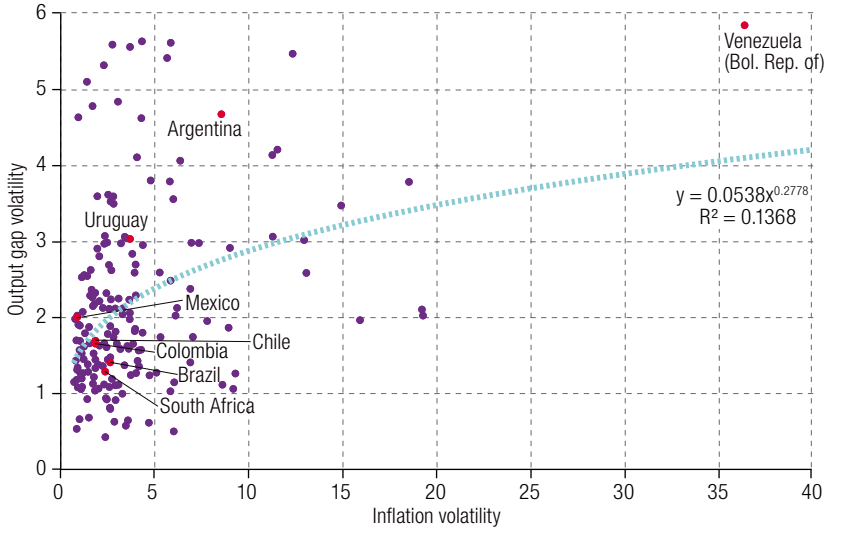
Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.

In the long term (1980–2015), the Bolivarian Republic of Venezuela, Uruguay and Mexico have relatively high inflation volatility, equivalent to three times that of Chile. But while the Bolivarian Republic of Venezuela

has a real or output gap volatility equivalent to more than twice that of Chile, Uruguay's is barely 30% higher and Mexico's is similar or even lower (see figure 9).[6] This indicates that there are other factors or variables that also contribute to real volatility, as will be discussed below.

For the period 2001–2015, the positive correlation between nominal and real volatility is also true. In this regard, the nominal and real volatility in the Bolivarian Republic of Venezuela are noteworthy, given that they are much higher than that of the rest of the region's countries during this period (see figure 10). The nominal volatility of the Bolivarian Republic of Venezuela is equivalent to more than seven times that of Chile, while its real volatility is equivalent to three times that of Chile in the period 2001–2015. The nominal and real volatility of Argentina are also high, more than twice those of Chile; in the case of Uruguay, the nominal volatility is similar to that of Chile, but its real volatility is 50% higher. Evidence suggests that output gap volatility is positively correlated with inflation volatility, although the latter does not have a unique or determinant effect.

Figure 10
Inflation volatility and output gap volatility, 2001-2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.

5. External and real volatility

It can be hypothesized that the growth problem in many emerging economies is one of external resource constraints; if they were able to finance large current account deficits it would encourage investment and boost GDP growth rates. This creates the myth that external capital inflows would stimulate growth.

Myth No. 3: Strong capital inflows that finance large current account deficits stimulate growth

Unfortunately, massive capital inflows do not always finance profitable investments and their reversals often lead to balance-of-payments crises with the usual negative effects on the financial system and on growth in economic activity and employment. In several articles, Calvo correlated balance-of-payments

[6] Inflation volatility in Argentina and Brazil was so high that they do not appear on the graph —the scale of which has a maximum of 40%—, owing to periods of hyperinflation in the twentieth century.

crises to sudden stops in capital inflows, stressing the importance of fiscal institutions and public debt in avoiding this source of instability (Calvo, 2003). Edwards (2002 and 2004) also produced various papers that focus on the costs of maintaining high external debts that lead to current account reversals, whereby large deficit episodes are followed by more or less abrupt adjustments that produce transient effects on growth and increase real volatility. Furthermore, Edwards points out that, in general, current account reversals are linked to sudden stops of capital inflows.

Several other authors have also analysed the phenomena associated with external stability, including Milesi-Ferretti and Razin (1998), who examine which factors help to predict current account reversals and how these events affect a large number of variables relevant to macroeconomic stability. Thus, low reserves and external factors, such as unfavourable terms of trade or high interest rates in industrialized economies, often trigger sharp current account reversals, starting from a high deficit level, especially in developing countries. However, according to Milesi-Ferretti and Razin, the effects of reversals on long-term growth are not as clear because there are other factors that also influence the post-reversal performance. Thus, high and stable rates of saving and investment, financial development, low inflation rates and good economic policy can enable countries to emerge from current account reversals with even higher growth rates than those experienced before the reversal. Conversely, without these factors, the effects of reversals on growth can be more profound and long-lasting. Last but not least, countries with more flexible exchange rate regimes are better able to adjust to current account reversals than those with fixed exchange rates. They can also achieve a better post-crisis macroeconomic performance. In addition, openness and financial development are important issues when analysing reversals. Those countries that allow the free movement of capital and have no internal liquidity restrictions are able to better cope with these events.

Current account reversals *(REV(CA))* are basically changes in the moving average of the current account balance *(CAB)* expressed as a percentage of GDP *(CA)*.[7] Thus, when economies' current account deficits widen this produces a negative reversal first and then, when it is corrected, a positive reversal. A current account reversal is defined by taking the anticipated and lagged three-year moving averages of the current account balance, expressed as a percentage of GDP. The difference between the two is the indicator of reversals. If it is positive, it indicates a correction or the end of a deficit period; if it is negative, it indicates the opposite, that the deficit is widening. The literature examines some criteria that must be met for the change in the current account balance to be considered a reversal, including that the average reduction in the current account deficit must be at least 3 percentage points of annual GDP; that the deficit must be reduced by at least one third with respect to the deficit or surplus before the event; and, third, that the sign indicates whether it is a reversal from a deficit or a surplus. We then define the current account reversal *(REV(CA))* as the difference between the average current account balance for the three-years after the event *(t+j)* and the average balance for the previous three-years *(t-i)*, where *j* and *i* range from 1 to 3. The current account balance is measured as a percentage of GDP.

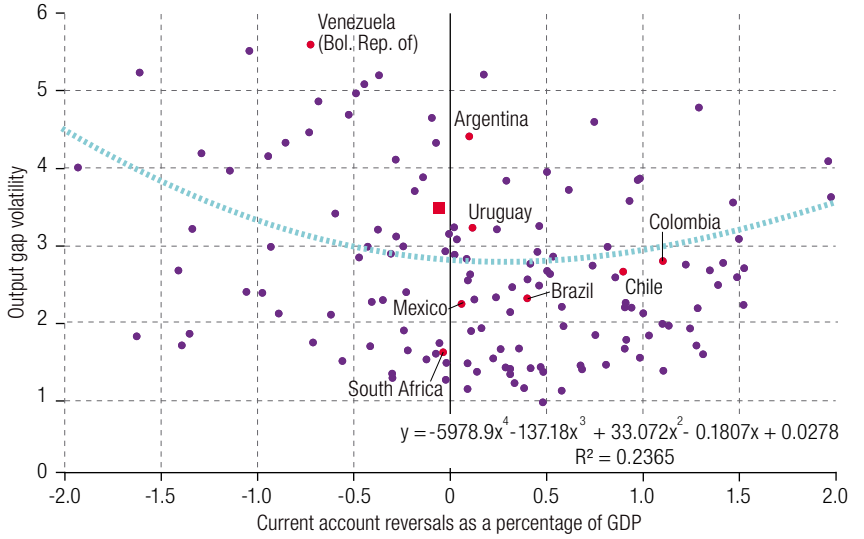
$$REV(CA)_t = \frac{\sum_{j=0}^{2} CA_{t+j}}{3} - \frac{\sum_{i=1}^{3} CA_{t-1}}{3}$$

$$CA_t = CAB_t / GDP_t$$

There is a non-linear relationship between average current account reversals and output gap volatility in the period 1980–2015. Thus, output gap volatility is minimal when the reversal is non-existent, tends to zero or is slightly positive (see figure 11). Volatility increases when the absolute value of the reversal is higher, but the effect is small and asymmetrical, weighted towards negative reversals. An increase in the average current account reversal from 0% to 2% of GDP increases output gap volatility by 0.5 percentage points; but a fall in the current account reversal from 0% to -2% of GDP increases output gap volatility by 1.5 percentage points.

[7] Current account balances expressed as percentages of GDP were obtained from the World Economic Outlook database (IMF, 2016).

Figure 11
Output gap volatility and current account reversals as a percentage of GDP, 1980–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.
Note: The red square indicates the average for the variable.

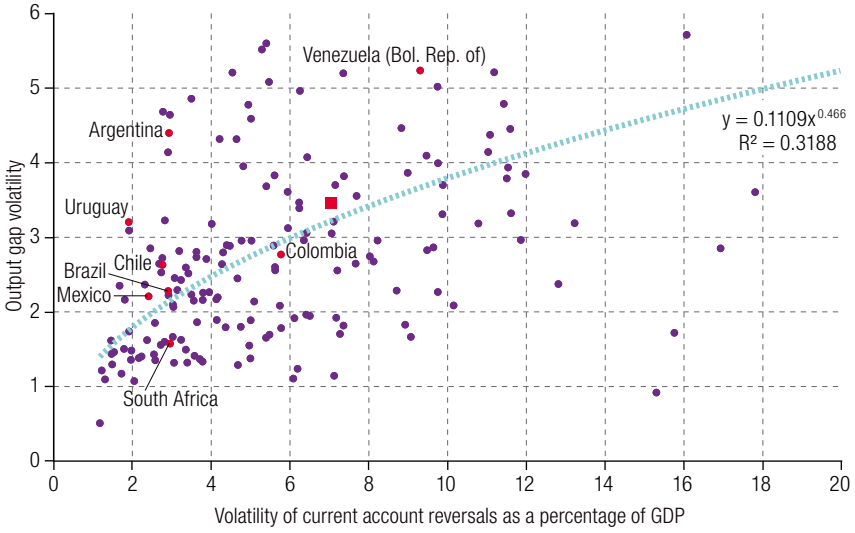
If, instead of focusing on the average current account reversal, the analysis focuses on its volatility, the relationship between external instability and real instability is much more evident. There is a significant positive correlation between the volatility of the current account reversal and output gap volatility. According to the estimated norm, an increase in the volatility of the current account reversal from 2% to 4% increases output gap volatility from 1.8% to 2.5%. The relationship is nonlinear and the effect on real volatility is smaller for higher levels of external volatility, but in any case the R-squared exceeds 0.32.

Fact No. 4: Current account reversals are associated with higher real volatility

For some Latin American economies, current account reversals have not been the main source of real volatility in the last 30 years, but for others, the volatility of reversals, or external volatility, comes very close to explaining output gap volatility (see figure 12). While the volatility of current account reversals in the period 1980–2015 for some countries is between 2% and 4% (Uruguay, Brazil, Chile, Mexico and Argentina), others register between 6% and 8% (Colombia and the Bolivarian Republic of Venezuela). Most notably, almost all of them are in a low volatility range for current account reversals and, with the exception of the Bolivarian Republic of Venezuela, below the global average.

At the same time, these economies have very different output gap volatilities, ranging from the Bolivarian Republic of Venezuela and Argentina, with values of over 4% and above the global average for real volatility, to Mexico and Brazil, with values close to 2%, well below the global average for real volatility. Furthermore, while output gap volatility in Brazil, Mexico, Chile and Colombia is close to the norm and is therefore "explained" by the volatility of their current account reversals, output gap volatility in Uruguay, Argentina and the Bolivarian Republic of Venezuela is much higher than the norm, indicating that there are other factors that explain the real volatility in these countries. From the outset, these last three countries had significant levels of nominal volatility, from which it could be concluded that external volatility and nominal volatility added to real volatility. This is certainly an interesting hypothesis to explore with more sophisticated econometric methods.

Figure 12
Output gap volatility and the volatility of current account reversals, 1980–2015
(Percentages)



Source: Prepared by the authors, on the basis of International Monetary Fund (IMF), "World Economic Outlook Database", 2016 [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.
Note: The red square indicates the average for the variable.

III. Econometric methodology and results

The relationships that we have been able to establish on the basis of data from all the countries, aggregated over different periods of time, do not allow us to test hypotheses and are instead descriptive of the situation. The econometric panel data methodology allows relevant parameters to be estimated and provides evidence of their significance, which may possibly support the hypotheses put forward in section II. We will estimate different relationships using data from the World Economic Outlook database, which provided us with a sample of annual data for 189 countries ranging from 1984 to 2015 (IMF, 2016).

1. Growth and volatility

The data used correspond to the five-year moving average for GDP growth and, as in the first models, volatility, such as output gap volatility *(VolGDP)*, is also measured in five-year windows. The following equation has been defined, where volatility explains growth:

$$dlogGDP_{i,t}(5) = \eta + \alpha_1 VolGDP_{i,t} + u_{i,t}$$

The simplicity of the equation should not be confused with the importance of the result. It seeks to show the nature of the relationship between output gap volatility and GDP growth. Two equations will be estimated, one for all the countries in the sample and the second for countries with output gap volatility of less than 50%. The results are shown in table 1.

Table 1
GDP growth and output gap volatility, sample of 189 countries, 1984–2019

Variables	(1) VolGDPL GDPP5	(2) VolGDPL50 GDPP5
VolGDP	-0.126***	-0.212***
	(0.00914)	(0.0134)
Constant	7.619***	8.468***
	(0.261)	(0.261)
Fixed effect (year)	No	No
Fixed effect (country)	No	No
Observations	6 237	6 138
Number of countries	189	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses. *** p<0.01; ** p<0.05; * p<0.1.

As expected, output gap volatility has a negative and statistically significant impact at 1% on trend GDP growth. It is interesting to note that the effect of volatility on growth is equally negative and significant, but of much greater absolute value, when extreme or atypical cases (those countries with excessive and persistent volatilities), are removed from the sample. This result is consistent with the preliminary information presented in the previous section.

2. Interaction between threshold and volatility

It has been proposed to incorporate additional models to include effects on levels of and with respect to thresholds for the relationship studied between GDP growth and output gap volatility. The data used correspond to the five-year moving average for GDP growth and, as in the first models, output gap volatility is also measured in five-year windows, represented by $VolGDP_{i,t}$; additionally, a dummy variable is incorporated, represented by $DVolGDP_{i,t}$, which takes a value of 1 for countries with an output gap volatility greater than 50%, and an interaction between this variable and $VolGDP_{i,t}$. The models to be estimated are:

$$GDP_{i,t}(5) = \eta + \alpha_1 VolGDP_{i,t} + \alpha_2 DVolGDP_{i,t} + \alpha_3 VolGDP_{i,t} \cdot DVolGDP_{i,t} + u_{i,t}$$
$$GDP_{i,t}(5) = \eta + \delta_t + \alpha_1 VolGDP_{i,t} + \alpha_2 DVolGDP_{i,t} + \alpha_3 VolGDP_{i,t} \cdot DVolGDP_{i,t} + u_{i,t}$$
$$GDP_{i,t}(5) = \eta + \delta_t + \delta_i + \alpha_1 VolGDP_{i,t} + \alpha_2 DVolGDP_{i,t} + \alpha_3 VolGDP_{i,t} \cdot DVolGDP_{i,t} + u_{i,t}$$

When calculating the aforementioned relationships, it is found that the results of the three equations demonstrate the same correlations, whereby output gap volatility generates less growth. Moreover, this negative effect will be more pronounced the more fixed effects are incorporated into the estimate. In turn, volatility above the 50% threshold produce an abrupt fall in growth rates; that is, countries with very high volatility grow little or undoubtedly suffer from recessions. Meanwhile, the interactive variable *(VolGDPDVolGDP)* shows that, for certain volatility points, combined with persistently high volatilities, higher growth is generated; this can be explained by countries' special circumstances, such as that of the Syrian Arab Republic, which years before the sub-prime crisis had very high negative growth, while after the crisis it recovered all or part of its lost growth (see table 2).

Table 2
GDP growth and output gap volatility, effects on levels and with respect to thresholds, sample of 189 countries, 1984–2019

Variables	(1) dlogGDPP5	(2) dlogGDPP5	(3) dlogGDPP5
VolGDP	-0.212***	-0.241***	-0.283***
	(0.0147)	(0.0139)	(0.0144)
DVolGDP	-14.48***	-14.76***	-15.39***
	(2.245)	(2.008)	(2.001)
VolGDPDVolGDP	0.272***	0.291***	0.323***
	(0.0300)	(0.0271)	(0.0274)
Constant	8.488***	2.897***	5.908***
	(0.283)	(0.621)	(1.828)
Fixed effect (year)	No	Yes	Yes
Fixed effect (country)	No	No	Yes
Observations	6 237	6 237	6 237
Number of countries	189	189	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

3. Nominal and real volatility

To estimate how growth behaves around nominal and real volatilities, we used a sample consisting of 189 countries in total and 186 countries when only those countries with less than 50% of inflation volatility are considered, with data from 1984 to 2019. The data used correspond to the five-year moving average for GDP growth and, as in the first models, volatility, such as output gap volatility, is also measured in five-year windows. The following model was determined:

$$VolInf_{i,t} = \eta + \alpha_1 Inf_{i,t}(5) + u_{i,t}$$

The model estimations were then carried out twice, once for all the countries and once omitting countries with inflation volatility above 50% (see table 3).

Table 3
Panel regression for inflation and inflation volatility, sample of 189 countries, 1984–2019

Variables	(1) VolINFL VolInf	(2) VolINFL50 VolInf
InfP5	0.102***	0.0493***
	(0.000887)	(0.00106)
Constant	1.798e+09*	3.747***
	(1.021e+09)	(0.403)
Fixed effect (year)	No	No
Fixed effect (country)	No	No
Observations	6 260	5 924
Number of countries	189	186

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

From column (1) of table 3 it can be seen that the model provides statistically significant estimates that show that inflation volatility is greater when the inflation rate is higher. With regard to the estimate for those countries with volatility below 50%, the effect is even more evident and decisive; in general, the average volatility is 3.7% and each extra percentage point of inflation generates an additional 0.049% of volatility.

It is possible to try to improve the relationship between real volatility and nominal volatility by introducing distinctions with respect to inflation levels.

$$ln(VolGDP_{i,t}) = \eta + \delta_i + \delta_t + \alpha_1 ln(VolInf_{i,t}) + \alpha_2 D(Inf_{i,t}(5) > 10\%) + u_{i,t}$$

The results indicate that the increase in inflation volatility generates positive and significant effects on output gap volatility. However, the constant is lower for high volatility levels. Thus, the results of the panel estimation reproduce what was observed by crossing the variables (see table 4).

Table 4
Panel regression for output gap volatility and inflation volatility
sample of 189 countries, 1984–2019

Variables	(1) EQ2 ln(VolGDP)
Ln(VolInf)	0.0389***
	(0.00776)
DInf	-0.545***
	(0.0420)
Constant	2.110***
	(0.156)
Fixed effect (year)	Yes
Fixed effect (country)	Yes
Observations	6 185
Number of countries	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

In order to explore further the empirical correlation between nominal and real volatilities, we decided to use the following polynomial models to estimate this relationship, three of them without the dummy variable that indicates output gap volatility over 50%, and another that includes it (it should also be noted that the estimate has only been made for countries with inflation volatility under 50%):

$$VolGDP_{i,t} = \eta + \delta_t + \alpha_1 VolInf_{i,t} + \alpha_2 VolInf_{i,t}^2 + \alpha_3 VolInf_{i,t}^3 + u_{i,t}$$
$$VolGDP_{i,t} = \eta + \delta_i + \alpha_1 VolInf_{i,t} + \alpha_2 VolInf_{i,t}^2 + \alpha_3 VolInf_{i,t}^3 + u_{i,t}$$
$$VolGDP_{i,t} = \eta + \delta_t + \delta_i + \alpha_1 VolInf_{i,t} + \alpha_2 VolInf_{i,t}^2 + \alpha_3 VolInf_{i,t}^3 + u_{i,t}$$
$$VolGDP_{i,t} = \eta + \delta_t + \delta_i + \alpha_1 VolInf_{i,t} + \alpha_2 VolInf_{i,t}^2 + \alpha_3 VolInf_{i,t}^3 + \alpha_4 DVolGDP50_{i,t} + u_{i,t}$$

The results of the estimations are presented in table 5.

All models use the third degree polynomials for inflation volatility as explanatory variables. In particular, the second and third degree polynomials appear to have greater statistical significance than the first degree component, which may be due to the large variance of the data and the use of fixed effects models that may be capturing variations in inflation volatility. As in the previous case, the marginal effect of inflation volatility on output gap volatility is positive for inflation volatility levels below 5% and above 35%. That is to say, for both low and high inflation volatility, the marginal effect of inflation volatility on output gap volatility is clearly positive and statistically significant.

Table 5
Polynomial models for output gap volatility and inflation volatility, sample of 181 countries, 1984–2019

Variables	(1) GDPINF VolGDP	(2) GDPINF2 VolGDP	(3) GDPINF3 VolGDP	(4) GDPINF4 VolGDP
VolInf	0.185	0.00938	0.170	0.116
	(0.113)	(0.113)	(0.115)	(0.0819)
VolInf2	-0.0193***	-0.0179**	-0.0202***	-0.00877*
	(0.00691)	(0.00713)	(0.00700)	(0.00499)
VolInf3	0.000332***	0.000338***	0.000355***	0.000136*
	(0.000112)	(0.000117)	(0.000113)	(8.08e-05)
DVolGDP50				61.72***
				(0.872)
Constant	10.02***	15.93***	15.22***	14.95***
	(1.119)	(2.645)	(2.702)	(1.927)
Fixed effect (year)	Yes	No	Yes	Yes
Fixed effect (country)	No	Yes	Yes	Yes
Observations	5 397	5 397	5 397	5 397
Number of countries	181	181	181	181

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
******* p<0.01; ** p<0.05; * p<0.1.

4. Inflation and growth

We undertook a panel estimate that sheds some light on the relationship between economic growth and inflation. The models to be estimated are:

$$dGDP_{i,t}(5) = \eta + \alpha_1 Inf_{i,t} + \alpha_2 DInf0_{i,t} + \alpha_3 DInf5_{i,t} + \alpha_4 DInf10_{i,t} + u_{i,t}$$
$$dGDP_{i,t}(5) = \eta + \delta_i + \delta_t + \alpha_1 Inf_{i,t} + \alpha_2 DInf0_{i,t} + \alpha_3 DInf5_{i,t} + \alpha_4 DInf10_{i,t} + u_{i,t}$$

Where $dGDP_{i,t}(5)$ medium-term GDP growth measured with a five-year moving average window; Inf is inflation for a similar window, and $DInf0$ to $DInf10$ are dummy variables (0 or 1) that represent the range of inflation volatility.[8] In particular, $Dinf0$ will take the value 1 when inflation volatility is less than or equal to 5%, $Dinf5$ will take the value 1 when inflation volatility is higher than 5% and less than or equal to 10%, and $Dinf10$ will take the value 1 when it is higher than 10% and less then or equal to 25%. In the first equation, only one constant (η) is considered and, in the second equation, fixed coefficients are added by country (δ_i) and by period (δ_t) in order to control for potentially unobservable effects that may affect the relationship between inflation and growth. The results are presented in table 6.[9]

The impact of inflation on growth is negative and significant under both specifications, although it can be considered a minor impact. The negative effect of inflation on growth is broader when considering the range of inflation volatility. The coefficients are negative and significant for the dummy variables that contemplate the different ranges considered.

In accordance with the above, in order to analyse the direct relationship between GDP growth and inflation, without using this last variable in levels, it can be observed from table 7 that the effect of inflation turns out to be negative and significant; however, it would be a small effect.

[8] Inflation volatility is calculated as the standard deviation of the annual variation in the annual average consumer price index (CPI) obtained from the IMF International Financial Statistics (IMF, 2020).

[9] The possibility of incorporating dummy variables by geographical areas was considered to control for the effects of particular crises that affected certain areas; however, the use of fixed effects by country was considered a better alternative to control for potential particular geographical effects.

Table 6
Panel regressions for GDP growth and the inflation rate, sample of 178 countries, 1980–2015

Variables	(1) dGDPP5	(2) dGDPP5
lnfP5	-0.00428***	-0.00383***
	(0.00139)	(0.00141)
DInf0	-0.559***	-0.613***
	(0.133)	(0.135)
DInfl5	-0.349**	-0.392***
	(0.144)	(0.146)
DInfl10	-0.272**	-0.275**
	(0.107)	(0.108)
Constant	2.252***	2.197***
	(0.118)	(0.111)
Observations	2 960	2 960
R squared		0.009
Number of countries	178	178

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

Table 7
Panel regressions for GDP growth and the inflation rate, sample of 189 countries, 1980–2015

Variables	(1) C1b1 GDPP5	(2) C1b2 GDPP5
lnfP5	-2.31e-13*	-2.71e-13**
	(1.35e-13)	(1.36e-13)
Constant	6.303***	3.554*
	(0.282)	(2.091)
Fixed effect (year)	No	Yes
Fixed effect (country)	No	Yes
Observations	6 239	6 239
Number of countries	189	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

It was then, in accordance with the findings of Khan and Senhadji (2001), deemed advantageous to estimate the effect of certain inflation threshold, in order to show that inflation higher than that range has negative effects on growth, while an inflation rate lower than that range might not be harmful. Thus, GDP growth is estimated based on an interactive variable $D(Inf > 10\%)$, which will take the value 1 if inflation exceeds 10% in the five-year moving average, and will interact with the level of inflation. Thus, we seek to find a nonlinear relationship, which indicates how large the effect is, depending on how much further away inflation is from 10%. So, the equation to be estimated is:

$$dGDP_{i,t}(5) = \eta + \delta_i + \delta_t + \alpha_1 Inf_{i,t}(5) \times D(Inf_{i,t}(5) > 10\%) + u_{i,t}$$

The results are presented in table 8.

It can be seen that the negative effect of inflation over a certain range on growth is small but significant. The effect is negative for countries with inflation above 10% and this effect increases with higher inflation rates. Meanwhile, in countries with inflation rates below 10%, inflation does not affect GDP growth, which averages 3.5%.

Table 8
Panel regressions for GDP growth and inflation from the 10% threshold, sample of 189 countries, 1980–2015

Variables	(1) EQ0 dGDP5
lnfDInf10	-2.71e-13**
	(1.36e-13)
Constant	3.554*
	(2.091)
Fixed effect (year)	Yes
Fixed effect (country)	Yes
Observations	6 239
Number of countries	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

5. Disinflation and its real costs

To observe the effects that the acceleration of inflation has on the speed of growth, the equations presented below were estimated, in which the variable $dGDP_{i,t}(5)$ reflects the speed of growth, while $dInf_{i,t}(5)$ reflects the acceleration of inflation:

$$dGDP_{i,t}(5) = \eta + \delta_i + \delta_t + \alpha_1 dInf_{i,t}(5) + \alpha_2 Inf_{i,t}(5) \times D(Inf_{i,t-1}(5) > 10\%) + u_{i,t}$$
$$dGDP_{i,t}(5) = \eta + \delta_i + \delta_t + \alpha_1 dInf_{i,t}(5) \times D(Inf_{i,t-1}(5) > 10\%) + u_{i,t}$$

The results of this estimate, based on the interaction term, should be interpreted as the acceleration effect in countries that have inflation levels consistently above 10% (see table 9).

Table 9
Panel regressions for the acceleration of GDP growth and of inflation, sample of 189 countries, 1980–2015

Variables	(1) EQ1 dGDPP5	(2) EQ1b dGDPP5
dInfP5	1.32e-12	
	(1.86e-12)	
lnfDInf2	-1.07e-13	
	(1.18e-13)	
dInfDinf2		1.73e-13
		(1.36e-12)
Constant	-0.00584	-0.000639
	(1.341)	(1.341)
Observations	6 050	6 050
Number of countries	189	189

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

A review of the results shows that there is no apparent relationship between the variables; that is to say, the inflation slowdown does not have a statistically significant impact on the growth slowdown for different specifications.

6. External and real volatility

Based on the revised stylized facts presented above, it is interesting to see how GDP growth volatility behaves with respect to current account volatility and their interaction in conjunction with the inflation threshold.

$$ln(VolGDP_{i,t}) = \eta + \delta_i + \delta_t + \alpha_1 ln(VolCAB_{i,t}) + \alpha_2 ln(VolCAB_{i,t}) D(Inf_{i,t}(5) > 10\%) + u_{i,t}$$

The results are presented in table 10.

Table 10
GDP growth volatility and current account volatility, sample of 188 countries, 1984–2019

Variables	(1) EQ3 ln(VolGDP)
Ln(VolCAB)	0.0523***
	(0.0146)
VolCABDInf	0.102***
	(0.00991)
Constant	2.127***
	(0.157)
Fixed effect (year)	Yes
Fixed effect (country)	Yes
Observations	6 164
Number of countries	188

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

Table 10 shows that those countries that experienced current account volatility see this transferred to GDP growth volatility. The significant positive coefficient of the variable $Ln(VolCAB)$ indicates that a 1% increase in current account volatility escalates GDP growth volatility by approximately 0.05%. Moreover, the real volatility of countries with inflation rates above 10% was affected to a greater extent by changes in current account volatility, probably because macroeconomic stability was already weakened by nominal volatility to such an extent that the additional effect of external volatility was more damaging than it was in economies with nominal stability.

In order to analyse whether there are additive effects of nominal and external volatilities on real volatility, an equation was calculated that includes the relationship between GDP growth volatility, inflation volatility and current account volatility. The equation is as follows:

$$ln(VolGDP_{i,t}) = \eta + \delta_i + \delta_t + \alpha_1 ln(VolInf_{i,t}) + \alpha_2 ln(VolCAB_{i,t}) + \alpha_3 ln(VolCAB_{i,t}) D(Inf_{i,t}(5) > 10\%) + u_{i,t}$$

The results are presented in table 11.

The results show that the relationships are all significant and that inflation volatility brings about greater GDP growth volatility, although the effect is small. Meanwhile, higher current account volatility also contributes positively to output gap volatility. Lastly, current account volatility combined with inflation levels above 10% also contributes positively, and quite significantly, to output gap volatility.

Table 11
GDP growth volatility, inflation volatility and current account volatility, sample of 188 countries, 1984–2019

Variables	(1) EQ4 ln(VolGDP)
Ln(VolInf)	0.0223***
	(0.00767)
Ln(VolCAB)	0.0315**
	(0.0157)
Ln(VolCAB)DInf	0.117***
	(0.0113)
Constant	2.069***
	(0.158)
Fixed effect (year)	Yes
Fixed effect (country)	Yes
Observations	6 119
Number of countries	188

Source: Prepared by the authors.
Note: Standard errors are shown in parentheses.
*** p<0.01; ** p<0.05; * p<0.1.

IV. Conclusions and policy implications

Macroeconomic stability, in its various dimensions —nominal, real and external—, is in itself desirable because it implies less uncertainty for risk-averse economic agents. Even so, there is a firm belief that macroeconomic instability, in the form of inflation, a sizeable external deficit or a large positive GDP gap with the consequent overutilization of resources, could boost economic growth. Even if this were the case, it is highly questionable whether this would improve well-being, because expansionary policies increase real volatility, so the burden of proof falls on the proponents of macroeconomic instability. For destabilizing expansionary policies to contribute to greater social well-being, they would have to exert such a positive impact on GDP growth that it would be more than sufficient to offset the negative effects wrought by uncertainty and volatility. Consequently, if it can be shown that real macroeconomic volatility does not stimulate growth, this is sufficient to show that instability does not contribute positively to well-being.

We have been able to show in this paper that medium-term or trend GDP growth is negatively associated with output gap volatility, defined as logarithmic deviations between GDP and its trend. We can interpret this as meaning that overzealous, procyclical demand policies that force subsequent corrective action not only increase output gap volatility, but also slow the trend growth rate significantly. The available evidence suggests that higher real volatility is correlated with a lower rate of GDP growth, so macro policies should be countercyclical and seek to reduce volatility.

We have explored the relationship between macroeconomic stability in its various dimensions and economic growth. The main conclusion is that there is no basis for the idea that the loss of macroeconomic stability contributes positively to growth. Rather, the available information suggests that expansionary policies, which lead to high inflation or unsustainable external current account balances that end in reversals, are detrimental to growth.

Inflation is seen in some circles as a kind of growth facilitator and in many situations there are those who call for “a little more inflation to boost growth”. In a context of rigid downward pricing there is some analytical basis for this argument, but not to a great extent. At first sight, long-term data tend to support the hypothesis of no correlation between growth and inflation.

Thus, a “little bit more inflation” creates more nominal and real volatility instead of boosting GDP growth. The relationship between the average rate of inflation and inflation volatility is clearly positive and

quite strong in the long and medium term. In addition, inflation volatility, or nominal volatility, is positively associated with output gap volatility, or real volatility, although it does not have a unique or determinant effect. An increase in inflation volatility escalates output gap volatility; the relationship is positive, but nonlinear and the response of real volatility decreases for very high levels of inflation and nominal volatility.

In a slightly more detailed analysis, we tried to identify a change in the relationship between growth and inflation, beyond certain thresholds of the inflation rate. Our results replicate those of Khan and Senhadji (2001), and the inflation threshold above which it would have a negative effect on trend GDP growth would be between 11% and 12% per year for developing countries. Lower inflation has no effect on growth, although there may be a minimum threshold of zero or negative inflation, under which the relationship between inflation and growth becomes positive. It was not possible to verify this, owing to data limitations, as the dataset did not contain many observations with zero or negative inflation rates.

Although high inflation can have considerable costs, when given the choice of stabilizing prices or reducing inflation, there are those who point to the real costs in terms of GDP growth of pursuing disinflation. But even if the ongoing benefits of stabilization are ignored, there is no clear evidence that the real costs of that process will persist over the medium term. For 15-year periods, the correlation between the acceleration of inflation and of growth is tenuous, and consistently negative, so the information indicates that many countries have been able to achieve nominal stabilization without a further slowdown in growth. The costs of stabilization are short-term and largely avoidable if an appropriate strategy is adopted, which includes pursuing disinflation only at high or moderately high inflation rates and never at very low rates of inflation, and regulating the pace of disinflation with gradual but sustained cuts. Similarly, it is preferable to do so with exchange rate flexibility in order to avoid real appreciation of the domestic currency and with independent local monetary authorities, although it was not possible to support these findings with the data that was available.

Real volatility also has other origins, such as those related to external and internal shocks that affect the balance-of-payments current account. Massive inflows of foreign capital tend to produce a spending and output boom, financed by a current account deficit.[10] But in the long run, this often ends in a reversal of the current account balance, with the usual negative effects on the financial system, economic activity and employment. Available information on the effects of current account reversals on medium-term growth indicates that these depend on many other factors that affect the post-reversal performance, but a much clearer and more evident direct correlation between external and real volatilities can be identified.

There is a positive nonlinear relationship between average current account reversals and output gap volatility in the period 1980–2015. Thus, output gap volatility is minimal when the current account reversal is non-existent or slightly positive, but real volatility increases when the absolute value of the reversal is higher. If, instead of analysing the average current account reversal, we focus on its volatility, the relationship between external instability and real instability is much more evident. There is a positive correlation between the volatility of the current account reversal and output gap volatility. This relationship is nonlinear and the effect on real volatility is smaller for higher levels of external volatility. For some Latin American economies, the volatility of current account reversals comes very close to explaining output gap volatility, but for others current account reversals do not seem to be a major source of real volatility.

The econometric analysis carried out has allowed us to verify that countries with higher real volatility tend to grow less than those with a less pronounced cycle. We have also been able to show that both high inflation rates and frequent current account reversals contribute significantly to real volatility and macroeconomic instability. As a result, countries that tend to have inflation accelerations and whose current account deficits widen precipitously, generally fail to increase their trend growth rate. Conversely, greater nominal, external and real volatility ends up acting as a brake on growth.

The policy implications of these results are obvious. It is important to promote nominal stability by maintaining low, single-digit, stable inflation. It is also important to adopt countercyclical aggregate

[10] See, for example, the situation in Chile before the Asian financial crisis, outlined in Le Fort and Lehmann (2003).

demand policies, such as monetary and fiscal policies, by reducing real volatility. Moreover, it is advisable to take steps to prevent the balance of the balance-of-payments current account from being subject to large reversals, which means avoiding the procyclical effect on domestic demand of strong capital inflows and large currency appreciations. This may require the implementation of various instruments, including floating exchange rates, a credible nominal anchor such as inflation targeting and prudential financial regulations, as well as the adoption of a countercyclical fiscal policy. However, the detail of these policy designs goes far beyond the scope of this paper, the available data and the models that were developed. They are left for a future endeavour.

Bibliography

Barro, R. (1995), "Inflation and economic growth", *NBER Working Paper*, No. 5326, Cambridge, National Bureau of Economic Research (NBER), October.

Blanchard, O. and J. Simon (2001), "The long and large decline in U.S. output volatility", *Brookings Papers on Economic Activity*, No. 1.

Bruno, M. and W. Easterly (1998), "Inflation crises and long-run growth", *Journal of Monetary Economics*, vol. 41, No. 1, February.

Calvo, G. (2003), "Explaining sudden stops, growth collapse and BOP crises: the case of distortionary output taxes", *NBER Working Paper*, No. 9864, Cambridge, National Bureau of Economic Research (NBER), July.

Calvo, G. and C. Végh (1999), "Inflation stabilization and BOP crises in developing countries", *Handbook of Macroeconomics*, vol. 1C, J. Taylor and M. Woodford (eds.), Amsterdam, North-Holland.

Calvo, G., O. Celasun and M. Kumhof (2003), "Inflation inertia and credible disinflation- the open economy case", *NBER Working Paper*, No. 9557, Cambridge, National Bureau of Economic Research (NBER), March.

Christoffersen, P. and P. Doyle (1998), "From inflation to growth: eight years of transition", *IMF Working Paper*, No. 98/100, Washington, D.C., International Monetary Fund (IMF), July.

Edwards, S. (2004), "Thirty years of current account imbalances, current account reversals, and sudden stops", *IMF Staff Papers*, vol. 51, special issue, Washington, D.C., Palgrave Macmillan.

___(2002), "Does the current account matter?", *Preventing currency crises in emerging markets*, S. Edwards and J. Frankel (eds.), Chicago, University of Chicago Press.

Faria, J. and F. Carneiro (2001), "Does high inflation affect growth in the long and short-run?", *Journal of Applied Economics*, vol. 4, No. 1.

Ghosh, A. and P. Steven (1998), "Warning! Inflation may be harmful to your growth", *IMF Staff Papers*, vol. 45, No. 4, Washington, D.C., Palgrave Macmillan.

IMF (International Monetary Fund) (2020), "International Financial Statistics" [online database] https://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B&sld=1409151240976.

___(2016), "World Economic Outlook Database" [online database] https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx.

Khan, M. and A. Senhadji (2001), "Threshold effects in the relationship between inflation and growth", *IMF Staff Papers*, vol. 48, No. 1, Washington, D.C., Palgrave Macmillan.

Le Fort, G. and S. Lehmann (2003), "The unremunerated reserve requirement and net capital flows: Chile in the 1990s", *CEPAL Review*, No. 81 (LC/G.2216-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), December.

Le Fort, G., B. Gallardo and F. Bustamante (2017), "Estabilidad macroeconómica y crecimiento económico: mitos y realidades", *Documento de Trabajo*, No. 456, Santiago, University of Chile, November.

Loungani, P. and N. Sheets (1997), "Central bank independence, inflation and growth in transition economies", *Journal of Money, Credit, and Banking*, vol. 29, No. 3.

Milesi-Ferretti, G. and A. Razin (1998), "Current account reversals and currency crises: empirical regularities", *NBER Working Paper*, No. 6620, Cambridge, National Bureau of Economic Research (NBER), June.

Sidrauski, M. (1967), "Rational choice and patterns of growth in a monetary economy", *The American Economic Review*, vol. 57, No. 2, May.

Végh, C. (1992), "Stopping high inflation: an analytical overview", *IMF Staff Papers*, vol. 39, No. 3, Washington, D.C., Palgrave Macmillan, September.

Zarnowitz, V. and G. Moore (1986), "Major changes in cyclical behavior", *The American Business Cycle: Continuity and Change*, R. Gordon (ed.), Chicago, University of Chicago Press.

The manufacturing industry in Mexico: a history of production without distribution

Germán Osorio Novela, Alejandro Mungaray Lagarda and Edison Jiménez López

Abstract

This paper analyses the historical performance of the Mexican manufacturing industry based on the strategies that began to be adopted in the 1960s. It examines in particular the relationship between the productive increases driven by the opening of the market and the levels of economic well-being observed among people involved in this sector. The results of a sequential analysis of historical trends and estimates of production functions and distribution mechanisms suggest that the productive success of the manufacturing industry has only served to boost the economic well-being of companies and their owners, but not that of their employees or the wider community.

Keywords

Industry, industrial enterprises, manufacturing enterprises, history, productivity, income, economic development, industrial statistics, Mexico

JEL classification

F20, F23, L60, O14, O54

Authors

Germán Osorio Novela is a full-time professor and researcher with the Faculty of Economics and International Relations of the Autonomous University of Baja California (Mexico). Email: gosorio@uabc.edu.mx.

Alejandro Mungaray Lagarda is a full-time professor with the Faculty of Economics and International Relations of the Autonomous University of Baja California (Mexico). Email: mungaray@uabc.edu.mx.

Edison Jiménez López has a PhD in Economics from the Autonomous University of Baja California (Mexico). Email: edison.jimenez@uabc.edu.mx.

I. Introduction

Following the end of temporary worker programmes between the United States and Mexico in the mid-1960s, and thanks to the trade openness that began in the 1980s, which was consolidated by the entry into force of the Northern American Free Trade Agreement (NAFTA) in the 1990s, the Mexican manufacturing industry has undergone fundamental structural and operational changes. One such change was reflected in the development of the maquiladora industry, which established itself as one of the most dynamic industrial activities, at first in the northern border states, where it was able to take advantage of the logistics and oversight operations with United States companies —the main drivers of demand for products— but then in some inland states, which the industry has gradually moved into specialized productive sectors. Since then, the maquiladora industry has been recognized as a strategic and important source of employment for regional and national manufacturing development.

In this connection, in recent years the importance has been recognized of evaluating the impact of industrial development on well-being, specifically on the monetary income of employees and companies, through distribution mechanisms (Isaksson, 2007). Recent evidence indicates that total factor productivity is closely related to business development, which in turn is closely related to the well-being of economies and society at large (Basu and others, 2012). Thus, based on the productivity trends of Mexico's industrial sector, the development of Mexican companies is at the centre of the debate surrounding their impact on the benefits reaped by society.

This paper seeks to measure the impact of productivity trends on the economic well-being of companies and employees, especially that of the so-called second- and third-generation maquiladoras, the introduction of which led to a considerable increase in the productive capacity of the country's manufacturing sector in general, as a result of both direct and indirect effects on the sector (Carrillo and Hualde, 1998; Morales, 2000). Our hypothesis is that a more consolidated and productive industrial sector generates greater profits for companies and higher wages for their employees, which contributes to social well-being. The aim of the paper is to provide empirical data that contribute to understanding the performance of the manufacturing sector within society.

Statistical data from the Monthly Industrial Survey (EIM) for the years prior to 2007 (INEGI, n/d) and the Monthly Survey of the Manufacturing Industry (EMIM) for the decade 2007–2017 (INEGI, 2017), both carried out by the National Institute of Statistics and Geography (INEGI), were used to verify the hypothesis and achieve the aims of this study. These data correspond to a comprehensive measurement of the manufacturing sector, which includes companies ranging from those engaged in traditional manufacturing activities to economic entities that export manufactures, in accordance with the manufacturing industry, maquiladora and export services (IMMEX) programme.

The article is divided into five sections. After this introduction, section II contains an analysis of the manufacturing industry trends in Mexico in the period 1960–2017, including a review of the frame of reference of the export industry, taking into account the debate surrounding its contribution to strengthening the local productive sector and the derived benefits for the country. Section III describes the methodological aspects for estimating total factor productivity (TFP) and the parameters for defining the sector's productive trends, as well as its impact on the monetary income of companies and their employees. The results and their interpretations are presented in section IV and the conclusions are set out in section V.

II. The manufacturing industry in Mexico and its growth strategy based on the external market

Following the end of the Bracero Program, under which temporary work permits were issued to Mexican labourers to allow them to work in the United Sates between 1942 and 1964, and with the return of those labourers to Mexico, the Government of Mexico began to think about strengthening the productive sector through mechanisms to attract foreign direct investment (FDI) that would generate sufficient labour demand to satisfy the growing supply. Thus, the policy to foster FDI in the maquiladora export industry was announced on 20 May 1965, which promoted the establishment of maquila plants along the northern border of the country and led to the construction of the first industrial parks in 1966.

The International Monetary Fund (IMF, 2009) defines FDI as arising when an investor resident in one economy makes an investment that gives control or a significant degree of influence on the management of an enterprise that is resident in another economy. The Organization for Economic Cooperation and Development (OECD, 2008), together with Krugman and Obstfeld (2003), defines it as capital from abroad that is intended for the exploitation, production and/or marketing of products, goods and services in the local economy, either for sale in the territory or for export.

According to the North American Industry Classification System (NAICS), the manufacturing industry includes all those economic branches grouped into activities related to food, tobacco, textiles and textile products; leather and hide tanning and finishing; wood; paper; petroleum and coal products; chemicals, plastics and rubber; minerals; metals; computer and electronic products and communication equipment; electrical equipment; electric power generation equipment and transport equipment. The term *maquila* dates back to the Middle Ages in Europe, specifically Spain, and refers to the practice whereby local farmers would pay mill owners for processing their wheat with a portion of the flour obtained. Currently, the Mexican National Council of the Maquiladora and Export Manufacturing Industry (INDEX) defines the maquiladora industry as any partial activity in a manufacturing process, such as assembly or packaging, carried out by a company other than the original manufacturer. However, the definition of *maquila* used by INEGI broader, referring to it as an economic unit that combines actions and resources under the control of a sole owner or controlling entity, to perform mainly activities for the transformation, production, assembly or processing of one or more products, in whole or in part (INEGI, 2015).

The origin of the maquiladora export industry in Mexico is related to two events. Firstly, the adoption of special tariffs in the United States that were applied only on the value added of maquila imports and not on their total value, and, secondly, the launch of the Border Industrialization Program (BIP) in Mexico in 1965, which allowed the duty-free, temporary importation of inputs and taxed export products on the added value of the final goods (Carrillo, 2000). These measures helped to stabilize the high unemployment rate along the northern border, by consolidating growth dynamics and providing a solid source of employment and foreign exchange.

Over time, these benefits were extended to other specific regions in Mexico, initiating a slow process of economic decentralization to other inland states. The entry into force of NAFTA in 1994 led to the development of maquiladora export industry plants in the Bajío and central areas of the country. The growth rates of the maquiladora export sector have been increasing every year since then, consolidating its position in the national economy and helping to attract more FDI (Mungaray, Ramírez and Texis, 2006).

According to Caves (2007), FDI promotes competitiveness by encouraging firms to improve their efficiency to ensure their productivity and survival. This is evident in Mexico from the fact that, initially, the productivity of maquiladoras was minimal, but then improved over time. In turn, it is logical to conclude that information on FDI operations and management styles are disseminated across the whole manufacturing sector through learning-by-doing processes (Lucas, 1988) and spillover effects (Romer, 1990).

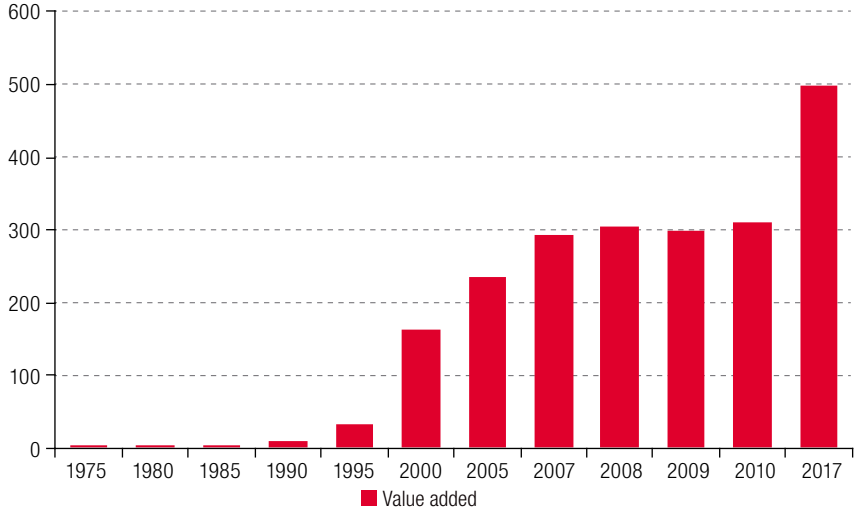
Thus, following the entry into force of NAFTA, the manufacturing industry underwent an accelerated development, thanks mainly to the confidence of foreign investors, the devaluation of the peso in December 1994, economic growth in the United States and the adoption of the just-in-time manufacturing model (Bendesky and others, 2004). According to INEGI data, in 2017, there were more than 5,000 active plants in Mexico belonging to the manufacturing, maquiladora and export services industry, employing approximately 2.5 million people, of which 2 million are hired directly and the rest are hired under subcontracting schemes. The national average of real wages per employed person was approximately US$ 770 per month. However, a considerable gap can be observed when analysed from the state level. For example, with regard to the northern states, wages are highest in the main maquiladora region of Nuevo León (US$ 876), followed by Coahuila and Baja California (around US$ 763). Wages are lowest in the maquiladora plants located in the states of Sonora and Chihuahua (US$ 650 a month).

There is still some discussion in Mexico about whether maquiladoras and trade openness were the appropriate development strategy for the country's manufacturing industry. An important aspect of the discussion focuses on the definition of development, whose interpretation ranges from the impact on economic growth to the structural change that provides a general increase in economic activity and output and results in an improved standard of living for the majority of the population (Anderson, 1990).

It is undeniable that the development of the manufacturing-maquiladora industry, which had its origins in the 1960s, generated economic benefits for the country, reflected in higher levels of production, employment, and new technology transfer and implementation, as well as in the creation of a new work culture and the establishment of new development hubs (Eaton, 2001). This favourable situation of increased production underpinned a remarkable growth trend, especially in the 1990s; however, investment began to decline in the early 2000s, before rallying again in 2003. The sector then underwent a crisis in 2008 and 2009.

There was a turning point in the 2010s following the global economic crisis of 2008, which caused a drop in production as a result of corporate readjustments affecting manufacturing plants. However, in general terms, value added production has followed a positive trend and achieved high growth rates (see figure 1). In 2017, the average real production value of the industry was 452.614 billion pesos a month, an increase of 555% with respect to 1990.[1]

Figure 1
Mexico: value added of the export industry
(Billions of constant pesos)



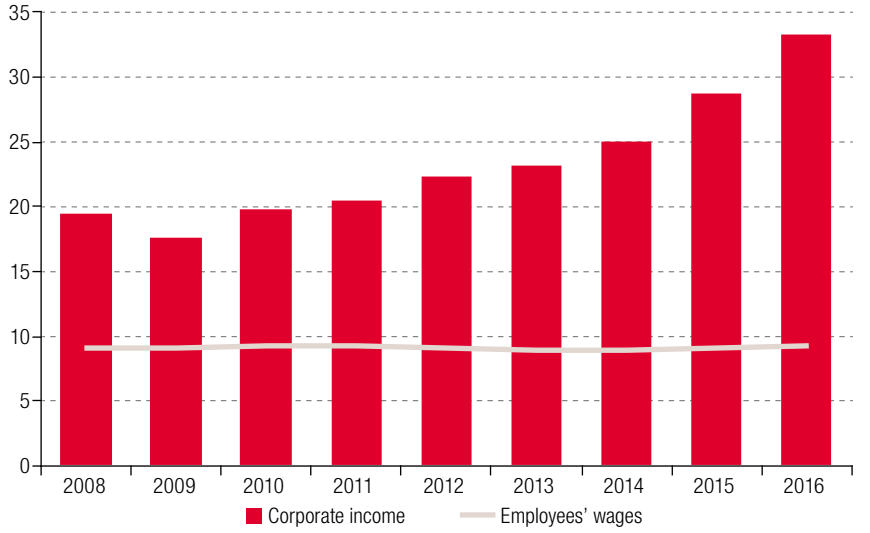
Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.

[1] All monetary data used were deflated according to the National Producer Price Index (NPPI), with 2012 as the base year.

The contribution of the manufacturing industry to job creation has grown by 391% over the last 25 years, which is reflected in more than 2 million new jobs. However, the rate slowed between 2007 and 2017: only 257,175 new jobs were created. This was largely as a result of the economic slowdown of 2008 which pushed up unemployment and lasted for four years. This shows the high sensitivity of manufacturing employment to economic imbalances; in most cases, critical adjustments in the industry are made through layoffs, which increases the productivity of the other workers.

The increase in production has translated into an increase in corporate income, but not in employees' wages, especially in the last decade (see figure 2). While wages increased in real terms from US$ 387 to US$ 626 per month between 1990 and 2007, they have not increased since then, and have even decreased. Wages were equivalent to 52% of corporate income in 2009, but this figure dropped to 28% in 2016. Yet, both production value and hours worked have increased steadily since 2008.

Figure 2
Mexico: relationship between income and wages in the manufacturing industry, 2008–2016
(Billions of United States dollars)

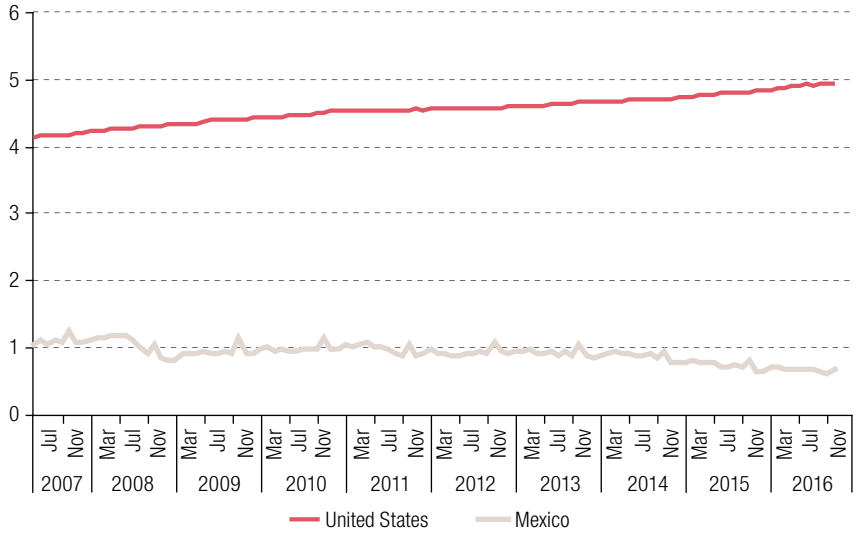


Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.

This scenario shows a clearly inefficient and unequal distribution of income. This trend is only observed in Mexico: if one compares the monthly wages in real terms paid to industrial workers in the United States with those of workers in Mexico, one can see a considerable and sustained increase in wages in the United States that contrasts markedly with the situation in Mexico. This widens the wage gap between the two countries further (see figure 3).

It is evident that the production capacity of the Mexican manufacturing industry has increased effectively. The industry's structure has evolved from its initial arrangements and capacities owing to its increasing strategic market opening and ability to attract FDI. However, this trend emerged against the backdrop of the wider discussion (Texis, Mungaray and Grijalva, 2009) surrounding the lack of mechanisms to distribute wealth to the workers and social sectors associated with the industry, which becomes increasingly relevant as the gap between corporate profits and employees' wages continues to grow. Ros (2015) argues that the problems of economic inequality that exist in Mexico are mainly the result of a process of increasing employment precariousness, linked specifically to a steady decline in workers' share of the functional distribution of income, as real wages have stagnated with respect to labour productivity.

Figure 3
Mexico and the United States: monthly wages per employee in the manufacturing industry, 2007–2016
(Thousands of dollars, adjusted for exchange rates)



Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.

The reasons for this, a consequence of the development of the Mexican manufacturing industry, are associated with the changes caused by maquiladora activities since the 1960s. The labour structures and plants' organization reached a turning point following a series of adjustments that took place as a result of market liberalization, the introduction of new materials and technological innovations and, above all, changes in the relationship between the government and the industry (Mungaray, 1990; Carrillo, 1990) and between large multinational companies and local firms.

When international companies are able to use the intermediate goods offered by local businesses to produce their products, links are created that boost the development of the local economy. Rodríguez-Clare (1996) points out that, since there are large communication costs between headquarters and production plants located in other countries, the presence of a variety of similar intermediate goods in the two economies means that multinational companies do not behave as enclaves in the host country, since they are integrated into the local economy and influence regional development. This may explain why production plants located in the interior of Mexico tend to generate more linkages and benefits at the local level, compared to those on the border with the products' final market. However, the dynamics of globalization, which are largely based on global production chains, create an important counterweight to the linking and generation of local supply networks.

Of the total inputs consumed by the manufacturing-maquiladora industry at the national level, 75% are imported (INEGI, 2017). This indicator increases considerably if we consider plants located in the northern part of the country, especially in Baja California and Chihuahua, where 97% of the total are imported, followed by Tamaulipas, with 88%. Surprisingly, only 60% of inputs consumed in the states of Sonora and Nuevo León are imported (INEGI, 2017).

The policies of the Government of Mexico aimed at promoting manufacturing have failed to establish a more effective relationship between local and foreign companies (Gallagher and Shafaeddin, 2010), which has led to a number of negative effects, mainly a lack of development of endogenous capacity of domestic firms and a slow and limited transfer of technology to local businesses. Hence, Jenkins,

Dussel and Mesquita (2008) point out that, in the field of international trade, competition between countries is strongly related to the focus or specialization that each nation seeks to channel into its economy, which defines losers or winners in this paradigm of globalization. In this regard, Gallagher and Shafaeddin (2010) note that, while China is developing through a socialist market mechanism, Mexico has only followed an open market path, without central planning.

As a result of this increase in international competitiveness, Mexican manufacturers have had to step up productivity, use idle capacity, improve plant management and develop products to compete with the lowest prices worldwide, especially those levied by emerging Asian countries (Utar and Torres, 2013). With respect to employment, Heid, Larch and Riaño (2013) point out that, during the 1990s, this industry was a mixed blessing for the economy: despite having helped to reduce unemployment, informality increased by 0.9%, overall welfare (measured by income, employment benefits, health and housing indicators) decreased by 3.7%. Other regional studies detected a drop in hourly wages, which leads employees to work longer hours and boosts companies' productivity, to the detriment of workers' quality of life (Mungaray, Ramírez and Texis, 2006).

Nevertheless, the companies established as a result of the manufacturing liberalization in Mexico are now in a highly productive or "third-generation" stage, where not only are have linkages been created, but also new ideas and products are being designed, researched and developed, while human capital is championed. To achieve this, it was necessary to go through a first stage or first generation, which was those companies that arrived in Mexico between 1965 and 1983 (Carrillo and Hualde, 1998). They are referred to as "footloose" investments because in periods of crisis they will uproot and move elsewhere. These plants were located in a 20-kilometre strip along the border with the United States, whose productive structure required the intensive use of labour mainly for assembly work (Cruz, 2001).

The second generation covers the period from 1983 to 1994, during which the industry and government entities set up new mass training programmes with regard to technology and robotization to cultivate qualified personnel, raise quality standards and create the first separate industrial park complexes in the country, less specialized in assembly processes and more focused on manufacturing processes. Another notable event during this period was Mexico's entry into what would become the World Trade Organization (WTO) in 1986. The so-called third generation came online in 1994, the main characteristic of which is the strong knowledge-based competition, underpinned by large investments in research and development (R&D) (Cruz, 2001).

Despite these developments, it has been difficult for the industry to integrate more fully with the national productive framework, because of both the competitive limitations of the other economic sectors and the absence of a business support policy that not only allows the industry to earn the profits that would be expected from its long-standing presence in Mexico, but also to reap regional and business benefits in line with the Mexican productivity advantages.

Recent research suggests that the keys to Mexico's development need to be analysed, taking into account manufacturing export trends and the country's poor economic growth. The evident lack of transmission mechanisms between the manufacturing industry and other economic sectors means that the national economy lacks factors that are indispensable for increasing the social and economic conditions of the population, such as integrated fixed investment processes, productive densification and better quality jobs (Moreno Brid and others, 2016).

Research by Ibarra (2011) and Vázquez and Avendaño (2012) has identified the weak effect that Mexican exports have on gross domestic product (GDP) growth owing to the large and rising share of the maquila sector in manufacturing exports. Although the industry's exports generate a positive trade balance for the sector, they depend mainly on imported inputs and intermediate goods that cannot be replaced by others of domestic origin. However, Ibarra and Blecker (2016) detect a positive trend in the use of domestic intermediate inputs in manufacturing activities in Mexico, which perhaps reflects a systematic and increasingly stable linkage between that sector and the local economy.

Thus, the positive and negative effects of the industrial development strategy of promoting the export sector —expressed in indicators such as levels of FDI, number of employees, hours worked, corporate income, wages per employee and production value, among others— make it possible to determine objectively whether the marginal productivity trend of manufacturing factors has led to an increase in the economic well-being of the people linked to that sector.

III. Methodology

To analyse the share and productivity of the manufacturing industry factors over time, a series of regressions were calculated for two periods covering the years in which the sector saw its greatest productive growth since the 1960s: the first from 1994 to 2006, based on the Monthly Industrial Survey, and the second from 2007 to 2017, based on the Monthly Survey of the Manufacturing Industry. The partition into two periods was due to the change in the data registration methodology of the official source of information in Mexico, INEGI. Given the methodological modifications, the variables are not compatible throughout the study period and should therefore be analysed separately for econometric purposes. The data used cover 240 classes of manufacturing activities based on the 2017 NAICS Manual (INEGI, 2017).

With respect to econometric analysis, the estimates were derived from production functions that reflect the technical relationship between the different variables involved in the manufacturing production process, so that:

$$Y = F(X_1, X_2, \dots, X_n, A) \tag{1}$$

Where, Y is production; X_n is inputs or production factors; and A is total factor productivity (TFP).

Thus, to obtain coefficients that show marginal changes and variations in production and efficiency, the following Cobb-Douglas production function was used:

$$Y_{it} = AK^{\alpha_1} L^{\alpha_2} \tag{2}$$

Where, K is the capital factor or input; L is the labour factor or input; and $\alpha_{1,2}$ is the share or elasticity of the capital and labour factors in production, respectively.

If equation (2) is transformed logarithmically into linear form, we get:

$$lnY = lnA + \alpha_1 lnK + \alpha_2 lnL \tag{3}$$

The production variable is the gross production value of the manufacturing sector. The capital variable comprises the total inputs consumed (except labour input). In this regard, some empirical studies on measuring productivity argue that it is important to calculate the flow of services produced by capital assets (in relation to total inputs that occur at the same time as the use of capital investment levels), rather than capital stocks alone (Jorgenson, Gollop and Fraumeni, 1987; Oulton, 2001), as they are not always used to its maximum capacity, depending on which point in the economic cycle they fall; thus, the degree of capital utilization can be measured through the use of inputs or service flows (CLAPES/ICARE, 2016) (see table 1). For the labour factor, the number of hours worked was considered.

Equation (3) was calculated using a cointegrated dynamic panel data structure for both periods; the viability of this type of partition has been verified for the estimation of functions linked to productive factors, particularly employment (Arellano and Bond, 1991), and they also allow the collection of information from all the industry's subsectors. The observations were deflated with respect to the producer price index (PPI), using 2003 and 2012 as base years, respectively. To deseasonalize the time-series data and minimize bias in the coefficients, the moving-average method was used, which takes averages that span and compensate for the high and low values and determine the group average.

Table 1
The main variables of analysis of the manufacturing sector, 2007–2017
(Thousands of United States dollars a month)

Variable	Average value	Maximum value	Deviation
Production value	37 454 640	44 254 539	3 419 594
Capital factor	20 481 956	32 032 696	4 056 893
Labour factor	59 257	67 539	3 580
Monetary income per company	2 906 158	3 566 144	247 046
Monetary income per employee	0.894	1.167	0.0709

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.

Before estimating the regressions, unit root tests were performed to avoid artificial regression problems (Arellano and Bond, 1991). Three tests were conducted: Fisher augmented Dickey-Fuller (Fisher-ADF); Im-Pesaran-Shin (IPS); and Hadri. For the first two, a null hypothesis of the existence of unit roots was assumed, and for the last one, a null hypothesis of stationarity in the panel data. When testing the variables at levels and subsequently the first differences, it was observed that they were all stationary at first difference in both periods, so they are integrated of order (1).

The dual estimation of equation (3) sought to determine both the factor intensity of manufacturing and the factors' shares and output. This allowed possible changes in the sector's productive behaviour to be detected. Once the shares and the types of output were determined, TFP was calculated based on the estimation of the parameter, under the methodology known as the Solow residual (López-Córdova, Esquivel and Monge-Naranjo, 2003; Céspedes and Ramírez-Rondán, 2014). To do this, equation (3) was used to calculate the derivative of the logarithms with respect to time, and thus the growth rate of the variables was obtained, which is expressed as follows: A

$$\Delta Y = \Delta A + \alpha_1 \Delta K + \alpha_2 \Delta L \tag{4}$$

The Solow residual methodology demonstrated that, while the growth rate of A, which is associated with TFP, is an unobservable variable, it can be estimated through the residual in equation (4) and is conditioned by the growth rate of observable variables such as production, capital and labour, with respect to their corresponding shares. The coefficient reflects that part of output growth that cannot be explained by growth in the primary factors or product inputs, such as capital and labour (Hulten, 2001). The TFP growth rate[2] is defined as follows:

$$\Delta TFP \equiv \Delta A = \Delta Y - \alpha_1 \Delta K - \alpha_2 \Delta L \tag{5}$$

Once TFP was obtained, it was contrasted with the variables of average remuneration per manufacturing employee (total remuneration divided by employed personnel) and of corporate profits (monetary income per company); these variables are considered indicators of the economic well-being of employees and companies, respectively. In addition, two control variables were established: the first, based on a dichotomous variable that reflects the effects of the economic crisis that affected Mexico in 2008; the second is associated with the degree of trade openness in the manufacturing industry, through the average openness index (AMIC) (Durán and Álvarez, 2008), according to the following equation:

$$AMIC = \frac{Z_i + M_i}{Y_i} \tag{6}$$

Where, Z_i is manufacturing exports; M_i is manufacturing imports; and Y_i is manufactures' production value.

[2] After checking the cointegration of the variables.

So, the regressions to be calculated are:

$$W = \beta_0 + \beta_1 A + \beta_2 AMIC + \beta_3 D_1 + \varepsilon \quad (7)$$

$$R = \beta_0 + \beta_1 A + \beta_2 AMIC + \beta_3 D_1 + \varepsilon \quad (8)$$

Where, W is the growth rate of average wages per employee; R is the growth rate of corporate profits; A is the TPF growth rate; $AMIC$ is the average openness index of the manufacturing trade; and D_1 is the economic crisis indicator.

The growth rates' variables confirmed the stationarity of the time series[3] and were estimated by ordinary least squares (OLS); this reveals the impact and benefits derived from the development of the manufacturing industry in terms of economic well-being. Both TFP and the trade openness index were expected to be significant and to have a positive impact on indicators of employees' and corporate well-being. Similarly, the indicator that captures the years of economic crisis was expected to be statistically significant.

IV. Analysis of results

Table 2 presents the regression coefficients of equation (3) by time period. With regard to the results of the data for the first period, the Hausman test suggested that the fixed effects model was appropriate for estimating the equation. The estimated coefficients were positive and significant, with a confidence level of 99% and an almost equal magnitude of 0.36. While this does not allow the intensive factor of the manufacturing activity in this period to be determined comprehensively, it can be affirmed that, based on the Wald test, the sum of its values was statistically less than one, which means that the production factors present decreasing returns to scale.

Table 2
Summary of the statistical estimates and tests for production function (3) using the panel data model

Variables	Period 1 (1994–2006)	Period 2 (2007–2017)
Constant	6.876*	-0.0000362
Capital	0.369*	0.1001*
Labour	0.351*	1.135*
Statistics		
F statistic	2 644.17	1 473.19
Prob. F	0.000	0.000
Hausman test Ho: Random Effects	Rejected	Not rejected
Chi^2	6.08	4.43
Hausman Prob.	0.0479	0.2186
Wald test Ho: $\alpha_1 + \alpha_2 = 1$	Rejected	Rejected
F-test	283.19	52.10
F Prob.	0.000	0.000
Observations	1 920	1 656

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.
Note: *significant at 1%.

[3] The stationarity of the time series was tested using the ADF and Kwiatkowski-Phillips-Schmidt-Shin tests.

Regarding the results for the second period, the Hausman test indicated that the random effects model was appropriate for interpreting the coefficients, which were significant at 99%. In this case, there was an increasing returns to scale; a large share of the coefficient was associated with the labour factor (of a magnitude of 1.13) compared to the share of the capital coefficient (just 0.10), which was confirmed by the Wald test. The robust data from this second regression suggest that manufacturing is labour-intensive, a result that was expected for the first period of analysis as well.

The fact that manufacturing companies increasingly integrated technology during the second period suggests that this process has not transformed this industry into a capital-intensive sector or led to a decrease in the relative demand for labour; rather it has translated into an increase in the productivity of their employees and higher output from their increasing returns to scale.

Table 3 presents the results of equations (7) and (8), which indicate that the evolution of manufacturing performance, expressed in TFP, was not statistically significant for the growth rate of employees' wages. However, the average trade openness index, which shows the constant increase in the average trade openness of manufacturing products, and the variable that reflects the effects of the 2008 economic crisis on Mexico, were statistically significant for the levels of economic well-being of employees.

Table 3
Summary of statistical estimates and tests of economic well-being functions using the ordinary least squares (OLS) model

Variables	Well-being of the employees	Well-being of the companies
Constant	0.378*	0.092**
TFP	-0.121	0.348***
Trade openness	0.231*	0.058**
Economic crisis	0.048***	0.003
F statistic	5.585	5.394
F Prob.	0.001	0.001
Observations	105	105

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI), "Encuesta Mensual de la Industria Manufacturera (EMIM)", Economic Information Bank, 2017 [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.
Note: *significant at 1%, **significant at 5% and ***significant at 10%.

Meanwhile, the evolution of TFP and the industry's trade openness were significant for the economic well-being of companies (understood as monetary income per economic unit), but the effects associated with the economic crisis were not statistically significant. This suggests that the negative impacts resulting from the economic instability were mainly transmitted to the economic well-being of employees, in other words, they were transferred to the direct income received by the employees, despite the fact that their productivity increased constantly during the whole period under analysis.

The manufacturing industry's development strategy since the market was opened up has therefore led to a steady increase in the productivity of each input, the industry's general performance and TFP. However, the impact on the economic well-being of the participating agents has been asymmetrical. The TFP trend and trade openness has been statistically significant for business owners' income levels, and the economic crisis did not affect their levels of well-being, probably due to the high growth in corporate productivity and competitiveness as a result of the adjustments to their number of employees. However, this increase in productive capacity has not been significantly reflected in the growth in average wages per employee, which were affected by the economic crisis.

V. Conclusions

The results of this research show that the strategy to promote Mexico's manufacturing industry through the openness to trade, technology and FDI of the maquiladora industry has improved its productive performance. This improvement is associated in particular with the consolidation of the second and third generations of this sector, when productivity increases were sought, linked to the acquisition of capital and investment in R&D.

There is statistical evidence that manufacturing production remains highly labour-intensive, so the increase in capital and technology has not changed the structure of factor use. Nevertheless, this increase led to the adoption of flexible production processes that have helped the industry to transition from declining returns to scale to increasing returns to scale over the past 20 years. This has boosted the corporate income of those companies that have been consolidating their presence in international markets and have thus become more resistant to economic recessions and crises, as evidenced by the fact that the economic imbalance that occurred in Mexico during the 2008 crisis did not have a statistically significant impact on the growth rates of the economic well-being of business owners.

The empirical data obtained also supports the hypothesis that this productive development has not translated into an improvement in the economic well-being of employees, something that is reflected in the growth rates of their average real wages per hour of work. Despite being increasingly productive thanks to investments in technology, training processes and a reduction in leisure time during the working day, employees can only increase their income by working more hours, instead of through contractual mechanisms to share the benefits of that higher productivity.

It can therefore be concluded that the right elements have not yet been put in place, both by companies and by the government, to ensure that the growth in the manufacturing industry is also reflected in a rise in the economic well-being of its employees through better and fairer wages, commensurate with the increase in productivity. Despite the fact that Mexico's manufacturing industry is now in a highly productive or third-generation stage, other studies (Ocegueda, 2003) also recognize the vicious circle that exists between the large proportion of labour employed in the sector and the low wages those employees receive.

The perspective presented herein points to the need to continue reflecting on the development strategy of the manufacturing industry in order to advance further not only with regard to job creation, but also conditions that promote equitable remuneration for employees, based on their productivity and linked to innovation and training. This discussion opens the door to the possibility that future research will address, in addition to economic well-being, the impact of business development on efforts to resolve challenges related to social well-being in general, and employees' living conditions in particular.

Bibliography

Anderson, J. (1990), "Maquiladoras and border industrialization: impact on economic development in Mexico", *Journal of Borderlands Studies*, vol. 5, No. 1.

Arellano, M. and S. Bond (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *The Review of Economic Studies*, vol. 58, No. 2, April.

Basu, S. and others (2012), "Productivity and the welfare of nations", *Policy Research Working Paper*, No. 6026, Washington, D.C., World Bank.

Bendesky, L. and others (2004), "La industria maquiladora de exportación en México: mitos, realidades y crisis", *Estudios Sociológicos*, vol. 22, No. 2.

Carrillo, J. (2000), "Las maquiladoras de exportación en México: evolución industrial, aglomeraciones y seguridad e higiene", document prepared for the project "Mejoramiento de las condiciones de empleo en la industria maquiladora", El Colegio de la Frontera Norte.
___(1990), "The de-ideologizing of studies on maquiladoras", *Journal of Borderlands Studies*, vol. 5, No. 1.
Carrillo, J. and A. Hualde (1998), "Third generation *maquiladoras*? The Delphi-General Motors case", *Journal of Borderlands Studies*, vol. 13, No. 1.
Caves, R. (2007), *Multinational Enterprise and Economic Analysis*, Cambridge, Cambridge University Press.
Céspedes, N. and N. Ramírez-Rondán (2014), "Total factor productivity estimation in Peru: primal and dual approaches", *Economía*, vol. 37, No. 73.
CLAPES/ICARE (Latin American Center for Economic and Social Policies/Chilean Institute of Rational Business Management) (2016), "Índice de Productividad Total de Factores (PTF)" [online] http://www.clapesuc.cl/assets/uploads/2016/05/metodologa-ndice-de-productividad-.pdf.
Cruz, R. (2001), "Los determinantes de la productividad en la industria maquiladora de exportación de México: un análisis regional y sectorial" [online] http://acacia.org.mx/busqueda/pdf/Roberto_pon11.PDF.
Durán, J. and M. Álvarez (2008), "Indicadores de comercio exterior y política comercial: mediciones de posición y dinamismo comercial", *Project Documents*, No. 217 (LC/W.217), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), November.
Eaton, D. (2001), *México y la globalización: hacia un nuevo amanecer*, Mexico City, Editorial Trillas.
Gallagher, K. and M. Shafaeddin (2010), "Policies for industrial learning in China and Mexico", *Technology in Society*, vol. 32, No. 2, May.
Heid, B., M. Larch and A. Riaño (2013), "The rise of the maquiladoras: a mixed blessing", *Review of Development Economics*, vol. 17, No. 2, May.
Hulten, C. (2001), "Total factor productivity: a short biography", *New Developments in Productivity Analysis*, C. Halten, E. Dean and M. Harper (eds.), Chicago, University of Chicago Press.
Ibarra, C. (2011), "Maquila, currency misalignment and export-led growth in Mexico", *CEPAL Review*, No. 104 (LC/G.2498-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), August.
Ibarra, C. and R. Blecker (2016), "Structural change, the real exchange rate and the balance of payments in Mexico 1960-2012", *Cambridge Journal of Economics*, vol. 40, No. 2, March.
IMF (International Monetary Fund) (2009), *Balance of Payments and International Investment Position Manual*, Washington, D.C.
INEGI (National Institute of Statistics and Geography) (2017) "Encuesta Mensual de la Industria Manufacturera", Economic Information Bank [online database] http://www.inegi.org.mx/sistemas/bie/?idserPadre=104001000010.
___(2015), "Estadística integral del Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportación (IMMEX)", August [online] https://boletin-infomail.typepad.com/IMMEX/Estadistica%20IMMEX-Agosto%202015.pdf.
___(n/d), "Monthly Industrial Survey (EIM) 1994-2008" [online] http://en.www.inegi.org.mx/programas/eim/1994/default.html#Publicaciones.
Isaksson, A. (2007), *Determinants of Total Factor Productivity: A Literature Review*, Vienna, United Nations Industrial Development Organization (UNIDO), July.
Jenkins, R., E. Dussel and M. Mesquita (2008), "The impact of China on Latin America and the Caribbean", *World Development*, vol. 36, No. 2, February.
Jorgenson, D., F. Gollop and B. Fraumeni (1987), "Productivity and US economic growth", *Contributions to Economic Analysis*, vol. 169, Cambridge, Harvard University Press.
Krugman, P. and M. Obstfeld (2003), *International Economics: Theory and Policy, 6th edition*, Boston, Pearson Education International.
López-Córdova, C., G. Esquivel and A. Monge-Naranjo (2003), "NAFTA and manufacturing productivity in Mexico", *Economía*, vol. 4, No. 1.
Lucas, R. (1988), "On the mechanics of economic development", *Journal of Monetary Economics*, vol. 22.
Morales, J. (coord.) (2000), *El eslabón industrial: cuatro imágenes de la maquila en México*, Mexico City, Editorial Nuestro Tiempo.
Moreno-Brid, J. and others (2016), "Inversión, cambio estructural y crecimiento", *Revista de Economía Mexicana*, No. 1.
Mungaray, A. (1990), *Crisis, automatización y maquiladoras*, Mexicali, Autonomous University of Baja California (UABC).

Mungaray, A., M. Ramírez and M. Texis (2006), "La industria maquiladora de exportación y su impacto sobre el bienestar, 1990–2005", *Estudios económicos sobre Baja California*, A. Mungaray and J. Ocegueda (coords.), Mexico City, Miguel Ángel Porrúa/Autonomous University of Baja California (UABC).

Ocegueda, J. (2003), "Estructura económica y especialización en Baja California: tendencias recientes", *Estructura económica y demanda de educación superior en el noroeste de México*, B. Burgos, A. Mungaray and J. Ocegueda (coords.), Mexico City, Miguel Ángel Porrúa/National Association of Universities and Higher Education Institutions (ANUIE).

OECD (Organization for Economic Cooperation and Development) (2008), *OECD Benchmark Definition of Foreign Direct Investment 2008*, Paris, OECD Publishing.

Oulton, N. (2001), "Measuring capital services in the United Kingdom", *Bank of England Quarterly Bulletin*, September.

Rodríguez-Clare, A. (1996), "Multinationals, linkages, and economic development", *The American Economic Review*, vol. 86, No. 4, September.

Romer, P. (1990), "Endogenous technological change", *Journal of Political Economy*, vol. 98, No. 5, October.

Ros, J. (2015), *¿Cómo salir de la trampa del lento crecimiento y alta desigualdad?*, Mexico City, El Colegio de México/National Autonomous University of Mexico (UNAM).

Texis, M., A. Mungaray and G. Grijalva (2009), "Maquiladoras y organización industrial en la frontera norte", *Cuatro décadas del modelo maquilador en el norte de México*, R. Barajas and others (coords.), Tijuana, El Colegio de la Frontera Norte/El Colegio de Sonora.

Utar, H. and L. Torres (2013), "International competition and industrial evolution: evidence from the impact of Chinese competition on Mexican maquiladoras", *Journal of Development Economics*, vol. 105, November.

Vázquez, J. and B. Avendaño (2012), "¿Modelo de crecimiento exportador o modelo de estancamiento exportador? El caso de México, 1961–2010", *Investigación Económica*, vol. 71, No. 282.

Brazilian industry and knowledge absorption: internal and external company determinants[1]

Philipe Scherrer Mendes, Gustavo Britto and Ana Maria Hermeto

Abstract

Technological composition and productive diversification are distinguishing features of countries' long-term growth trajectories. Investing in research and development (R&D), infrastructure and technology is a possible alternative for developing countries looking to accelerate their growth trajectory. In the case of Brazil, the production structure must be modified and productivity increased, by endogenizing technological advances, in order to narrow the technology gap. The factors that determine investment in absorption of external knowledge must be defined. To this end, a multilevel analysis was performed, based on microdata from the local unit section of the Annual Industrial Survey-Enterprise (Pesquisa Industrial Anual–Unidade Local) and the Survey of Innovation (PINTEC) (2008, 2011 and 2014) conducted by the Brazilian Institute of Geography and Statistics (IBGE). The results bear out the theory regarding the internal determinants of firms' innovative activities. Municipal determinants appear consistent with the literature only for "machinery and equipment" and "training" expenditure, while diversified spaces have little influence on levels of R&D expenditure.

Keywords

Industry, industrial enterprises, investments, technological innovations, know-how, technological change, industrial development, Brazil

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O14, R11

Authors

Philipe Scherrer Mendes has a doctorate in Economics from the Federal University of Minas Gerais, Brazil. Email: philipescherrer@gmail.com.

Gustavo Britto is an Associate Professor in the Department of Economics of the Federal University of Minas Gerais. Email: gustavo@cedeplar.ufmg.br.

Ana Maria Hermeto is an Associate Professor in the Department of Economics of the Federal University of Minas Gerais. Email: ahermeto@cedeplar.ufmg.br.

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I. Introduction

One of the central aspects of economic development relates to the process of innovation, which according to Schumpeter (1982) is the only phenomenon capable of increasing the wealth of an economy in the long term. In the discussion on the processes that lead to innovation, the production, adoption and diffusion of technological innovation are identified as essential factors for economic growth and social change. Technological innovation is also a distinctive feature of countries' products and sectors that compete successfully in the global market.

Countries with more diverse, high-tech production tend to differ from countries whose production structure is based on products with limited processing or technological content, which compete on price. This difference has been alluded to as a reason for structural imbalances in developing countries' balance of trade, as a result of the uneven generation and diffusion of technological progress (Kaldor, 1957; Thirlwall, 1979; McCombie and Thirlwall, 1994, among others). The technological gap among countries has created severe problems in terms of international competitiveness, whereby growth in exports from developing countries (which manufacture low-tech products) is intrinsically linked to trends in international demand.

Industrialized countries aim to create conditions that will enable them to stay at the forefront of technological progress, reducing the vulnerability of their import and export structures by exporting products with higher income elasticity and reducing imports of such products. Industrialization alone does not seem able to reduce the vulnerability of economies to external constraints (Tavares, 2016). This is why the technological frontier and the endogenization of ongoing processes of progress and innovation are important. Fajnzylber (1990) states that underdeveloped economies have been unable to open the "black box" of technical progress and do not have the right conditions to increase their output and productivity.

Innovation in peripheral countries has a number of features that distinguish it from innovation in countries with developed industries. Viewing economic development as a historical process, it is important to consider the socioeconomic elements of the structure of developing countries based on the idea that development consists "of the transplantation of an advanced technology into a backward economy which is unable to produce it endogenously, as the outcome of its own evolutionary processes" (Merhav, 1969). In that regard, investing in knowledge acquisition can be an alternative means of achieving growth. However, this acquisition should not be understood as a mere purchase. For there to be real opportunities for knowledge acquisition, companies must invest in the capacity to absorb knowledge internally. This capacity appears to be a key factor in differentiating companies. Cohen and Levinthal (1990) define absorptive capacity as the ability to "recognize the value of new, external information, assimilate it, and apply it to commercial ends", and they underscore the importance of prior related knowledge. It would seem that external sources are critical to the innovation process, and the ability to explore the aforementioned knowledge, evaluate it and use it is crucial to a firm's ability to innovate.

Having identified the industrial sector as capable of being a generator of more growth and having connected the possible outcomes of these investments in terms of productivity and growth, it is possible to draw a parallel between firms' innovation aims, namely profits and market share, and the eventual outcome of this process, in terms of greater industrial productivity and the importance of this growth for the economy's overall performance. In that respect, the purpose of this study is to measure, within the Brazilian process industry, the determinants of Brazilian industrial 'firms' investment in absorptive capacity, controlling for the territory's influence.

This analysis contributes to the literature by jointly analysing internal and external determinants of firms' investment decisions regarding knowledge absorption. The importance of this analysis and its results and conclusions are strengthened by the level of disaggregation of the data, the representativeness

of the two databases used —the Annual Industrial Survey (Pesquisa Industrial Anual, PIA) and the Survey of Innovation (Pesquisa de Inovação, PINTEC) overseen by the Brazilian Institute of Geography and Statistics (IBGE)— and the controls for spatial heterogeneity using indicators of the formal labour market, especially in view of the size of Brazil's territory and the differences within the country.[2] This study also seeks to contribute to the subject by differentiating between two types of investment in knowledge acquisition that may generate innovation and which are interrelated in different ways with territorial characteristics.

II. Theoretical aspects of technological absorptive capacity

1. The importance of developing these capacities

Students of the processes that lead to innovation recognize that the production, adoption and diffusion of technological innovation are essential for economic development and social change (Malerba, 1992; Teece and Pisano, 1994; Bell and Pavitt, 1997, among others) and that technological innovation is a distinctive feature of high-income countries' products and sectors that compete successfully in the global market. Therefore, the magnitude of a company's (micro) absorptive capacity is intertwined with the profile of its industry (meso) and the wealth-generating capacity of the country (macro). Hence why this literature is important for understanding development as a whole.

Innovative activities, such as those described below, play an important role in building technological capabilities by enabling a better understanding of where the market is heading and optimizing investments for the opportunities that are created. Malerba (1992) affirms that firms' technological activities are responsible for generating knowledge that is fundamental in the processes of learning by doing, using, searching and interacting, among other actions. Adopting a similar perspective, Bell and Pavitt (1997) highlight the importance of building capacities to generate and manage technical change, in particular the development of productive skills and accumulation of knowledge and experience.

The decisions that determine a company's path and its accumulated knowledge and skills lead to the development of an almost inimitable set of capabilities, which are drawn on to carry out its activities (Teece and Pisano, 1994). The challenge, however, is to create conditions that are conducive to investment in knowledge and innovative activities that will yield the expected results when approaching or upon reaching the technological frontier. While this problem is faced by firms that are established in developed countries, the situation is even more complex in late industrializing countries. The fact that accumulation is part of the process of technological progress gives companies that are at the technological frontier advantages over those that lag behind. It is precisely the pursuit of this differentiating advantage that drives technological progress.

The speed of technological progress depends on a number of factors and a minimum level of capabilities must exist within a company to prevent it from being pushed out of the market.[3] Regardless of considerations relating to the pace of growth in each sector, companies must be well versed in their operating environments, so that, at the very least, they do not drift away from the production frontier to the point of being pushed out of the market. If the company does not grow fast enough or accumulate sufficient knowledge to set the rules that shape a sector, it must at least have the capacity to understand the sector's characteristics, in order to remain in the market.

[2] According to the Annual Social Information Report (RAIS) of the Ministry of Economic Affairs (2019).

[3] Factors such as technological opportunities or technological paradigms.

Cohen and Levinthal (1990) coined the term "absorptive capacity" and defined it as the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends, which is largely a function of a firm's level of prior related knowledge. External sources are critical to the innovation process, and the ability to exploit outside knowledge is a crucial part of a firm's ability to innovate.

When examining the interaction between universities and firms, Meyer-Krahmer and Schmoch (1998) highlight the importance of developing absorptive capacity, since this allows firms to recognize and adopt new technological paradigms. Van den Bosh, Volberda and de Boer (1999) state that companies must build knowledge absorption capacity, because it enables them to speed up technological advances and can differentiate them from competitors. Capabilities that allow companies to integrate, build and reconfigure competences to address rapidly changing environments or paradigms are fundamental to their performance (Teece, Pisano and Shuen, 1997). According to Zahra and George (2002), absorptive capacity should be understood as a set of organizational routines and processes that create favourable conditions for production advances. This also enables companies to build skills and capabilities to cope with changes and restructure their activities, enabling them to gain and maintain competitive advantages. Historically, companies that have invested more in absorptive capacity have increased their chances of seizing greater opportunities.

As a form of learning, absorptive capacity differs from learning by doing in that it is not an automatic process through which one acquires ever greater practical experience and efficiency in the same activity. Although firms have different means of accumulating knowledge (learning processes), the generation of stocks of knowledge and technological capabilities yields enhancements in trajectories of technological advance, not just production cost reductions (Malerba, 1992). It is a costly process, and one that requires effort and discipline, but it generates technological advantages for companies by creating the right conditions for the internalization of knowledge. However, it cannot be created overnight or with simple, short-term solutions.

Regarding the search for ways to optimize construction of knowledge absorption capacity, Cohen and Levinthal (1989) find a strong parallel between this capacity and investment in research and development (R&D). Companies not only invest in R&D to seek new processes or products directly, but also to develop and expand their capabilities to assimilate and exploit externally available information. Thus, the incentive for absorption through spillovers is seemingly greater in sectors where learning hurdles are greater. In addition, the learning environment affects the impact of spillovers on R&D expenditure, and the importance of expanding absorptive capacity —in relation to negative appropriability conditions— is determined by the degree of interdependence among competitors.

Identifying the determinants of capability building is fundamental to optimizing paths and creating conditions that minimize the technology gap. This is the challenge that must be addressed by late industrializing economies, on the understanding that industrial progress is a determinant of a country's economic growth, based on more productive companies, improved processes, more complex output and greater income elasticity of products. This allows firms to secure a better position in international markets and, through aggregate demand, higher income levels, faster production growth and increasing levels of productivity and, consequently, of remuneration for work.

The acquisition of external technologies and knowledge facilitates —but does not guarantee— improved technological performance by the importing country. In this regard, while it is possible for the least developed nations to expand their technological frontiers with respect to advanced nations, a minimum capacity is needed to enable effective absorption and use of the knowledge acquired. Therefore, ongoing technological training must be provided to expand the technological capabilities that allow better use to be made of imported technologies (Chiarini, 2014).

Technological innovation should be understood as a learning process in which innovations are not necessarily radical, but rather one where small incremental innovations may contribute to increasing the productivity of a firm or a country (Rosenberg, 1983). Abramovitz (1986) describes learning that is

made possible by a differential among countries' stages of technological development, in which the performance of follower countries depends on their initial circumstances. The development of "social capabilities" appears to be crucial to creating the right conditions for identifying and absorbing existing know-how, which when appropriated by followers should increase their productivity. These "social capabilities" are technical competences that cannot be understood without taking into account other important actors or institutions of a political, commercial, industrial and financial nature, among others, in addition to considering educational levels and the organizational and institutional frameworks in which enterprises exist. Abramovitz (1986) considers that the combination of the technological gap and "social capability" defines a country's potentiality to stimulate its catch-up process, improving productivity. For that to happen, there must be channels to promote flows of knowledge from leaders to followers.

Some late industrializing economies went from being technologically backward and poor to being relatively modern and affluent by assembling a significant collection of industrial firms that produce technologically complex products and compete effectively against firms based in industrially advanced countries (Kim and Nelson, 2000). The acquisition and progressive control of new technologies has been a key feature of the late industrializing economies that grew rapidly after the 1980s. In addition to substantial investment in physical and human capital, it was crucial that some countries that were considered imitators in the 1960s acquired and assimilated technologies that existed in advanced economies. Together, these two factors transformed those countries into innovators in the 1990s. However, this is not a simple process or one with a quick return. The fact that technological know-how is not evenly distributed among firms and cannot be easily imitated or transferred among them means that transfers require significant absorptive capacity, as the underlying principles are not easily assimilated.

Within the developmentalist-industrial paradigm, in order to surmount underdevelopment, technological dependence must be overcome and conditions created that favour endogenizing technological development, even if foreign practices have to be adopted to accelerate the process. Adopting foreign techniques or importing technology should not be seen as an end, but as an opportunity to create the internal conditions for the future development of new forms of production or new products. Caution should be exercised when importing technology, as it can result in underdeveloped economies remaining caught in the technological dependence trap. Readily available technologies tend to be mature technologies whose technological growth has been exhausted. However such technologies may be superior to the domestic technology of the country, moving it further away from the technological frontier and helping to maintain the technological distance between advanced and less advanced countries (Chiarini, 2014).

An important aspect to be considered in this debate is that the conditions for the dissemination and absorption of knowledge are geographically limited. This study therefore also attempts to explain how companies' locations are linked to creating the conditions for knowledge absorption. The next section addresses the debate on the dynamics of technological progress from a regional perspective, presenting and discussing the territorial features that drive innovation and production.

2. Territorial determinants

The literature on economies of agglomeration describes the relationship between industrial growth and firms' productivity, derived from external economies of scale, as determined by the region's productive structure. Geographical proximity, which is fundamental in determining the level of innovative activity and technological progress, enables companies to exchange information and make technological progress. This helps to mitigate uncertainty, an inherent feature of innovative activity (Feldman, 1994), and to create a productive externality that reduces the cost of new discoveries. Thus, technological spillovers tend to be concentrated in space, hence productive clustering in an effort to benefit from them. Broadly speaking, two different lines of theory can be distinguished within this debate. Although the

considerations behind these two currents are not mutually exclusive, there is a clear distinction between Marshall (1890) and Jacobs (1969). According to Marshall (1890), these externalities come from the specialization of industrial activity and can be summarized as follows: effects of intersectoral-supplier-user linkages, technological spillovers of knowledge among firms and benefits from creating specialized hubs. Meanwhile, Jacobs (1969) states that the main source of beneficial externalities for companies is the diversity of economic activities carried out in cities. The multiplicity of goods and services, technologies and knowledge characteristic of a diversified urban area enhances the cross-fertilization of ideas (Glaeser and others, 1992). In other words, innovations originate from the cross-fertilization of ideas among the various sectors of activity in the same city, which are driven by the generation of new types of work, increasing the capacity to generate new goods and services.

The advantages of urban agglomeration are not limited to the area of production. Large cities offer a greater variety of consumer goods and public services and greater possibilities for social contact, which should translate into externalities. Thus, they are also attractive to workers and consumers. The arrangement of productive activities in the space is also influenced by dispersive forces. However, these forces should not be understood as the absence or non-existence of agglomerative forces. In other words, the benefits of urban agglomeration are valid for all actors in the production process even while dispersive forces act. Nevertheless, only actors who overcome the difficulties arising from centrifugal forces tend to occupy the best positions or central locations. The main dispersive factor is related to land income or urban land income, which is derived from the existence of property rights. This results in a need for a consideration in exchange for use of a site (rent per unit of floor area) and tends to differentiate rental values according to location and proximity to the consumer market (Von Thünen, 1966). The tendency towards high prices in central locations and lower prices further from the centre determines the type of activity that is typically located in each place. The ability to pay this rent differential is linked to the profitability of an activity, meaning that only the most profitable (profit per unit of floor area) activities have access to the central spaces. Hence, the localization of production is determined by a productivity gradient, which generates a spatial hierarchy, and income from urban land applies a dispersive force, because it pushes out those who cannot afford to establish themselves in privileged locations.

Glaeser and others (1992) suggest that technological spillovers occur between companies in the same industry and positively affect growth. They argue that industrial specialization facilitates access to inputs, intermediate goods and services, labour and markets. Advocates of the existence of an externality derived from industrial specialization gained prominence in regional economic theory and have carried out various empirical studies to assess the extent to which this theory reflects reality (Glaeser and others, 1992; Combes, 2000; Henderson, 2003, among others). Despite the empirical evidence, provided in several works, it is well-known that there are cities or regions with significant economic growth that are not specialized spaces. Regarding this lacuna, Jacobs (1969) gives another important characterization of space as a factor that generates dynamism. Without refuting the productive efficiency gained through specialization, Jacobs (1969) considers that the possibilities created by specialized spaces are relatively limited compared to those created in diversified spaces. She states that production diversification is largely responsible for the flowering of new ideas and knowledge. Accordingly, although the importance that Jacobs (1969) attaches to the region and to face-to-face contact is similar to that of Marshall (1890), in her work the possibility of complementarity or cross-fertilization of different information and technologies in various sectors is considered to be primarily responsible for the emergence of greater economic dynamism. Thus, regions with a wide variety of productive sectors would have a better chance of innovating, especially owing to the possibilities created by exchanging and recombining knowledge and practices (Jacobs, 1969).

As suggested by Duranton and Puga (2000), diversification and specialization can coexist, with a tendency for large cities, and the activities within them, to become more diversified and stable in terms of size. While most innovations tend to occur in diversified cities, where most new production plants are also based, specialized cities are the main destination for companies relocating from diversified cities.

On this last point, the argument is that once companies find their ideal production process, they do not necessarily have other incentives to stay in diversified cities, so they offset high production costs with location-related benefits and tend to move to where other companies share their specialization.

The constant search for new products and market niches fostered geographical dispersion of production, breaking away from the productive rigidity of the Fordist period to seek greater flexibility in labour markets, with new forms of supplying inputs and services that required a number of transformations in organizational and commercial patterns. According to Ernst and Kim (2002), what they call "global network flagships" will play a central role in this new model, by maximizing the use of globally dispersed resources and accessing competencies located in different places, which complement each other to improve productive efficiency. While productive activity was spreading throughout territories, new forms of territorial centralization emerged, generally related to high-level management and central control of operations. To some degree, these movements show reorganization, driven by dispersive factors related to the cost of localization. In this context, the most labour-intensive companies tend to relocate first (Puga and Venables, 1996), affected by increases in wages in developed regions, leading to the formation of new centres of activity, which possess the critical mass for production.

Technological advances have reduced the cost of spreading out productive activity, creating a strong incentive for cities to shift their specialization from a sectoral dimension to one that is function-based. As a large number of companies make the same choice, it comes to define the employment pattern in cities and gives rise to industrial cities and cities that are home to companies' core activities.[4] This new division brings greater benefits of proximity to core activities than to productive activities. This reflection in turn leads to the observation that cities that are home to firms' core activities are much larger and fewer in number, while industrial cities are smaller in size and more numerous (Duranton and Puga, 2000).

Barbour and Markusen (2007) state that innovative and developmental activities tend to be anchored in a company's region of origin, while more routine production and service functions are dispersed to lower-cost and downstream-consuming locations. They stress the importance of occupational analysis over industrial analysis, and affirm that, with this new industrial structure, companies in the same sector may present completely different occupational structures in different locations, which would be a determining factor in productivity growth and regional performance.

3. Peculiarities of Brazil

Turning this discussion to Brazil, a late industrializing country with significant spatial heterogeneity, there are certain territorial characteristics that favour dissemination of technological know-how to different degrees.[5] The lack of a minimum social capability that allows knowledge to be absorbed (Abramovitz, 1986) excludes a large portion of Brazil's territory from productive and industrial progress. However, the country clearly underwent a reorganization of its productive structure and spatial distribution following the 1990s. This restructuring, which was closely linked to the external market and higher demand for skilled labour, became more influenced by location factors. In that context, urbanization emerged more clearly as a key element of the new productive restructuring dynamic. As part of this process, new studies on economies of agglomeration, which link external economies of scale and the regional production structure to productivity levels, have recently begun to play a more prominent role (Galinari, Lemos and Amaral, 2006; Fontes, Simões and Oliveira, 2010; Freitas, 2012).

The economic growth and income distribution seen in Brazil in the 2000s was largely influenced by external demand for commodities, which allowed for an uptick in domestic labour market participation

[4] Company headquarters, which include activities such as management, commercial services and R&D hubs.

[5] The Brazilian production and industrial structure is largely concentrated in the state of São Paulo and in the South-East region, despite recent policies that encouraged regional redistribution of industry, especially into the North-East region.

and income. The international crisis of 2008 seems to have changed the course of history somewhat: this process lost momentum in the Brazilian economy, negatively affecting economic, employment and income growth. The collapse of the Brazilian economic model of the 2000s again highlights the importance of examining the factors that determine increases in productivity.[6] In this debate, it is accepted that industry plays an incontrovertible role (Messa, 2015), both because it is more capital-intensive and because it is an important source of innovation and is able to generate better quality jobs, higher remuneration and lower employee turnover, promoting the development of specialized human capital. Cavalcante, Jacinto and De Negri (2015) stress the importance of increasing the productivity of the Brazilian economy in order to return to the cycle of economic growth. In that connection, they identify investment in R&D and innovation as drivers of future labour productivity. In the same paper, they test the hypothesis that labour productivity in less technology-intensive sectors is more sensitive to the acquisition of machinery and equipment than to investment in R&D, and find results that confirm this theory.

Just as the innovation process is influenced to a large extent by its local dimension, over the years the knowledge absorption capacity of Brazilian industry has tended to be more influenced by factors related to proximity. It can therefore be inferred that companies in specialized regions tend to spend more on machinery and equipment and on training their workforces, in search of better productive practices, while the performance of companies in diversified regions depends on their capacity to take advantage of the benefits of the diversity of a localized space which, in addition to offering a larger supply of skilled labour, promotes innovative activity related to the R&D process.

In this study, the determinants of the knowledge absorption capacity of the Brazilian processing industry are estimated based on PINTEC microdata. The analysis was carried out for all the companies included in PINTEC in 2008, 2011 and 2014, and takes into account companies' internal and municipal determinants, ranking them byfirm and municipality. The chosen period was one of major national productive restructuring, marked by the repercussions of the international crisis of 2008.

III. Database and methodology

The empirical analysis entailed combining different databases. The main databases used were PINTEC and the PIA-Enterprise, both overseen by IBGE, and the Annual Social Information Report (RAIS) of the Ministry of Economy. Given that the first two databases are organized using the National Register of Legal Entities (CNPJ) to identify companies, a database was created in which the observation unit is the enterprise-local unit and the RAIS data are aggregated at the municipal level. In accordance with the frequency of PINTEC, the analysis was performed for 2008, 2011 and 2014. The empirical analysis was carried out with microdata from PINTEC and PIA-Enterprise that is difficult to access owing to the confidentiality of the information.

1. Methodology

The analysis of Brazilian industrial companies' investment in innovative activities reveals the importance of considering the environment in which they operate. Assuming that this is also a determinant of their trajectories, the empirical analysis therefore takes into account controls for the effects of the municipality. A decision was therefore made to use a multilevel model. This decision was based on the characteristics that the analysis assumes are related to interaction with the environment in which companies operate, with a possible mutual causality relationship between individuals (in this case companies) and the environment. This interrelation cannot be ignored in the analysis (Goldstein, 1995). The possibility of a

[6] Rising commodity prices, capital inflows, expanding consumption, low savings rates, among other factors.

relationship between the variability of individual characteristics determined by the environment in which the firms operate must be considered in the analysis, because, although there is a control for individual and environmental characteristics, there is the possibility that —since no distinction is made between the hierarchical levels and their correlation— the estimates are spurious. With this approach to the analysis, with companies included in different groups, it must be assumed that their characteristics are not entirely independent of the environment and that there may be groups that, on average, have a more or less determining impact on certain characteristics of the companies.

The simplest model of hierarchical analysis is random effects analysis of variance. This initial specification captures the differences between the overall mean of the response variable and the specific mean of each second-level group. It is represented as follows (Raudenbush and Bryk, 2002):

$$Y_{ij} = \beta_{0j} + r_{ij} \quad (1)$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad (2)$$

$$\gamma_{ij} = \gamma_{00} + u_{0j} + r_{ij} \quad (3)$$

where Y_{ij} = dependent variable for each individual i in a group j; β_{0j} = mean of the dependent variable for each group j; r_{ij} = error term of individual i in group j (normally distributed with mean 0 and variance σ^2); γ_{00} = population mean of the dependent variable; and u_{0j} = random effect of group j (or deviation of group j from the population mean), with a normal distribution of u_{0j}. The variance of the response variable is given by:

$$Var\,(Y_{ij} = Var(u_{0j} + r_{ij}) = \tau_{00} + \sigma^2 \quad (4)$$

Variance decomposition (τ_{00} – between groups and σ^2 – within groups) allows the intraclass correlation coefficient (ICC) to be calculated, indicating the portion of total variance that is explained by the second hierarchical level, that is to say the extent to which the environment determines individual behaviour. The ICC is represented by:

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2), \quad (5)$$

Applying a generic multilevel analysis model to the analysis of absorptive capacity (AC), the following is obtained:[7]

$$AC_{ij} = \beta_{0j} + \beta_{1j}(1\ level_{ij}) + r_{ij}, \quad (6)$$

with:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(2\ level_{j}) + u_{0j} \quad (7)$$

$$\beta_{1j} = \gamma_{10} \quad (8)$$

Adapting the proposal of Cohen and Levinthal (1990) to the specificities of PINTEC, including explanatory variables for the labour market and urban structure, the determinants of expenditure on creating absorptive capacity are measured. The "absorptive capacity" variable was constructed using the variables for a company's innovative activity. In PINTEC these are: internal R&D, acquisition of external R&D, acquisition of other external knowledge, acquisition of software, acquisition of machinery and equipment, and training.[8] According to Araújo and Salerno (2015), it is possible to group innovative activities into two distinct factors: "R&D-driven innovation", which is highly correlated with internal and external R&D, and "machinery- and training-driven innovation", correlated with the acquisition of

[7] Neither interaction between first and second level variables nor randomization of the slope were included, so the specification of β_{1j} is simpler.

[8] Although investments in "Introduction of technological innovations into the market" and "Other preparations for production and distribution" are also innovative activities according to PINTEC (IBGE, n/d), these two forms of investment were not included because they do not relate to either of the two dimensions of innovation examined and presented in this paper.

machinery and equipment and training.[9] Based on Araújo and Salerno (2015), innovative activities are divided into two groups. The first group is intended to represent a type of absorptive capacity that is closer to Cohen and Levinthal's (1990) original concept, which is highly correlated with expenditure on internal or external R&D —responsible for generating the capabilities that favour recognition, assimilation and application of external information in firms' internal routines. The second group, presented as a possible alternative to economies that lag behind in economic and industrial development, is related to investment in machinery and equipment and training, which allows the generated knowledge to be absorbed and incorporated into more modern machinery and equipment, assuming that such investments tend to be made to increase production efficiency.

Based on the idea of activities that are "R&D-driven" and "machinery- and training- driven", two distinct groups of innovative activities were formed:

- The sum of the amounts spent on internal R&D, the acquisition of external R&D and the acquisition of other knowledge, defined as "AC-product";[10] and
- The sum of the amounts spent on acquiring software, machinery and equipment and on training, defined as "AC-process".

The first group represents a form of absorptive capacity that is more conducive to developing new products and the second group is intended to correlate with the possibility of innovation in production processes.

Having defined how the dependent variables were constructed, a strategy needed to be formulated to enable analysis of the effects of investments on knowledge absorption capacity from a territorial perspective. It was required because the PINTEC data are not disaggregated to a point that would allow for assessment of the influence of the territory (in this case, the municipality).[11] To this end, two strategies were established that involved aggregating PINTEC data with company location information, using the "Unidade Local" (local unit) section of the Annual Industrial Survey -Enterprise (PIA-UL), based on National Register of Legal Entities entries for each company. The first strategy was to use companies with PIA-UL data that had only one local unit, excluding the others, and the second strategy was to generate a second database by dividing PINTEC (National Registry of Legal Entities) values among the different local units that were in the same Register.[12] The next section presents the results of the econometric estimation for the two strategies.

Table 1 shows the variables used in the empirical exercises and the two hierarchical levels considered in the analysis. The table also includes a short description of each of the variables.[13]

The goal of estimation of absorptive capacity, differentiating between absorption that favours product innovation and absorption that favours process innovation, is to verify possible differences between these two forms of absorption, controlling for company characteristics and observing how they differ in terms of the territorial-level determinants, to identify the relationships between different urban structures and knowledge absorption activities.

[9] Araújo and Salerno (2015) performed a factor analysis of the innovative activities in PINTEC 2008 and obtained two factors that condense their importance: one that is highly correlated with intramural and external R&D, which they call "R&D-driven innovation", and another that is highly correlated with the acquisition of machinery and equipment and training, which they call "machinery- and training-driven innovation".

[10] The variables were deflated using the industrial wholesale price index (IPA-indústria) at 2008 prices, and a log transformation (ln) was performed.

[11] The only territorial breakdown of PINTEC is the unit of the federation (IBGE, n/d).

[12] The information present in PIA-UL did not allow for better determination of the local units that were responsible for expenditure or where the R&D professionals were assigned, among other data collected by PINTEC, so a simple division was performed, whereby each local unit received the same portion of the expenditure.

[13] The indicators of occupational technological hierarchy were constructed according to Rodrigues, Oliveira and Albuquerque (2007) and the indicators of sectoral technological intensity were constructed according to Cavalcante (2014).

Table 1
Description of the variables used in the empirical analysis

Variable name	Indicator	Construction of the variable
First level: company characteristics		
Net revenue	Scale of production	Ln of net sales revenue recorded in the company's balance sheet
Ongoing R&D	Technological opportunity	Dummy variable for companies that reported ongoing R&D
Maintain market	Degree of appropriability	Dummy variable for companies that considered it very important to innovate in order to maintain their market share
Expand market		Dummy variable for companies that considered it very important to innovate in order to expand their market share
Cooperation agreement	Cooperation to innovate	Dummy variable for companies that participated in cooperation agreements with other organizations
Doctors - working exclusively	Profile of workforce in R&D	Number of staff with masters or doctorate degrees working exclusively on R&D
Masters - working exclusively		
National Classification of Economic Activities, version 2.0 (CNAE 2.0) - Division	Industrial sector control	Dummy variables for the 24 industrial sectors - process industry
Second level: municipal characteristics		
Industrial diversification	Urbanization indicators	Industrial diversification index (modified Herfindahl-Hirschmann Index)
Distance from São Paulo		Distance from the city of São Paulo, measured in hours
Location quotient - production services		Location quotient (LQ) for production services (Annual Social Information Report (RAIS))
Location quotient - low intensity	Indicators of production specialization	Location quotient (LQ) for industries with low technology-intensity (RAIS)
Location quotient - lower-moderate intensity		Location quotient (LQ) for industries with lower-moderate technology-intensity (RAIS)
Location quotient - upper-moderate intensity		Location quotient (LQ) for industries with upper-moderate technology-intensity (RAIS)
Location quotient - high intensity		Location quotient (LQ) for industries with high technology-intensity (RAIS)
Employment - upper-senior	Labour market indicators	Employee participation in "upper-senior" technology hierarchy positions (RAIS)
Employment - lower-senior		Employee participation in "lower-senior" technology hierarchy positions (RAIS)
Employment - middle-senior		Employee participation in "middle-senior" technology hierarchy positions (RAIS)
Education - full higher education		Participation in the industry by employees with full higher education (RAIS)
Education – master's degree		Participation in the industry by employees with master's degrees (RAIS)
Education - doctorate		Participation in the industry by employees with doctorates (RAIS)
Regional and year controls		
North	Dummy variables for controls for regional characteristics	Dummy variable North
North-East		Dummy variable North-East
South-East		Dummy variable South-East – state of São Paulo was omitted
Central-West		Dummy variable Central-West
South		Dummy variable South
2011	Dummy variables for 2011 and 2014 — 2008 omitted	Dummy variable for 2011
2014		Dummy variable for 2014

Source: Prepared by the authors.

The following hypotheses are tested: that the most R&D-intensive innovative activities —which also therefore create knowledge absorption capacity that is conducive to product innovation— are strongly correlated with production diversification (Jacobs, 1969; Duranton and Puga, 2001; Storper and Venables, 2004; Araújo, 2014, among others) and with the most technology-intensive sectors (Henderson, Kuncoro and Turner, 1995; Araújo, 2014, among others), and that innovative activities that are more intensive in machinery, equipment and training —generating, therefore, the capacity to absorb knowledge that is conducive to process innovation— show greater correlation with industrial specialization and with sectors that are less technology-intensive (Duranton and Puga, 2001; Barbour and Markusen, 2007; among others).

IV. Analysis of the results

The results relating to the two empirical strategies adopted are presented and discussed below, with estimates that take into account only companies with a single "local unit", which did not bias the territorial perspective but did mean excluding a significant portion of the companies,[14] and estimates that take into account all the companies in PINTEC, dividing the amounts spent on innovative activities among the different local units, as mentioned above, with the resulting bias in the territorial perspective.

1. Absorptive capacity and product innovation

The results presented in this section contribute to the discussion surrounding which company and municipality characteristics are most favourable for investment in innovative activities that resulted in capabilities to recognize, assimilate and use existing or available know-how in the innovation process (AC-product).

The first step in structuring the hierarchical model was estimation of the unconditional model (analysis of variance), to determine the proportion of the model's total variance that is explained at the first and second levels, thus measuring the influence of the environment (municipality) on individual behaviour (company). Having outlined this initial specification, table 2 presents the results of the estimation of indicators for companies (first level) and for the general model, also including municipal controls.

The analysis of variance estimate justifies the use of the hierarchical model, the intraclass correlation coefficient is significant at 1% and the municipalities account for 4.02% and 4.42% of the variance in the data, for the two databases. As expected, the inclusion of first-level explanatory variables reduces the municipal share of total variance in the data and the variance remains significant.

In the estimation of first-level determinants, the results are as expected for the two groups of companies: an increase in net revenue (company size) increases expenditure on "AC-product"; companies that reported ongoing R&D spend more than other companies; companies that considered it very important to innovate in order to maintain or expand their market shares spend more than other companies; companies that were parties to cooperation agreements to perform innovative activities spend more than others; an increase in staff with master's degrees or doctorates working exclusively on R&D increases expenditure on "AC-product". In the case of the last of these results, there is a marked difference in magnitude between the two estimations: the result for "single local units" is significantly higher than that for "division of amounts between local units". This suggests there may be a limitation on the empirical strategy of dividing amounts equally among local units. Also at the company level, sector dummy variables (National Classification of Economic Activities, version 2.0 (CNAE 2.0)-Division) and dummy variables for 2011 and 2014 were included, showing that in 2011 expenditure was lower than in 2008 and that in 2014 it was higher.

The aim of including second-level variables in the general model was to filter all possible company- and territory-level impacts that might be responsible for determining investment in absorptive capacity for product development. The results for the first-level variables were significant and as expected, as in the previous specifications. The results were also maintained for sector controls and for the dummy year variables. Overall, despite some changes in the statistical significance of the control coefficients for municipal characteristics and a change in the sign of the full higher education variable, the results of the estimations of determinants of expenditure on "AC-product" are supported by theory.

[14] It can be assumed that larger companies were excluded from this analysis.

Table 2
Brazil: absorptive capacity (product) of the processing industry (analysis of variance estimates, controls and first-level and general model), 2008, 2011 and 2014

Dependent	AC-product											
	Single local units						Division of local units					
	Analysis of variance		First level		General model		Analysis of variance		First level		General model	
Explanatory	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation
Constant	0.7883***	0.0223	-2.1252 ***	0.1063	0.0389	2.2627	0.8265***	0.0194	-2.3081***	0.0828	-4.6442**	2.0677
Company												
Net revenue			0.1357 ***	0.0062	0.1347***	0.0063			0.1367***	0.0048	0.1390***	0.0048
Ongoing R&D			4.4005 ***	0.0320	4.4000***	0.0321			3.3122***	0.0253	3.3203***	0.0253
Market												
Maintain			0.2515 ***	0.0287	0.2519***	0.0287			0.2694***	0.0253	0.2658***	0.0253
Expand			0.2275 ***	0.0314	0.2258***	0.0314			0.2266***	0.0271	0.2223***	0.0271
Cooperation agreement			0.7192 ***	0.0315	0.7164***	0.0315			0.3591***	0.0257	0.3640***	0.0257
Workforce												
Doctors - working exclusively			0.1921 ***	0.0237	0.1921***	0.0237			0.0291***	0.0055	0.0287***	0.0055
Masters - working exclusively			0.1595 ***	0.0103	0.1590***	0.0103			0.0193***	0.0030	0.0194***	0.0030
National Classification of Economic Activities. Version 2.0 (CNAE 2.0) - Division												
Urbanization												
Industrial diversification					-0.0487	0.0343					0.0470	0.0453
Distance from São Paulo					-0.0005	0.0218					-0.0016	0.0028
Location quotient - production services					0.0052**	0.0026					0.0031	0.0245
Specialization												
Location quotient - low intensity					-1.1408	1.1594					1.0794	1.0594
Location quotient - lower-moderate intensity					-0.5551	0.5807					0.5831	0.5307
Location quotient - upper-moderate intensity					-0.4328	0.4424					0.4258	0.4041
Location quotient - high intensity					-0.0796	0.0797					0.0907	0.0729
Labour market												
Employment - upper-senior					-1.8147	24.4748					35.9331	25.3033
Employment - lower-senior					-0.4031	7.4460					6.5437	5.9141
Employment - middle-senior					0.2260	0.6427					-0.0920	0.6680
Education - full higher education					0.7402**	0.3101					-0.6784**	0.2894

Table 2 (concluded)

Dependent	AC-product											
	Single local units						Division of local units					
	Analysis of variance		First level		General model		Analysis of variance		First level		General model	
National Classification of Economic Activities. Version 2.0 (CNAE 2.0) - Division												
Education - master's degree					-5.9490	7.0991					7.5295	6.6190
Education - doctorate					-2.9725	15.6294					-3.6970	14.5838
Regions												
North					-0.1330	0.1097					0.3539***	0.1147
North-East					-0.0674	0.0689					0.2673***	0.0743
South-East					-0.0086	0.0314					0.1975***	0.0363
Central-West					0.0169	0.0576					0.2976***	0.0643
South					0.0211	0.0300					0.1837***	0.0348
Dummy variable - Year												
2011			-0.1385***	0.0213	-0.1453***	0.0216			-0.0662***	0.0197	-0.0672***	0.0201
2014			0.1038***	0.0220	0.0832***	0.0242			0.0704***	0.0201	0.0661***	0.0229
Number of companies	23 246		23 218		23 216		37 998		36 322		36 315	
Number of municipalities	1 915		1 914		1 913		2 361		2 271		2 267	
	Variance	Intraclass correlation coefficient (ICC)	Variance	ICC	Variance	ICC	Variance	ICC	Variance	ICC	Variance	ICC
Municipality	0.1910***	4.02%	0.0035**	0.20%	0.0012	0.07%	0.2147***	4.42%	0.0386***	1.59%	0.0290***	1.20%
Company	4.5549***	95.98%	1.8054**	99.80%	1.8054	99.93%	4.6432***	95.58%	2.3881***	98.41%	2.3867***	98.80%

Source: Prepared by the authors, on the basis of Brazilian Institute of Geography and Statistics (IBGE). "Survey of Innovation - PINTEC" [online] https://www.ibge.gov.br/en/statistics/multi-domain/science-technology-and-innovation/17379-survey-of-innovation.html?edicao=17383&t=downloads. (n/d), and Ministry of Economic Affairs. Annual Social Information Report (RAIS). Brasilia. 2019 [online] http://trabalho.gov.br/rais.

Note: *** significant at 1%. ** significant at 5% and * significant at 10%.

As expected, the controls for the urbanization variables were not significant in this general specification. The intention with these controls was to verify the localization effects when determining knowledge absorption capacity expenditure, testing the hypotheses of Jacobs (1969) and Marshall (1890) and the literature on the outcomes of these two original proposals for expenditure on innovative R&D activities. There was expected to be positive correlation between municipal determinants of "AC-product" expenditure and urbanization, production diversification and the most technology-intensive sectors, but this was not observed. Only the production services variable for the "single local unit" model was significant, at 5%. The controls for production specialization were not significant in either estimate.

The only municipal control that was significant (at 5%) was the municipal proportion of employees with full higher education in the industry. However, this result has different signs for the two groups of companies analysed. In the estimation that divided expenditure among firms' local units, the results suggest that an increase in the proportion of employees with full higher education in municipalities decreases expenditure on "AC-product". This can be explained by the greater territorial dispersion of employees with full higher education, as opposed to the spatial concentration of expenditure on R&D-related activities, in addition to the greater growth in the proportion of employees with full higher education in the least technology-intensive sectors, which are also less intensive in such expenditure. In addition, companies with "single local units" appear to have been able to take advantage of this space, with greater expenditure on these innovative activities in the municipalities with a larger proportion of such workers.

2. Absorptive capacity and process innovation

Applying procedures that are similar to those used in the previous section, the results presented here feed into the discussion of the characteristics that are conducive to investment in absorption of external knowledge, from the perspective that backward economies have the option of absorbing production knowledge by acquiring better production inputs, machinery and equipment, and by training their labour forces. These investments tend to generate production improvements by enabling new ways of doing things and thus potentially resulting in process innovations. Companies' internal factors and locational factors that determine expenses are evaluated in what we have called "AC-process" in this study. The expected result is of less dependence on spatial effects related to urbanization (proximity to São Paulo, available production services and industrial diversification) and greater dependence on specialized spaces (industrial location quotients (LQ)) and on factors that contribute to lower labour costs (Puga and Venables, 1996; Duranton and Puga, 2001; Duranton and Puga, 2005; Barbour and Markusen, 2007; among others).

The first finding from table 3 is that there is a lower intraclass correlation coefficient than in the analysis of variance model that measured the determinants of R&D-related investments. This suggests that, as expected, R&D-related activities and investments are more sensitive to territorial factors than expenditure on machinery, equipment and training.

Table 3

Brazil: absorptive capacity (process) of the processing industry (analysis of variance estimations, controls and first-level and general model), 2008, 2011 and 2014

Dependent	AC-process											
	Single local units						Division of local units					
	Analysis of variance		First level		General model		Analysis of variance		First level		General model	
Explanatory	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation
Constant	1.9803***	0.0268	-2.8321***	0.1891	-7.7455*	4.0063	1.7617***	0.0216	-2.0140***	0.1269	-10.1898***	3.1723
Company												
Net revenue			0.2506***	0.0110	0.2569***	0.0111			0.1886***	0.0073	0.1928***	0.0073
Ongoing R&D			0.9072***	0.0568	0.9075***	0.0568			0.3398***	0.0387	0.3573***	0.0388
Market												
Maintain			2.1603***	0.0509	2.1577***	0.0508			1.7666***	0.0388	1.7659***	0.0388
Expand			0.9069***	0.0556	0.9018***	0.0556			0.7898***	0.0416	0.7815***	0.0416
Cooperation agreement			1.1220***	0.0558	1.1243***	0.0557			0.6651***	0.0395	0.6726***	0.0394
Workforce												
Doctors - working exclusively			0.1485***	0.0421	0.1486***	0.0420			-0.0016	0.0085	-0.0004	0.0085
Masters - working exclusively			-0.0342*	0.0182	-0.0344*	0.0182			0.0006	0.0046	0.0003	0.0046
National Classification of Economic Activities. Version 2.0 (CNAE 2.0) - Division	Control		Control		Control		Control		Control		Control	
Urbanization												
Industrial diversification					-0.0627	0.0627					0.0902	0.0651
Distance from São Paulo					0.0079*	0.0047					-0.0019	0.0042
Location quotient - production services					0.0169	0.0390					0.0167	0.0363
Specialization												
Location quotient - low intensity					2.4226	2.0528					4.0687**	1.6254
Location quotient - lower-moderate intensity					1.2575	1.0282					2.1159***	0.8143
Location quotient - upper-moderate intensity					0.9691	0.7833					1.5853**	0.6200
Location quotient - high intensity					0.1685	0.1412					0.2907***	0.1118
Labour market												
Employment - upper-senior					-87.3386**	43.9798					-106.6491***	37.6115
Employment - lower-senior					15.3638	13.3516					4.7511	8.9321

Table 3 (concluded)

Dependent	AC-process											
	Single local units						Division of local units					
	Analysis of variance		First level		General model		Analysis of variance		First level		General model	
Labour market												
Employment - middle-senior					2.4564**	1.1503					1.6697*	1.0011
Education - full higher education					-1.6431***	0.5553					-1.6391***	0.4329
Education - master's degree					-7.7890	12.6813					-3.4013	10.0356
Education - doctorate					3.2838	27.7709					12.6201	22.0676
Regions												
North					-0.2696	0.1955					0.2088	0.1713
North-East					-0.1368	0.1232					0.2112*	0.1102
South-East					-0.0489	0.0565					0.0880*	0.0534
Central-West					0.0008	0.1032					0.3691***	0.0950
South					0.0633	0.0540					0.1468***	0.0511
Dummy variable - Year												
2011			-0.3088***	0.0377	-0.2865***	0.0382			-0.2955***	0.0303	-0.2719***	0.0308
2014			-0.1460***	0.0389	-0.1033**	0.0431			-0.1916***	0.0308	-0.1316***	0.0349
Number of companies	23 246		23 218		23 216		37 998		36 322		36 315	
Number of municipalities	1 915		1 914		1 913		2 361		2 271		2 267	
	Variance	Intraclass correlation coefficient (ICC)	Variance	ICC	Variance	ICC	Variance	ICC	Variance	ICC	Variance	ICC
Municipality	0.1919***	2.30%	0.0269***	0.47%	0.0073	0.13%	0.1973***	2.69%	0.0715***	1.25%	0.0489***	0.86%
Company	8.1425***	97.70%	5.6555***	99.53%	5.6560	99.87%	7.1480***	97.31%	5.6315***	98.75%	5.6288***	99.14%

Source: Prepared by the authors, on the basis of Brazilian Institute of Geography and Statistics (IBGE). "Survey of Innovation - PINTEC" [online] https://www.ibge.gov.br/en/statistics/multi-domain/science-technology-and-innovation/17379-survey-of-innovation.html?edicao=17383&t=downloads, (n/d), and Ministry of Economic Affairs. Annual Social Information Report (RAIS). Brasilia. 2019 [online] http://trabalho.gov.br/rais.

Note: *** significant at 1%. ** significant at 5% and * significant at 10%.

Growth in net revenues has greater positive influence on expenditure on "AC-process" than on "AC-product", with a positive and significant relationship in both cases; greater importance —significant at 1%— is attached to innovative investments as a strategy to expand or maintain market share when determining "AC-process" expenditure than when determining "AC-product" expenditure; ongoing R&D has a positive effect on "AC-process" expenditure, but its influence on "AC-product" is greater; participation in cooperation agreements with other organizations increases "AC-process" expenditure; the presence of staff with master's degrees and doctorates was not shown to significantly influence "AC-process" expenditure in the analysis where expenditure was divided between local units, while it significantly affected such expenditure in the analysis by "single local units". In this case, the number of staff with doctorates working exclusively on R&D increases "AC-process" expenditure and the number of staff with master's degrees reduces such expenditure. The dummy variables for 2011 and 2014 show that this expenditure declined following the international crisis of 2008, although the impact was greater in 2011 than in 2014. With the inclusion of first-level variables, the intraclass correlation coefficient decreases but remains significant at 1%.

The results of the general model are consistent with those obtained previously and the first-level controls maintain their signs, with significances and magnitudes that are similar to the first-level only estimates. In the general model, a reduction in "AC-process" expenditure was observed when there was growth in the municipal proportion of workers in upper-senior hierarchical positions and a reduction was observed when there was growth in the proportion of workers with full higher education. Both these factors are linked to the municipal profile of industrial workers and increases in labour costs. Larger proportions of workers in middle-senior positions of the technological hierarchy in municipalities had a positive influence on such expenditure by Brazilian industrial companies.

Concerning localization controls, differences in the results are observed when comparing the two groups of companies ("single local units" and "all companies, with amounts divided between local units"). For the first group, the "specialization" controls were not significant; therefore, there was no major influence from this "space" on increases in "AC-process" expenditure, as expected. Another expected result for this group of companies is a rise in expenditure as the distance from the municipality of São Paulo increases, suggesting a relationship with dispersive factors (Von Thünen, 1966). When the analysis is extended to all of PINTEC, adapting its reality to the goal of this article, the locational specialization factors are within the range that would be expected based on theory, with influence from this space on growth in expenditure.[15] This influence grows as the technological intensity of the sector decreases. In this second estimation exercise, the distance from São Paulo declined in significance.

The company determinants of expenditure on absorptive capacity showed the expected signs and significances. The proxy for technological opportunities was the presence of ongoing R&D, based on the understanding that companies located in economic sectors with major opportunities need to be constantly connected to production and scientific advances (Cohen and Levinthal, 1990; Klevorick and others, 1995; Albuquerque, 1998; among others). The possibility of benefiting from the results of expenditure on innovative activities was defined as an appropriability condition (Nelson and Winter, 1982; Cohen and Levinthal, 1990; Albuquerque, 1998; among others). The existence of such conditions would strengthen the strategy of companies to invest in innovation. The proxy used assumes that the results of the innovative process enabled maintenance or expansion of market share, suggesting the existence of favourable returns on the innovative process. Once again, the observed sign was as expected. The results confirmed the positive influence of cooperation agreements for innovation on development of absorptive capacities, as highlighted by Vega-Jurado, Gutiérrez-Gracia and Fernández-de-Lucio (2008).

[15] Not disaggregated at the municipal level.

V. Conclusions

This article contributes to the literature on this topic by measuring the determinants of investment in absorptive capacity by Brazilian industrial firms, taking into account the importance of territorial determinants. Overall, the results obtained from the econometric exercises are supported by theory, with internal company determinants of "AC-product" and "AC-process" showing the expected signs and significances.

In the case of territorial determinants, greater correlation was expected between R&D and urban attributes (production diversification, specialization in production services and proximity to the city of São Paulo); this was not supported by the results (Jacobs, 1969; Duranton and Puga, 2000; Storper and Venables, 2004; among others). This can be explained by Brazil's weakness in developing more efficient and voluminous expenditure on these activities. This would explain the lag in the Brazilian economy, suggesting that increasing spending would have a significant impact at the national level, improving productivity and market shares, albeit with progress initially limited to reaching a domestic market.

As expected, the results for "AC-process" indicate that specialized spaces are the main "destinations" for expenditure on machinery and equipment, training and software (for the results where expenditures were divided among local units). Duranton and Puga (2001) had already drawn attention to the possibility that, despite being very favourable to R&D activities, diversified urban spaces hinder expansion of production activity, so that specialized spaces become preferable, offering localization/MAR[16] externalities without the high costs that diversified urban spaces entail. Also, as expected and as observed in the results, the increase in the influence of specialization on expenditure as technological intensity decreases is explained by the fact that the lower the intensity, the lower the production complexity and productivity. Lower production complexity means less capacity to cover the costs of this "localized space" and, as it demands fewer urban attributes, production ultimately becomes located in specialized spaces. Another factor that reinforces this movement, and which was also observed in the empirical exercises relates to labour costs (Puga and Venables, 1996).

Although the results are satisfactory in that they are in line with the theories on which the analysis was based, the results concerning urban attributes may have been influenced by the limitations of PINTEC with regard to territorial analysis. The two strategies implemented to overcome these limitations entailed either excluding firms with more than one local unit[17] or distributing expenditure on innovative activities among local units arbitrarily, as there was no alternative within PIA-UL that would have allowed for a better indication of the municipality of the expenditure. However, identification of these problems, combined with the results, reaffirms the importance of further analysis of how the environments in which companies operate influence the innovation process. PINTEC, the main national database on the characteristics of the innovation process, limits such progress. These problems would be avoidable if the database indicated the municipality of the expenditure on innovative activities, among other data that would enable evaluation of the Brazilian innovative process from a territorial perspective. As explained, evaluation of the Brazilian innovation process from a purely sectorial perspective overlooks important factors related to territory and localization-related externalities.

[16] Marshall-Arrow-Romer externalities (Combes, 2000).

[17] Larger and (because of the characteristics of the innovative process) more innovative companies were probably excluded.

Bibliography

Abramovitz, M. (1986), "Catching up, forging ahead, and falling behind", *The Journal of Economic History*, vol. 46, No. 2, June.

Albuquerque, E. (1998), "Patentes segundo a abordagem neo-schumpeteriana: uma discussão introdutória", *Brazilian Journal of Political Economy*, vol. 18, No. 4.

Araújo, B. and M. Salerno (2015), "Technological strategies and learning-by-exporting: the case of Brazilian manufacturing firms, 2006–2008", *International Business Review*, vol. 24, No. 5, October.

Araújo, V. (2014), "Dimensão local da inovação no Brasil: determinantes e efeitos de proximidade", doctoral thesis, São Paulo, University of São Paulo.

Barbour, E. and A. Markusen (2007), "Regional occupational and industrial structure: does one imply the other?", *International Regional Science Review*, vol. 30, No. 1, January, SAGE.

Bell, M. and K. Pavitt (1997), "Technological accumulation and industrial growth: contrasts between developed and developing countries", *Technology, Globalisation and Economic Performance*, D. Archibugi and J. Michie (eds.), Cambridge, Cambridge University Press.

Cavalcante, L. (2014), "Classificações tecnológicas: uma sistematização", *Nota Técnica*, No. 17, Brasilia, Institute of Applied Economic Research (IPEA), March.

Cavalcante, L., P. Jacinto and F. De Negri (2015), "P&D, Inovação e produtividade na indústria brasileira", *Produtividade no Brasil: desempenho e determinantes. Volume 2 – Determinantes*, F. De Negri and L. Cavalcante (coords.), Brasilia, Brazilian Industrial Development Agency (ABDI)/Institute of Applied Economic Research (IPEA).

Chiarini, T. (2014), "Transferência internacional da tecnologia: interpretações e reflexões: o caso brasileiro no paradigma das TICs na última década do século XX e no alvorecer do século XXI", doctoral thesis, Campinas, State University at Campinas (UNICAMP).

Cohen, W. and D. Levinthal (1990), "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, vol. 35, No. 1, March.

___(1989), "Innovation and learning: the two faces of R & D", *The Economic Journal*, vol. 99, No. 397, September.

Combes, P. (2000), "Marshall-Arrow-Romer externalities and city growth", *CERAS working paper*, No. 99–06, January.

De Negri, F. (2006), "Determinantes da capacidade de absorção das firmas brasileiras: qual a influência do perfil da mão-de-obra?", *Tecnologia, exportação e emprego*, J. De Negri, F. De Negri and D. Coelho (coords.), Brasilia, Institute of Applied Economic Research (IPEA).

Duranton, G. and D. Puga (2005), "From sectoral to functional urban specialisation", *Journal of Urban Economics*, vol. 57, No. 2, March.

___(2001), "Nursery cities: urban diversity, process innovation, and the life cycle of products", *American Economic Review*, vol. 91, No. 5.

___(2000), "Diversity and specialisation in cities: why, where and when does it matter?", *Urban Studies*, vol. 37, No. 3, SAGE, March.

Ernst, D. and L. Kim (2002), "Global production networks, knowledge diffusion, and local capability formation", *Research Policy*, vol. 31, No. 8–9, December.

Fajnzylber, F. (1990), "Industrialization in Latin America: from the 'black box' to the 'empty box'", *Cuadernos de la CEPAL*, No. 60 (LC/G.1534/Rev.1-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), August.

Feldman, M. (1994), *The Geography of Innovation*, Boston, Kluwer Academic Publishers.

Fontes, G., R. Simões and A. Oliveira (2010), "Urban attributes and wage disparities in Brazil: a multilevel hierarchical model", *Regional Studies*, vol. 44, No. 5.

Freitas, E. (2012), "Economias externas, atributos urbanos e produtividade: evidências a partir do nível salarial industrial das microrregiões brasileiras, 2000–2010", master's thesis, Belo Horizonte, Federal University of Minas Gerais (UFMG).

Galinari, R., M. Lemos and P. Amaral (2006), "Retornos crescentes urbanos: a influência do espaço na diferenciação da taxa salarial no Brasil", *Tecnologia, exportação e emprego*, J. De Negri, F. De Negri and D. Coelho (coords.), Brasilia, Institute of Applied Economic Research (IPEA).

Glaeser, E. and others (1992), "Growth in cities", *Journal of Political Economy*, vol. 100, No. 6, December.

Goldstein, H. (1995), *Multilevel Statistical Models*, London, Edward Arnold.

Henderson, J. (2003), "Marshall's scale economies", *Journal of Urban Economics*, vol. 53, No. 1, January.

Henderson, J., A. Kuncoro and M. Turner (1995), "Industrial development in cities", *Journal of Political Economy*, vol. 103, No. 5.

IBGE (Brazilian Institute of Geography and Statistics) (2017), "Pesquisa Industrial Anual - Empresa - PIA-Empresa" [online] https://sidra.ibge.gov.br/pesquisa/pia-empresa/quadros/brasil/2017.
___(n/d), "Pesquisa de Inovação - PINTEC" [online] https://www.ibge.gov.br/estatisticas/multidominio/ciencia-tecnologia-e-inovacao/9141-pesquisa-de-inovacao.html?edicao=9142&t=downloads.
Jacobs, J. (1969), *The Economy of Cities*, New York, Random House.
Kaldor, N. (1957), "A model of economic growth", *The Economic Journal*, vol. 57, No. 268, December.
Kim, L. and R. Nelson (2000), *Technology, Learning and Innovation: experiences of Newly Industrializing Economies*, Cambridge, Cambridge University Press.
Klevorick, A. and others (1995), "On the sources and significance of interindustry differences in technological opportunities", *Research Policy*, vol. 24, No. 2, March.
Malerba, F. (1992), "Learning by firms and incremental technical change", *The Economic Journal*, vol. 102, No. 413, July.
Marshall, A. (1890), *Principles of Economics*, vol. I, New York, Macmillan and Co.
McCombie, J. and P. Thirlwall (1994), *Economic Growth and the Balance-of- Payments Constraint*, New York, St. Martin's Press.
Merhav, M. (1969), *Technological Dependence, Monopoly and Growth*, London, Pergamon Press.
Messa, A. (2015), "Determinantes da produtividade na indústria brasileira", *Produtividade no Brasil: desempenho e determinantes. Volume 2 – Determinantes*, F. De Negri and L. Cavalcante (coords.), Brasilia, Brazilian Industrial Development Agency (ABDI)/Institute of Applied Economic Research (IPEA).
Meyer-Krahmer, F. and U. Schmoch (1998), "Science-based technologies: university–industry interactions in four fields", *Research Policy*, vol. 27, No. 8, December.
Ministry of Economic Affairs (2019), Relação Anual de Informações Sociais (RAIS), Brasilia [online] http://trabalho.gov.br/rais.
Nelson, R, and S. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, The Belknap Press.
Puga, D. and A. Venables (1996), "The spread of industry: spatial agglomeration in economic development", *Discussion Paper*, No. 279, Centre for Economic Performance (CEP).
Raudenbush, S. and A. Bryk (2002), *Hierarchical Linear Models: Applications and Data Analysis Methods*, Thousand Oaks, SAGE Publications.
Rodrigues, E., A. de Oliveira and E. Albuquerque (2007), "Uma análise da mobilidade ocupacional no Brasil segundo o nível tecnológico das ocupações" [online] http://www.abep.org.br/publicacoes/index.php/anais/article/view/1888/1846.
Rosa, A. (2013), "Capacidade absortiva de empresas que possuem interação com universidades", master's tesis, São Leopoldo, University do Vale do Rio dos Sinos (UNISINOS).
Rosenberg, N. (1983), *Inside the Black Box: Technology and Economics*, Cambridge, Cambridge University Press.
Schumpeter, J. (1982), A *teoria do desenvolvimento econômico*, Os economistas, São Paulo, Abril Cultural.
Storper, M. and A. Venables (2004), "Buzz: face-to-face contact and the urban economy", *Journal of Economic Geography*, vol. 4, No. 4, August.
Tavares, M. (2016), "The growth and decline of import substitution in Brazil", *ECLAC Thinking: Selected Texts (1948-1998)* (LC/G.26699), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC)/Fondo de Cultura Económica (FCE).
Teece, D. and G. Pisano (1994), "The dynamic capabilities of firms: an introduction", *Industrial and Corporate Change*, vol. 3, No. 3, September.
Teece, D., G. Pisano and A. Shuen (1997), "Dynamic capabilities and strategic management", *Strategic Management Journal*, vol. 18, No. 7, August.
Thirlwall, P. (1979), "The balance of payments constraint as an explanation of international growth rate differences", *Banca Nazionale del Lavoro Quarterly Review*, vol. 32, No. 138, Rome, Banca Nazionale del Lavoro.
Van den Bosch, F., H. Volberda and M. de Boer (1999), "Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities", *Organization Science*, vol. 10, No. 5.
Vega-Jurado, J., A. Gutiérrez-Gracia and I. Fernández-de-Lucio (2008), "Analyzing the determinants of firm's absorptive capacity: beyond R&D", *R&D Management*, vol. 38, No. 4, September.
Von Thünen, J. (1966), *Von Thünen's Isolated State: An English Edition of Der Isolierte Staat*, P. Hall (ed.), Oxford, Pergamon Press.
Zahra, S. and G. George (2002), "Absorptive capacity: a review, reconceptualization, and extension", *The Academy of Management Review*, vol. 27, No. 2, April.

The determinants of life satisfaction among Chilean workers

Rodrigo Montero and Álvaro Miranda

Abstract

This article puts forward evidence to identify the different domains that contribute to life satisfaction among a sample of Chilean workers, using the two-layer model developed by van Praag, Frijters and Ferrer-i-Carbonell (2003). The results show that satisfaction in the domains of money, privacy, leisure, family life, health and work have a positive (and statistically significant) effect on life satisfaction, when controlling for a variable that attempts to measure workers' personality traits. The evidence reveals that the effects of family life, leisure, health and work outweigh those of money and privacy. Separate estimations were made by gender, age and educational level, to analyse heterogeneity in the relationship between degrees of satisfaction in the different life domains and overall life satisfaction. The results are robust to the different specifications used to explain satisfaction domains.

Keywords

Standard of living, living conditions, job satisfaction, quality of life, employees, measurement, surveys, Chile

JEL classification

C25, I31

Authors

Rodrigo Montero is Director of the Commercial Engineering Programme of the Faculty of Economics and Business of the Universidad Andrés Bello. Email: rodrigo.montero@unab.cl.

Álvaro Miranda is Research Coordinator in the Studies Division of the Budgetary Affairs Bureau (DIPRES) in Chile. Email: amiranda@dipres.gob.cl.

I. Introduction

Although research aimed at elucidating the complex process of subjective well-being, or happiness, has been increasing steadily over time, it has seldom targeted developing countries. Accordingly, the aim of this article is to explore subjective well-being in Chile.

Chile is an interesting country to analyse, since it is a middle-income economy that has experienced high levels of economic growth consistently over the last 30 years, although the pace has slackened recently. World Bank figures show that per capita gross domestic product (GDP) increased from US$ 9,244 at purchasing power parity (PPP) in 1990 to US$ 22,197 PPP in 2015, and the poverty rate dropped from 38.6% to 11.7% over the same period. As a result, the Chilean economy has approached the threshold between developing and developed States, and today exhibits relatively positive socioeconomic indicators. It is therefore to be expected that the trends of more subjective indicators should start to be measured, to gain a clearer understanding of what drives the well-being of the Chilean population (Stiglitz, Sen and Fitoussi, 2009). Indeed, over the last decade, questions related to subjective well-being have started to appear in Chilean national surveys, such as the first National Survey on Employment, Labour, Health and Quality of Life (ENETS) (2009/10)

The present study uses the data from the first ENETS to provide a more complete view of the determinants of life satisfaction in Chile. Using a two-layer model, it explores the dimensions that are most important in explaining life satisfaction, as well as heterogeneity by age, gender and education level.

This article is organized as follows. Section II discusses the recent literature on life satisfaction in both developed and developing countries. Section III describes the data and methodology used; and section IV reports on the main results and a robustness check. Lastly, Section V sets forth the main conclusions with final remarks discussing the limitations of the study and suggestions for future research.

II. Literature review

Evaluating human progress, defined in terms of economic performance, has been difficult because both material goods and their non-material counterparts contribute to an individual's overall well-being. This means that a higher (lower) GDP or income does not necessarily mean greater (lesser) subjective well-being (Fitoussi and Stiglitz, 2013).

Empirical evidence suggests that life satisfaction decreases as a result of losing a spouse or being fired, and that it increases with income (at a decreasing rate), and also with marriage and agency (Ambrey and Fleming, 2014; Frijters, Haisken-DeNew and Shields, 2004; Hojman and Miranda, 2018; Kahnemnan and Deaton, 2010). Income in absolute terms is less important than income relative to that of others: individuals that have a higher income than their reference group experience greater well-being (Clark and Senik, 2010; Ferrer-i-Carbonell, 2005; Senik, 2007).

1. Aggregation approach

Empirical analysis to study the determinants of life satisfaction frequently uses an aggregation approach. This model views an individual's overall life satisfaction as a combination of the levels of satisfaction he or she obtains in each of the domains considered relevant to the life of the average human being (including work, family life and health status). The main disadvantage of this approach is that it is impossible to control for unobserved heterogeneity.

A study by Rojas (2006), which uses an aggregation approach to analyse the determinants of life satisfaction in Mexico, found that satisfaction in the economic, health, work, family and personal domains are relevant predictors of overall life satisfaction. In a similar study, using data from the United States, Easterlin and Sawangfa (2007) find that how satisfied people are, on average, with their finances, health, work and family life are all important for individual life satisfaction.

Thus, when using this method, the empirical evidence suggests that the economic, health, family and work domains are important predictors of overall life satisfaction. However, the aforementioned studies did not analyse the relative importance of each domain in subjective well-being.

2. The two-layer model

Van Praag, Frijters and Ferrer-i-Carbonell (2003) propose an enhanced version of the aggregation approach, which they called "the two-layer model". The first layer establishes that life satisfaction is the result of the satisfaction achieved in different domains of life (in other words, it adheres to the logic of the aggregation approach); then, the second layer posits that each domain is determined by a set of exogenous variables (gender, age, education and income, among others). The main advantage of this approach is that it allows unobservable variables to be measured, attenuating the omitted variable bias that can arise from ignoring personality traits as a determinant of life satisfaction.

Using the two-layer model and the German Socio-Economic Panel (GSOEP), van Praag, Frijters and Ferrer-i-Carbonell (2003) provide evidence to identify the main subjective domains in Germany. The authors found that satisfaction in the work, financial, housing, health, leisure and environmental domains are all important contributors to general satisfaction. They also found that the results are sensitive to inclusion or otherwise of the measure of unobserved heterogeneity.

Similarly, using the British Household Panel Survey (BHPS), Ferrer-i-Carbonell and van Praag (2008) find that satisfaction in the work, financial, housing, health, leisure-use, leisure-amount, marriage and social life domains all contribute to life satisfaction in the United Kingdom.

Accordingly, as the aggregation approach has demonstrated, the empirical evidence obtained using the two-layer model suggests that the economic, health and work domains are all very important for life satisfaction.

Applying an alternative methodology to data from Canada, Kant and others (2014) show that satisfaction in the social, cultural and land-use (SCLU) domains are the most important determinants of well-being. They also show that SCLU factors contributed to satisfaction in all other domains (education, employment, income, health and housing).

3. Evidence for developing countries

Efforts have recently been made to extend the two-layer model to less developed countries. Mahmud and Sawada (2015) apply this approach to explain overall happiness in Bangladesh as a function of different life domains and conventional explanatory variables such as income. Their results "suggest that income explains a large part of the variation in total happiness and that income is closely related with domain-specific happiness, even with non-economic domains". In addition, financial and job satisfaction along with happiness in social life are also relevant to people's overall life satisfaction.

Using a sample of Latin American countries, Amestoy, García-Muñoz and Egido (2016), also analyse dimensions of subjective well-being related to a very wide range of domains, such as institutional and social circumstances, satisfaction with access to health care and education, the availability of green areas and public spaces, municipal services, roads and paving, public transport, refuse collection,

sewerage services and the pension system. They also included domains related to satisfaction with democracy and with the economy. Their results suggest that these dimensions also help to explain happiness levels.

Lastly, Loewe and others (2014) evaluate the determinants of life satisfaction for a sample of 530 Chilean workers. They simultaneously tested the effects on overall life satisfaction of satisfaction in seven life domains, and found that an individual's financial situation was the dominant predictor of overall life satisfaction. They also found that satisfaction with self-worth, leisure-time and social relationships did not have statistically significant effects on life satisfaction.

The present study aims to complement those findings by performing a two-layer analysis of data from the first ENETS. It also includes a statistical analysis of the dimensions that are most important in explaining life satisfaction in Chile, and explores heterogeneity by age, gender, and educational level. The next section gives details of the data and methodology used to undertake this analysis.

III. Data and methodology

1. Data

This article aims to validate the two-layer model using data from a nationally representative sample of 4,157 Chilean workers aged between 15 and 65 years, employed in both white- and blue-collar jobs.[1] The data for this research come mainly from the first ENETS. This is a cross-sectional survey that seeks to describe and analyse the situation of Chilean workers in terms of employment conditions, work and health equity. It contains information on variables such as education, household income, job characteristics and quality of life, among others. It also measures personal satisfaction in domains that include the privacy of the place of residence, the amount of money in the household, the amount of fun the person has in his or her life, family life, health status and work. The survey poses the following question: How do you feel about your life in general? The response alternatives are: (1) very bad; (2) bad; (3) below average; (4) average; (5) above average; (6) good and (7) very good. The same criteria are used for each of the domains mentioned above.

Table 1 presents data on the average overall life satisfaction and domain-specific satisfaction reported by Chilean workers. Although average life satisfaction is rated as 5.8, this is higher than the simple average for the six domains (5.4). It can therefore be inferred that workers are overvaluing certain domains. Satisfaction with family life is the domain with the highest average in the sample (5.9), followed by satisfaction with the privacy of the place of residence (5.8), personal health status (5.6) and job satisfaction (5.6). Satisfaction with the amount of money in the household reports the lowest average at 4.6.

Table 1 also reports average life satisfaction and domain-specific satisfaction disaggregated by gender, age, education level and total household income quintile. For both men and women, the same hierarchical order of satisfaction is maintained for each of the domains (columns 2 and 3), where satisfaction with money is again ranked last.

The results suggest that men are relatively more satisfied with life than women. When comparing satisfaction levels for each of the domains, no significant differences are observed. However, there is a significant difference in favour of men in terms of job satisfaction. When analysing the age-specific data (columns 4 and 5), there are no significant differences among workers aged 15–39 years, and those in the 40–65 year age bracket, except for overall life satisfaction and job satisfaction, in which individuals in the younger group appear more satisfied.

[1] In Chile, individuals aged between 15 and 17 years can work subject to parental consent.

Table 1
Life satisfaction and domain satisfaction for Chilean workers
(On a scale of 1–7)

Satisfaction with:	All	Gender		Age		Education level			Total household income quintile				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		Men	Women	15–39 years	40–65 years	Primary	Secondary	Tertiary	I	II	III	IV	V
Life	5.82	5.88	5.72	5.90	5.74	5.67	5.86	5.86	5.55	5.72	5.85	5.87	6.02
	(0.82)	(0.75)	(0.92)	(0.77)	(0.86)	(0.84)	(0.79)	(0.83)	(0.95)	(0.86)	(0.80)	(0.79)	(0.65)
Money	4.62	4.62	4.60	4.75	4.47	4.10	4.57	5.06	3.76	4.26	4.50	4.79	5.39
	(1.45)	(1.45)	(1.43)	(1.39)	(1.49)	(1.46)	(1.42)	(1.35)	(1.54)	(1.29)	(1.35)	(1.34)	(1.23)
Privacy	5.75	5.72	5.82	5.71	5.80	5.74	5.68	5.89	5.60	5.63	5.80	5.72	5.95
	(1.10)	(1.10)	(1.11)	(1.13)	(1.07)	(1.03)	(1.15)	(1.06)	(1.21)	(1.11)	(1.07)	(1.15)	(0.97)
Leisure	5.25	5.37	5.03	5.38	5.10	5.04	5.30	5.30	4.91	5.15	5.33	5.34	5.40
	(1.27)	(1.17)	(1.42)	(1.25)	(1.28)	(1.34)	(1.25)	(1.25)	(1.47)	(1.28)	(1.15)	(1.27)	(1.19)
Family life	5.92	5.96	5.83	5.97	5.86	5.79	5.92	6.01	5.73	5.84	5.95	5.96	6.03
	(0.83)	(0.76)	(0.94)	(0.80)	(0.86)	(0.87)	(0.83)	(0.79)	(0.86)	(0.83)	(0.84)	(0.81)	(0.81)
Health	5.55	5.59	5.48	5.55	5.55	5.35	5.53	5.73	5.13	5.47	5.65	5.47	5.88
	(1.19)	(1.14)	(1.26)	(1.20)	(1.17)	(1.24)	(1.21)	(1.08)	(1.49)	(1.12)	(1.07)	(1.26)	(0.87)
Job	5.56	5.70	5.31	5.73	5.38	5.32	5.61	5.65	5.31	5.47	5.53	5.66	5.74
	(1.12)	(1.00)	(1.27)	(1.08)	(1.14)	(1.10)	(1.05)	(1.22)	(1.16)	(1.11)	(1.17)	(1.16)	(0.96)

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.
Note: Standard errors in parentheses.

The findings are also broken down by education level (columns 6–8). Individuals educated to the primary level report average satisfaction of 5.7, while those educated to the secondary and tertiary levels average 5.9. Individuals educated to the primary level consistently report a lower average in each domain than persons educated to the secondary and tertiary levels. For instance, in terms of satisfaction with the amount of money in the household, there is a large gap between individuals educated to the primary level and those who have completed tertiary education; and job satisfaction also increases significantly as education levels rise.

Lastly, the results are presented by total household income quintiles (columns 9–13). This reveals a correlation between income and satisfaction, both in life generally and in the specific domains. Individuals in the first income quintile report an average of 5.6, while those in the fifth quintile average 6.0. There is also a considerable gap between the extreme quintiles in the money domain: individuals in the first income quintile report an average of 3.8 in terms of satisfaction with money, while those in the fifth quintile have an average of 5.4.

2. Methodology

Van Praag, Frijters and Ferrer-i-Carbonell (2003) propose a model that views life satisfaction as the result of the levels of satisfaction obtained in each of the different dimensions that are relevant to the life of a human being (such as satisfaction with work, family life, health and the like). More formally:

$$LS=f(DS_1,DS_2,...,DS_J,Z) \quad (1)$$

where LS denotes life satisfaction; $DS_1,DS_2,...,DS_J$ represent the life domains (work, health, family life and so forth); and Z is an unobservable variable that affects general satisfaction. An additive specification is commonly assumed for equation 1. To complete the model, the authors postulate that the domain-specific satisfaction depends on the individual's objective situation (X) and on his or her personality (optimism) or some other common unobservable variable (Z); these personality traits are unobservable and they co-determine both LS and DS. Hence:

$$DS_j = g(X_j;Z) \qquad \forall_j = 1,...,J \quad (2)$$

Estimating equation (1) without controlling for Z generates endogeneity bias.

Van Praag, Frijters and Ferrer-i-Carbonell (2003) suggest instrumentalizing Z through the following procedure. After estimating the determinants of the J domains, the authors calculate the residuals to estimate the portion of Z that is common to all of them. The instrument is the result of the first principal component of the JxJ error covariance matrix. This new variable can then be added as an additional covariate to the LS equation, allowing for the assumption that the remaining LS error is no longer correlated with the DS errors.

The first stage entails using ordinary least squares (OLS) to estimate the socioeconomic determinants of satisfaction in the different domains (equation (2)), and then predicting their residual vectors. A principal components analysis is then performed, and the first component is extracted, which is the instrument for Z.

The second stage consists of estimating equation (1) using the domains and the instrument for as covariates.

The procedure is as follows: first, the determinants of the J domains are estimated separately. Then, the residuals from these regressions are predicted, and a principal components analysis is performed on the residuals. The first principal component is chosen as an estimate of Z. Lastly, to avoid bias, Z is included in the estimation of equation (1).[2]

As noted above, the first step in the methodology involved estimating the sociodemographic determinants of each domain of satisfaction. According to empirical evidence and data availability, the following covariates were considered as determinants of domain satisfaction: a dummy variable representing women; years of schooling; age; age-squared; indigenous background; country of origin (Chilean=1); head of household; dummies for geographic area and marital status; logarithm of income (for all domains except work); logarithm of wage (for job satisfaction only); and a variable measuring household size (number of members).

Key variables for the actual analysis were wage and total income, because they are important determinants of domain satisfaction. Unfortunately, the data for these variables only existed in the form of intervals and participants were asked to self-classify in one of the 14 that were predefined. This caused two difficulties for this study: firstly, it made it necessary to incorporate 13 dummy variables in the econometric model; and secondly, it made it impossible to create a reference wage as a control variable in the job satisfaction domain, which the empirical evidence in this area shows is very important (Card and others, 2012; Clark, Kristensen and Westergård-Nielsen, 2009; Montero and Rau, 2016; Montero and Vásquez, 2015; Mumford and Smith, 2012).

To solve these problems, an interval regression analysis was performed, which made it possible to predict individual wages and household incomes. This strategy eliminates the need to include several dummy variables in the equations for the domains, and allows wages or income to be considered directly as covariates (for more details of the methodology see Montero and Vásquez, 2015).[3]

The job satisfaction domain received special treatment in this analysis, since there is a branch of economic research in this area that suggests a different model for explaining workers' job satisfaction (Assadullah and Fernandez, 2008; Booth and van Ours, 2008; Clark, Oswald and Warr, 1996; Clark, Kristensen and Westergård-Nielsen, 2009; López Bóo, Madrigal and Pagés, 2010; Montero and Rau, 2015; Montero and Vásquez, 2015; Sousa-Poza and Sousa-Poza, 2000). Moreover, the labour data were abundant, so the following covariates were added to explain job satisfaction: a dummy for first job; unionization; commute time; having a contract; formal self-employment; working in the public sector; contributing to a retirement pension; contributing to the social health system; outsourced workers; fixed wage; whether or not the individual works from home; logarithm of wage; logarithm of hours worked; dummies for tenure, satisfaction with promotion opportunities, workplace conditions, environmental conditions at work, economic sector and shift work; and a variable measuring the wage of the reference group (peer salary).[4]

[2] Variable Z can be interpreted as a measure of unobserved heterogeneity. It constitutes an alternative to fixed-effects models in panel-data settings. While Z may be a good proxy for fixed effects, it assumes that there is a common element to all the different domains that co-determine both life satisfaction and domain-specific satisfaction. Nonetheless, there might be other variables that determine some domains more than others, which may not be fully included in Z. This suggests that the Z variable can only attenuate the endogeneity bias, and there are still some sources of endogeneity that cannot be taken into account, such as non-constant variables correlated with both life and domain-specific satisfaction.

[3] A key issue is the choice of variables that determine wages (or income) within the interval. Following Montero and Vásquez (2015), years of schooling, age, age-squared, and a dummy variable representing women, were used as covariates for wages. On the other hand, to estimate household income, information on the head of the household (years of schooling, age, age-squared, a dummy variable representing women) and household (number of people in a household, number of people who contribute to the household income, and geographical dummies) were used as covariates.

[4] The level of satisfaction associated with promotion opportunities, workplace conditions and the environmental conditions of work, were measured by the following question: "How satisfied are you with:". The response alternatives were: (1) not satisfied at all; (2) not satisfied; (3) neither satisfied nor dissatisfied; (4) satisfied; (5) very satisfied.

The methodology proposed by Ferrer-i-Carbonell (2005) was used to generate a variable to measure the wage of the peer group. This entails constructing the peer group using information from key variables. For this study, information on economic activity (grouped into nine activities) and schooling were used. The schooling variable was split into five categories: no schooling or incomplete primary education; complete primary education; incomplete secondary education; complete secondary education; and complete and incomplete tertiary education. These two variables were combined to obtain 45 cells. The average wage for each cell was computed and used as the peer wage. It should be noted that the sign for the coefficient of this variable could be positive or negative, depending on whether the comparison effect or the information effect dominates.[5] Having clarified the data and methodology used for this study, the next section presents the results of applying the methodology.

IV. Results

In general, the results show that levels of satisfaction with money, privacy, leisure, family life, health and work have a positive and statistically significant effect on overall life satisfaction among Chilean workers. They also reveal that family life, leisure and health are valued more highly than money, work and privacy. These results are robust to different functional forms. The empirical evidence presented in this study is thus in line with that found for other countries; but the estimates do not coincide with the results reported by Loewe and others (2014), where satisfaction with one's financial situation was the dominant predictor of life satisfaction. Indeed, the results reported in this article suggest that domains associated with money and work are less important than those pertaining to family life, leisure and health.

1. Sociodemographic determinants of satisfaction domains

Table 2 reports estimations of the sociodemographic determinants of each domain of satisfaction. Column (1) confirms that satisfaction with the amount of money in the household increases with the logarithm of income, as would be expected. Moreover, married persons, widows and widowers, and single individuals are more satisfied with the amount of money in the household than those who are separated. Lastly, women are less satisfied than men in this regard. This finding may be reflective of Chilean society, which is relatively sexist, and where the man is the main contributor to household income.

Column (2) shows the sociodemographic determinants of the individual's satisfaction with the privacy of his or her place of residence. The results indicate that the logarithm of income and years of schooling increase satisfaction in this domain, possibly because both schooling and income enable a worker to access higher-standard housing. Conversely, a larger number of household members is associated with a lower level of satisfaction.

Column (3) in table 2 reports determinants of satisfaction with leisure. Here again, the results show that women are less satisfied than men with the amount of leisure available to them. Satisfaction with this domain increases with the logarithm of income and years of schooling, but it decreases with age and the number of individuals living at home. Lastly, married and single people are more satisfied with their amount of leisure time than those who are separated.

[5] It seems reasonable to assume a negative relationship between relative wages and individual job satisfaction; this has been called the comparison effect (Card and others, 2012; Clark, Kristensen and Westergård-Nielsen, 2009; Mumford and Smith, 2012). However, Clark, Kristensen and N. Westergård-Nielsen (2009) also argue for a different potential relationship, such that a higher reference group wage level (something like a peer salary) could increase job satisfaction because it reveals valuable information about prospects. The higher the future prospective wage, the higher the level of job satisfaction. This phenomenon has been called the information effect (Manski, 2000).

Table 2
Sociodemographic determinants of satisfaction domains for Chilean workers
(On a scale of 1-7)

	Satisfaction with:					
	(1) Money	(2) Privacy	(3) Leisure	(4) Family life	(5) Health	(6) Job
Women=1	-0.155***	-0.0135	-0.400***	-0.0936***	-0.335***	0.0321
	(0.0508)	(0.0439)	(0.0511)	(0.0359)	(0.0416)	(0.0414)
Years of schooling	0.00783	0.0119**	0.0116**	0.00779**	0.00819	0.000834
	(0.00621)	(0.00512)	(0.00578)	(0.00377)	(0.00503)	(0.00904)
Age	-0.0109	0.00690	-0.0733***	-0.0260***	-0.0184*	-0.0154
	(0.0131)	(0.0103)	(0.0116)	(0.00834)	(0.0101)	(0.00990)
Age-squared	0.000103	-8.91e-06	0.000755***	0.000253***	1.32e-05	0.000188
	(0.000156)	(0.000119)	(0.000136)	(9.81e-05)	(0.000121)	(0.000116)
Number household members	-0.135***	-0.0592***	-0.0430***	0.0128	-0.0212**	-0.00363
	(0.0133)	(0.0125)	(0.0132)	(0.00874)	(0.0105)	(0.0106)
Head of household=1	-0.116**	0.00853	-0.0244	0.0137	-0.00410	-0.0365
	(0.0569)	(0.0486)	(0.0564)	(0.0388)	(0.0454)	(0.0417)
Married=1	0.260***	0.134*	0.275***	0.238***	0.129*	0.0133
	(0.0864)	(0.0740)	(0.0878)	(0.0626)	(0.0726)	(0.0637)
Live together=1	0.121	-0.0543	0.160	0.168**	0.0821	-0.0414
	(0.0972)	(0.0861)	(0.0980)	(0.0675)	(0.0787)	(0.0732)
Widow/widower=1	0.444**	0.0799	-0.0872	0.149	0.371**	0.0520
	(0.187)	(0.164)	(0.189)	(0.146)	(0.148)	(0.136)
Single=1	0.374***	0.0857	0.254***	0.0520	0.191**	0.0183
	(0.0949)	(0.0824)	(0.0963)	(0.0698)	(0.0789)	(0.0704)
Indigenous=1	-0.120	-0.0365	-0.169**	0.0474	-0.125**	0.0364
	(0.0833)	(0.0681)	(0.0805)	(0.0424)	(0.0614)	(0.0527)
Chilean=1	0.225	-0.197	0.0921	-0.0412	-0.267**	-0.316***
	(0.238)	(0.215)	(0.206)	(0.174)	(0.130)	(0.121)
Urban=1	-0.233***	-0.171***	-0.00946	-0.0353	-0.0547	-0.0288
	(0.0603)	(0.0467)	(0.0581)	(0.0360)	(0.0451)	(0.0511)
Log (income)	1.040***	0.292***	0.278***	0.181***	0.259***	-
	(0.0421)	(0.0358)	(0.0394)	(0.0260)	(0.0343)	
Log (wage)	-	-	-	-	-	0.245***
						(0.0353)
First job=1	-	-	-	-	-	0.0888**
Unionized=1	-	-	-	-	-	0.0538
						(0.0424)

Table 2 (concluded)

	Satisfaction with:					
	(1) Money	(2) Privacy	(3) Leisure	(4) Family life	(5) Health	(6) Job
Contract=1	-	-	-	-	-	0.180*** (0.0607)
Formal self-employment=1	-	-	-	-	-	-0.153* (0.0815)
Log (hours worked)	-	-	-	-	-	0.0265 (0.0738)
Public sector=1	-	-	-	-	-	0.171** (0.0781)
Contributes to retirement pension=1	-	-	-	-	-	-0.0670 (0.0960)
Social health system=1	-	-	-	-	-	0.225* (0.124)
Promotion opportunities=1	-	-	-	-	-	0.281*** (0.0175)
Workplace=1	-	-	-	-	-	0.193*** (0.0283)
Environmental conditions at work	-	-	-	-	-	0.149*** (0.0217)
Individual outsourced=1	-	-	-	-	-	-0.0289 (0.0541)
Fixed wage=1	-	-	-	-	-	0.0296 (0.0458)
Works from household=1	-	-	-	-	-	0.239* (0.139)
Log (reference wage)	-	-	-	-	-	-0.105 (0.117)
Constant	-7.925***	2.227***	3.259***	4.098***	3.402***	1.914
	(0.618)	(0.518)	(0.574)	(0.402)	(0.481)	(1.484)
Observations	4 157	4 157	4 157	4 157	4 157	4 157
R^2	0.207	0.050	0.072	0.049	0.089	0.262

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Note: OLS estimation. (***): p<0.01, (**): p<0.05, (*): p<0.1. Robust standard errors in parentheses. The model for job satisfaction also includes dummies for economic sector, shift work, geographical location, and tenure. The models for other domains also include dummies for geographical location.

Determinants of satisfaction in relation to family life are presented in column (4) of table 2. Life satisfaction increases with the logarithm of income and years of schooling, but decreases with age. Moreover, married people and cohabiting couples are more satisfied with their family life than those who are separated. Once again, women are less satisfied than men in this domain.

Column (5) of table 2 reports determinants of satisfaction in relation to health. Higher-income individuals are more satisfied with their health status, which is to be expected since wealthier individuals can afford better health care. In contrast, satisfaction with health decreases as the number of household members rises, possibly because fewer resources are available for each family member's health care due to the large number of people in the family. Women also express less satisfaction than men in this domain.

Lastly, column (6) of table 2 reports on the determinants job satisfaction. The higher the wage that individuals earn, the more satisfied they tend to be. Moreover, individuals with an employment contract are more satisfied than those without a formal job. On the other hand, formally self-employed individuals are less satisfied than those who do not have a formal job. Job characteristics are also found to be relevant to enjoying greater satisfaction. Having promotion opportunities, a good workplace and better environmental conditions at work are correlated with greater job satisfaction. It is also found that the higher the wage of the peer group, the lower the satisfaction with work, although this effect is not statistically significant. As noted above, there are two opposing effects in play here: the comparison effect and the information effect. The fact that the coefficient is not statistically significant may be because the comparison effect predominates for some workers, while the information effect predominates for others, with the two effects cancelling each other out in net terms. Lastly, it is interesting to note that Chilean workers are less satisfied with their jobs than immigrant workers.

In summary, women are generally less satisfied than men in the different domains; and higher-income individuals experience a higher level of satisfaction, as do married people. Members of large households experience lower levels of subjective well-being.

It is also important to note that the goodness-of-fit of the regressions for each of the domains was within the expected range. For instance, van Praag, Frijters and Ferrer-i-Carbonell (2003) report R^2 values ranging between 2% and 20%. In the present analysis, R^2 varied from 5% to 26%. This helps to ensure that the data contained in the error term were unobserved variables.

After estimating the determinants of each satisfaction domain, the residuals of each regression were predicted. The correlations between the residuals of each regression are shown in table 3 and vary between 15% and 38.2%, suggesting that there were common unobservable variables in the residuals.

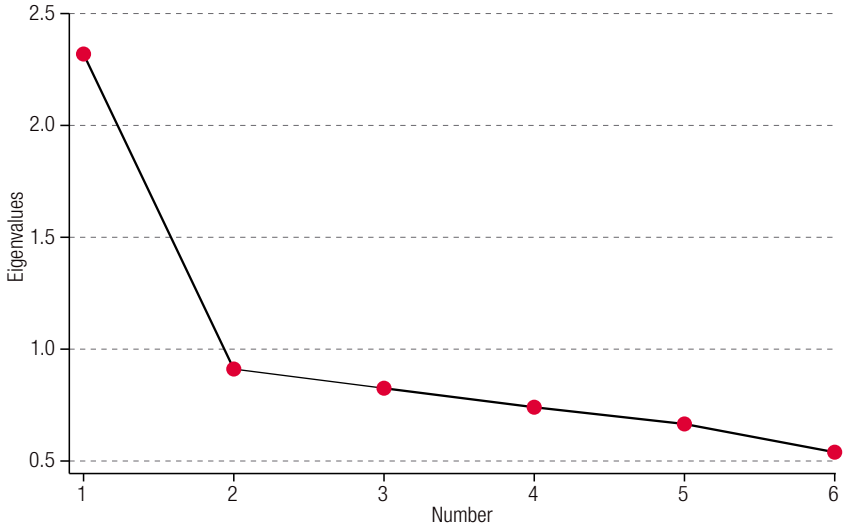
Table 3
Correlation between residuals from the estimation of determinants in each satisfaction domain

Satisfaction with:	(1) Money	(2) Privacy	(3) Leisure	(4) Family life	(5) Health	(6) Job
Money	1					
Privacy	0.293	1				
Leisure	0.316	0.262	1			
Family life	0.212	0.350	0.382	1		
Health	0.246	0.180	0.306	0.339	1	
Job	0.216	0.150	0.214	0.184	0.260	1

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Next, the principal components analysis was performed on the residuals of each regression. In figure 1, a scree plot illustrates the components chosen to be a proxy for personality traits *(Z)*. The breakpoint of the trend is clearly associated with the second component, so the first principal component was used as the estimator of *Z*. Column (1) in table 4 shows the correlation of each residual with the first component, which were high and varied between 27% and 45%.

Figure 1
Scree plot of eigenvalues after principal component analysis



Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Table 4
Correlation between the first principal component and the residuals of the estimation of each satisfaction domain

Satisfaction with:	All	Gender		Age		Education			Total household income quintile				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		Men	Women	15–39 years	40–65 years	Primary	Secondary	Tertiary	I	II	III	IV	V
Money	0.41	0.38	0.42	0.41	0.39	0.40	0.37	0.46	0.41	0.39	0.44	0.38	0.38
Privacy	0.36	0.39	0.40	0.40	0.38	0.36	0.42	0.34	0.39	0.37	0.40	0.38	0.41
Leisure	0.44	0.44	0.46	0.46	0.45	0.47	0.44	0.45	0.41	0.43	0.49	0.50	0.40
Family life	0.42	0.44	0.47	0.46	0.45	0.44	0.46	0.45	0.42	0.46	0.45	0.43	0.50
Health	0.41	0.36	0.28	0.39	0.44	0.40	0.43	0.38	0.43	0.43	0.36	0.42	0.43
Job	0.41	0.43	0.40	0.32	0.33	0.37	0.31	0.36	0.40	0.35	0.27	0.31	0.31

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Using the methodology described above, it was possible to construct a variable to partially control for the influence of the unobservable factors in the model *(Z)*.

2. Domains and life satisfaction

Equation (1) is estimated by OLS, using the domains as covariates (satisfaction with money, privacy, leisure, family life, health and work), and controlling for *Z* with the newly created instrument. The results are reported in column (1) of table 5.

Table 5
Determinants of life satisfaction among Chilean workers

(On a scale of 1–7)

Satisfaction with:	All	Gender		Age		Education			Total household income quintile					All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
		Men	Women	15-39 years	40-65 years	Primary	Secondary	Tertiary	I	II	III	IV	V	CES[a]
Money	0.0632***	0.0471**	0.0840***	0.0623***	0.0564***	0.0238	0.0555***	0.153***	0.0379	0.0743**	0.0359	0.0717*	0.0423	0.409**
	(0.0153)	(0.0192)	(0.0248)	(0.0204)	(0.0200)	(0.0249)	(0.0185)	(0.0586)	(0.0289)	(0.0351)	(0.0351)	(0.0430)	(0.0305)	(0.194)
Privacy	0.0709***	0.0290	0.146***	0.0910***	0.0398	0.0747*	0.0842**	0.0325	0.0746	0.140**	0.0122	0.00129	0.0800	0.309**
	(0.0243)	(0.0277)	(0.0433)	(0.0328)	(0.0358)	(0.0439)	(0.0354)	(0.0464)	(0.0631)	(0.0557)	(0.0469)	(0.0573)	(0.0516)	(0.120)
Leisure	0.147***	0.120***	0.171***	0.132***	0.156***	0.177***	0.143***	0.126**	0.182***	0.218***	0.134***	0.136**	0.0350	0.784***
	(0.0222)	(0.0316)	(0.0329)	(0.0316)	(0.0290)	(0.0412)	(0.0265)	(0.0569)	(0.0394)	(0.0493)	(0.0420)	(0.0631)	(0.0353)	(0.262)
Family life	0.317***	0.320***	0.289***	0.303***	0.317***	0.244***	0.365***	0.339***	0.300***	0.307***	0.354***	0.298***	0.256***	1.272***
	(0.0399)	(0.0463)	(0.0657)	(0.0515)	(0.0556)	(0.0855)	(0.0464)	(0.0839)	(0.0835)	(0.102)	(0.0798)	(0.0841)	(0.0714)	(0.343)
Health	0.176***	0.127***	0.227***	0.176***	0.170***	0.260***	0.127***	0.171**	0.268***	0.178***	0.0944	0.111	0.227***	0.882***
	(0.0309)	(0.0337)	(0.0488)	(0.0469)	(0.0441)	(0.0616)	(0.0369)	(0.0684)	(0.0562)	(0.0652)	(0.0622)	(0.0769)	(0.0514)	(0.265)
Job	0.118***	0.144***	0.0889**	0.0935**	0.143***	0.213***	0.0762**	0.184***	0.257***	0.0930*	0.0454	0.0307	0.158***	0.606***
	(0.0279)	(0.0303)	(0.0440)	(0.0401)	(0.0345)	(0.0494)	(0.0308)	(0.0611)	(0.0444)	(0.0495)	(0.0421)	(0.0508)	(0.0525)	(0.200)
Z	-0.0903***	-0.0613	-0.121**	-0.0639	-0.0985**	-0.198**	-0.0521	-0.135	-0.257***	-0.139	0.0169	0.0405	-0.0482	-0.201**
	(0.0344)	(0.0412)	(0.0524)	(0.0472)	(0.0474)	(0.0856)	(0.0449)	(0.0848)	(0.0787)	(0.0902)	(0.0732)	(0.105)	(0.0700)	(0.0895)
ε														0.762***
														(0.0452)
σ														2.177***
														(0.527)
Observations	4 157	2 805	1 352	2 031	2 126	1 070	2 131	956	832	831	832	831	831	4 157
R^2	0.413	0.364	0.486	0.437	0.386	0.342	0.457	0.446	0.414	0.373	0.385	0.465	0.447	

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Note: (***): p<0.01, (**): p<0.05, (*): p<0.1. Robust standard errors in parentheses.

[a] CES stands for "constant-elasticity-of-substitution".

Three features stand out in these results. Firstly, variable Z, which makes it possible to control for the influence of unobservable factors, is very important in the model; omitting it would generate a bias in the coefficients that are estimated for each of the domains. In fact, the estimated coefficient for this variable is negative and statistically significant at 1%. Secondly, each of the six domains used to explain overall life satisfaction among Chilean workers has a positive effect which is statistically significant at 1%. Lastly, it is worth noting the goodness-of-fit shown by the model, given that the estimation used cross-sectional data.

An interesting feature of the relationship between domain-specific satisfaction and overall life satisfaction is the relative effect of each domain; in other words, which domain has the greatest effect on overall life satisfaction.

Table 6 reports the values of a t-test to assess whether the effect of one domain is statistically different from that of another. For example, in panel A the value 4.13 indicates rejection of the null hypothesis, which suggests that the effects of the leisure and family domains are the same, since the effect of family on life satisfaction was greater than that of leisure. It can therefore be concluded that family life has a greater effect than other domains.

Table 6
Comparison of the effects of the domains on life satisfaction

Satisfaction with:	(1) Family life	(2) Leisure	(3) Health	(4) Job	(5) Money
Panel A			All (OLS)		
Leisure	4.13				
Health	2.91	-0.74			
Job	4.00	0.77	1.47		
Money	6.34	3.63	3.19	1.53	
Privacy	5.28	3.02	2.84	1.35	-0.27
Panel B			Men		
Leisure	4.07				
Health	3.63	-0.14			
Job	3.03	-0.54	-0.38		
Money	5.94	2.35	2.10	2.46	
Privacy	5.48	2.87	2.45	3.08	0.55
Panel C			Women		
Leisure	1.81				
Health	0.75	-0.91			
Job	2.55	1.41	2.12		
Money	3.04	2.48	2.58	0.08	
Privacy	1.80	0.59	1.20	-0.94	-1.27
Panel D			Age: 15–39 years		
Leisure	3.01				
Health	1.79	-0.75			
Job	3.14	0.76	1.41		
Money	4.64	2.23	2.27	0.62	
Privacy	3.40	1.30	1.55	0.05	-0.79
Panel E			Age: 40–65 years		
Leisure	2.86				
Health	2.38	-0.28			
Job	2.70	0.25	0.51		
Money	4.52	3.07	2.25	1.99	
Privacy	4.24	3.00	2.52	2.11	0.40
Panel F			Primary education		
Leisure	0.83				
Health	-0.20	-1.45			
Job	0.33	-0.57	0.60		
Money	2.60	4.01	4.01	3.38	
Privacy	1.77	2.14	2.78	2.14	-1.18

Table 6 (concluded)

Satisfaction with:	(1) Family life	(2) Leisure	(3) Health	(4) Job	(5) Money
Panel G			Secondary education		
Leisure	4.35				
Health	3.97	0.38			
Job	5.14	1.62	1.24		
Money	6.56	3.13	1.78	0.55	
Privacy	4.78	1.78	1.10	-0.18	-0.81
Panel H			Tertiary education		
Leisure	2.42				
Health	1.55	-0.45			
Job	1.45	-0.81	-0.13		
Money	2.43	-0.46	0.20	0.33	
Privacy	3.04	1.71	1.60	2.60	1.55
Panel I			Quintile I		
Leisure	1.40				
Health	0.29	-1.43			
Job	0.44	-1.23	0.15		
Money	3.23	3.59	3.88	3.97	
Privacy	2.14	1.82	3.04	2.59	-0.58
Panel J			Quintile II		
Leisure	0.85				
Health	1.25	0.55			
Job	2.17	1.90	1.12		
Money	2.35	2.70	1.64	0.33	
Privacy	1.39	1.32	0.49	-0.66	-1.06
Panel K			Quintile III		
Leisure	2.72				
Health	2.52	0.49			
Job	3.75	1.44	0.66		
Money	4.28	2.28	0.72	0.16	
Privacy	4.29	2.16	1.11	0.74	0.42
Panel M			Quintile IV		
Leisure	1.85				
Health	2.30	0.27			
Job	2.62	1.28	0.89		
Money	2.63	1.10	0.52	-0.55	
Privacy	3.35	2.59	1.49	0.40	1.20
Panel N			Quintile V		
Leisure	3.30				
Health	0.34	-3.44			
Job	1.13	-2.09	1.07		
Money	2.89	-0.17	3.26	1.96	
Privacy	2.22	-0.95	2.71	1.14	-0.67
Panel L			All (CES)[a]		
Leisure	2.37				
Health	1.79	-0.51			
Job	2.61	0.89	1.37		
Money	3.74	2.63	2.50	1.06	
Privacy	2.86	2.02	2.25	1.44	0.52

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

Note: The value shown corresponds to a *t*-test to assess whether the effect of one domain is statistically different from those of others. For example, the value 4.13 indicates rejection of the null hypothesis, which suggests that the effects of satisfaction in the leisure and family domains are the same, since the family has a greater effect on life satisfaction than leisure does.

[a] CES stands for "constant-elasticity-of-substitution".

Similarly, leisure has a greater effect on life satisfaction than money and privacy, while health proves more important than either of these two domains. In contrast, the parameters associated with job satisfaction, money and privacy are not statistically different.

The evidence thus shows that all domains have positive and statistically significant effects on life satisfaction; but satisfaction in the domains of family life, leisure and health are more important to overall life satisfaction than those of money, work and privacy.

3. Heterogeneity by gender, age, schooling and household income quintile

This section explores heterogeneity in the relationship between domain satisfaction and overall life satisfaction by gender, age, educational level and total household income quintile.[6]

Columns (2)–(13) of table 5 report estimations of the effect of each domain on life satisfaction when controlling for unobservable heterogeneity.[7] The results for men, displayed in column (2),[8] show that all domains are important for life satisfaction (money, leisure, family life, health and work), except privacy. In this case, the variable Z is not statistically significant. On the other hand, analysis of the data reported in table 6 (panel B) shows that the effects of family life, leisure, health and work are more important than the those of money and privacy.

For women too, the results reported in column (3) of table 5 show that all domains are relevant. In this case, the variable Z is statistically significant at 1%. According to the information provided in table 6 (panel C) family life, leisure and health have the most important effects.

Differences by age were also explored. The sample was split into two groups, consisting of individuals aged between 15 and 39 years and those aged from 40 to 65. For the younger group, all domains are important for life satisfaction, as shown in columns (4) and (5) of table 5. As is the case with men, personality traits are not statistically significant. Meanwhile table 6 (panel D) shows that family life, leisure and health have a greater effect on life satisfaction than work, money and privacy. For individuals aged between 40 and 65 years, satisfaction with privacy has no effect on life satisfaction; in contrast, satisfaction with money, leisure, family life, health and work are very important. Variable Z is statistically significant at 5%. Table 6 (panel E) shows that the main contributors to overall life satisfaction are family life, leisure, health and work.

Differences by educational level were also studied (see columns (6)–(8) in table 5). For individuals educated to the primary level, only four domains are important for life satisfaction, namely leisure, family life, health and work. According to table 6 (panel F), family life, leisure, health and work have the strongest effects on life satisfaction. In contrast, for individuals educated to the secondary level, table 5 shows that all domains are important. The greatest effects are obtained from family life and leisure (see panel G in table 6). Lastly, for individuals educated to the tertiary level, satisfaction with privacy is the only domain that is not important. Panel H shows that family life and work have the greatest effects on life satisfaction. It is worth noting that the variable summarizing personality traits is only statistically significant at 5% for workers educated to the primary level.

Lastly, differences according to household total income quintile were analysed (see columns (9)–(13) of table 5). These findings are similar to those obtained in respect of education level, with the results in

[6] Columns (2)–(13) in table 4 show the correlation of each residual with the first principal component used to estimate *Z*. Here again, the correlations are high which suggests that the principal component is a good instrument for variable *Z*.

[7] The first stage of each of the regressions and the principal components analysis are available upon request.

[8] Instead of dividing the sample, dummy variables could have been included in the model to maintain the estimation's efficiency. Nonetheless, the estimates remain efficient, and the domains that are not statistically significant reflect the fact that the point estimates are very close to zero.

income quintile I actually consistent with those for individuals educated to the primary level. In particular, family life, leisure, health and work are the most important domains for explaining their life satisfaction. On the other hand, individuals in income quintile V, derive life satisfaction from their satisfaction with family life, health and their job. It is also worth noting that only those in quintiles II and IV recognize a degree of importance for satisfaction with money, and Z is only statistically significant in income quintile I. Three features stand out in the results presented in tables 5 and 6. First, some domains —namely leisure, family life, work and health— are important for nearly all groups of workers analysed. Second, the domains with the greatest effect on life satisfaction are family life, leisure, health and work. Lastly, in most cases it is important to control for the variable Z, since it is statistically significant (either at 1% or at 5%).

4. Robustness analysis

An initial concern with the methodology employed in this study is the fact that the relationship between life satisfaction and domain satisfaction is assumed to be linear. To address this issue this study follows Rojas (2006) by estimating a constant-elasticity-of-substitution (CES) production function for life satisfaction.[9] Column (14) of table 5 reports the results. As with the linear approach, all domains appear significantly correlated with life satisfaction. The relative importance of each domain is also explored; and panel L of table 6 reports the results of the linear combination tests. The results of the CES estimation are consistent with the ranking of the linear estimation; that is, satisfaction with family life, leisure and health are the most important domains, in decreasing order. In summary, the results are robust to different specifications of the relationship between overall life satisfaction and domain satisfaction.[10]

A second concern about the robustness of the results relates to the construction of Z. The two-layer methodology developed by van Praag, Frijters and Ferrer-i-Carbonell (2003) entails constructing a variable Z that summarizes the information on individuals' personality traits. As explained above, the authors proposed instrumentalizing Z through a procedure in which the determinants of the domains are estimated, and then the residuals are calculated to estimate the portion of that is common to all the residuals. Lastly, the instrument is the result of the first principal component of the x error covariance matrix.

Accordingly, this procedure may be sensitive to the econometric specification used to model each of the domains. The model proposed thus far assumes that the determinants (covariates) of domains related to money, privacy, leisure, family life and health are the same. Nevertheless, the model proposed for job satisfaction is different, and it includes variables related to the characteristics of employment. This section studies the robustness of the results by estimating alternative specifications for the determinants of domain satisfaction.

The first robustness check consisted of estimating all domains of satisfaction using the same covariates. Hence, the job-satisfaction model included the same covariates as in the other five domains. This is called the reduced model. In the second check, the covariates originally included in job satisfaction were considered for other domains. This is referred to as the extended model. The estimates of the effects of the domains on life satisfaction are reported in table 7.

Column (1) reports the estimates for the reduced model. All domains have effects on life satisfaction that are statistically significant at 1%. Variable Z (representing personality traits) is also statistically significant at 5%. Column (2) presents the estimates of the effects of the different domains for the extended model, which are similar to those obtained from the reduced model. Table 8 shows the values of a t-test to assess whether the effect of one domain is statistically different from that of another, for both the reduced and the extended models. The results show that, for the reduced model, the effects of family life, leisure and

[9] Formally, the following equation is estimated: $LS = \left(\sum_{i=1}^{n} \alpha_i DS_i^{\rho}\right)^{\frac{\varepsilon}{\rho}}$ with α_i $(i=1,...,n)$, ε and σ as parameters.

[10] The same relationship is also estimated using an ordered Probit. The main qualitative results, which are available upon request, remained unchanged.

health are more important than those of money, job and privacy. These are identical to the results found previously with the original model (see panel A in table 6). Analysis of the results of the extended model show that the effects of family life, leisure and health are the most important.

Table 7
The determinants of life satisfaction: the reduced model and the extended model
(On a scale of 1-7)

Satisfaction with:	Reduced model	Extended model
	(1)	(2)
Money	0.0624*** (0.0153)	0.0592*** (0.0153)
Privacidad	0.0679*** (0.0245)	0.0583*** (0.0223)
Leisure	0.145*** (0.0222)	0.135*** (0.0207)
Family life	0.312*** (0.0394)	0.304*** (0.0377)
Health	0.173*** (0.0310)	0.166*** (0.0289)
Job	0.124*** (0.0282)	0.101*** (0.0273)
Z	-0.0841** (0.0334)	-0.0621** (0.0287)
Constant	0.888** (0.446)	1.226*** (0.339)
Observations	4 157	4 157
R^2	0.413	0.413

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.
Note: OLS estimation. (***) p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

Table 8
Comparison of the effects of the different domains on life satisfaction

Satisfaction with:	(1) Family life	(2) Leisure	(3) Health	(4) Job	(5) Money
Reduced model					
Leisure	4.056				
Health	2.851	-0.734			
Job	3.855	0.580	1.285		
Money	6.277	3.571	3.148	1.707	
Privacy	5.243	3.048	2.853	1.611	-0.192
Extended model					
Leisure	4.084				
Health	2.843	-0.780			
Job	4.058	0.915	1.676		
Money	6.304	3.398	3.095	1.150	
Privacy	5.254	3.065	2.938	1.213	0.032

Source: Prepared by the authors, on the basis of Ministry of Health (MINSAL), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)", 2011 [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.

In short, it can be concluded that the results obtained are not sensitive to changes to the functional form or the econometric specification used to model the different domains. All domains had a statistically significant effect on life satisfaction, with family life, leisure and health being the most important.

V. Conclusions

This study has implemented the two-layer model methodology developed by van Praag, Frijters and Ferrer-i-Carbonell (2003), in which life satisfaction is viewed as the aggregate of domain-specific happiness components. The article presents evidence for a country, namely Chile, that has reached the threshold between developing and developed States, and therefore needs to gain a better understanding of the complex phenomenon of the subjective well-being of its population. As such, it makes a good attempt to identify the drivers of life satisfaction among Chilean workers.

Using data from a sample of Chilean workers, the study found that levels of satisfaction with money, privacy, leisure, family life, health and work each have a positive and statistically significant effect on life satisfaction. The evidence also reveals that the effects of family life, leisure and health are more important to life satisfaction than those of money, work and privacy. These results are robust to different specifications for the domains. The empirical evidence presented in this study is in line with that found for other countries (both developed and developing). However, another finding is that the domains associated with money and work are apparently less important than family life, leisure and health status. The results presented in this paper are robust to changes in the production function used to model life satisfaction.

These results are at odds with prior evidence from Chile, however. In particular, Loewe and others (2014) found that satisfaction with one's financial situation was the dominant predictor of overall life satisfaction; and that satisfaction with one's self-worth, leisure time and social relationships did not have statistically significant effects.

There may be several reasons for these the differences. Firstly, the dataset used by Loewe and others (2014) is not representative of Chilean workers, unlike the one used in this study. Secondly, the number of observations in that study is considerably smaller (530) than the number available in this study (4,157). Thirdly, this research uses a different estimation methodology which takes unobserved heterogeneity explicitly into account. Nonetheless, the findings of the present study should be considered with caution given its limitations (which are also present in Loewe and others, 2014). In particular, it is possible to identify at least two shortcomings. First, this study has exogenously imposed the domains that determine Chilean workers' life satisfaction. It would be interesting to question individuals themselves about the domains that they consider relevant to their lives. Secondly, it would be useful to perform this type of analysis (to understand the determinants of life satisfaction) using longitudinal instead of cross-sectional data. This would certainly enrich the econometric analysis of the relationship between domain satisfaction and overall life satisfaction; and it would afford better control over the role of unobservable characteristics in the determination of life satisfaction.

Despite these limitations, this article reports new results that contribute to the empirical literature on subjective well-being, by validating the two-layer model using data from Chile. It has been observed that, for an economy in transition, it is important to investigate the drivers of life satisfaction, since non-pecuniary factors (family life, leisure) are relevant to people's subjective well-being. Since Chile is in this transitional phase, it is essential to understand these drivers properly, so that public and managerial policies can be designed to promote more efficiently the subjective well-being of workers and the population at large. In particular, business managers may be interested in investing in some of these areas in order to improve their workers' productivity, with which happiness is correlated (Oswald, Proto and Sgroi, 2015). Since Chilean workers value family life and leisure more than other domains, it may be appropriate to design policies that give workers greater flexibility to achieve a better work-life balance. For instance, allowing individuals to work remotely may improve both performance (Harker and MacDonnell, 2012) and subjective well-being (Anderson, Kaplan and Vega, 2015). It could also help them to save commuting time, which, for instance, averages 1 hour and 40 minutes per day in

Santiago (Ministry of Social Development, 2015). Long commutes have been shown to reduce subjective well-being (Stutzer and Frey, 2008; Lorenz, 2018). In addition, the importance of health to life satisfaction suggests that attempts by policymakers and/or managers to provide better conditions at work that could result in better health will have a positive effect on an individual's well-being.

Bibliography

Ambrey, C. and C. Fleming (2014), "The causal effect of income on life satisfaction and the implications for valuing non-market goods", *Economic Letters*, vol. 123, No. 2, May.

Amestoy, V., T. García-Muñoz and A. Egido (2016), "Individual and social dimensions of subjective well-being: evidence across Latin-American Countries", *Handbook of Happiness Research in Latin America*, M. Rojas (ed.), Dordrecht, Springer.

Anderson, A., S. Kaplan and R. Vega (2015), "The impact of telework on emotional experience: when, and for whom, does telework improve daily affective well-being?", *European Journal of Work and Organizational Psychology*, vol. 24, No. 6.

Assadullah, M. and R. Fernandez (2008), "Work-life balance practices and the gender gap in job satisfaction in the UK: evidence from matched employer-employee data", *IZA Discussion Paper*, No. 3582, Bonn, Institute of Labor Economics (IZA), July.

Booth, A. and J. van Ours (2008), "Job satisfaction and family happiness: the part-time work puzzle", *The Economic Journal*, vol. 118, No. 526, February.

Card, D. and others (2012), "Inequality at work: the effect of peer salaries on job satisfaction", *American Economic Review*, vol. 102, No. 6, October.

Clark, A., A. Oswald and P. Warr (1996), "Is job satisfaction u-shaped in age?", *Journal of Occupational and Organizational Psychology*, vol. 69, No. 1.

Clark, A. and C. Senik (2010), "Who compares to whom? The anatomy of income comparisons in Europe", *The Economic Journal*, vol. 120, No. 544, May.

Clark, A., N. Kristensen and N. Westergård-Nielsen (2009), "Job satisfaction and co-worker wages: status or signal?", *The Economic Journal*, vol. 119, No. 536, March.

Easterlin, R. and O. Sawangfa (2007), "Happiness and domain satisfaction: theory and evidence", *IZA Discussion Paper*, No. 2584, Bonn, Institute of Labor Economics (IZA), January.

Ferrer-i-Carbonell, A. (2005), "Income and well-being: an empirical analysis of the comparison income effect", *Journal of Public Economics*, vol. 89, No. 5–6, June.

Ferrer-i-Carbonell, A. and B. van Praag (2008), *Happiness Quantified: a Satisfaction Calculus Approach*, New York, Oxford University Press.

Fitoussi, J. and J. Stiglitz (2013), "On the measurement of social progress and wellbeing: some further thoughts", *Global Policy*, vol. 4, No. 3, September.

Frijters, P., J. Haisken-DeNew and M. Shields (2004), "Money does matter! Evidence from increasing real income and life satisfaction in East Germany following reunification", *American Economic Review*, vol. 94, No. 3, June.

Harker, B. and R. MacDonnell (2012), "Is telework effective for organizations? A meta-analysis of empirical research on perceptions of telework and organizational outcomes", *Management Research Review*, vol. 35, No. 7, June.

Hojman, D. and A. Miranda (2018), "Agency, human dignity, and subjective well-being", *World Development*, vol. 101, January.

Kahneman, D. and A. Deaton (2010), "High income improves evaluation of life but not emotional well-being", *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, vol. 107, No. 38, September.

Kant, S. and others (2014), "Multi-domain subjective wellbeing of two Canadian First Nations communities", *World Development*, vol. 64, December.

Loewe, N. and others (2014), "Life domain satisfactions as predictors of overall life satisfaction among workers: evidence from Chile", *Social Indicators Research*, vol. 118, No. 1.

López Bóo, F., L. Madrigal and C. Pagés (2010), "Part-time work, gender and job satisfaction: evidence from a developing country", *The Journal of Development Studies*, vol. 46, No. 9.

Lorenz, O. (2018), "Does commuting matter to subjective well-being?", *Journal of Transport Geography*, vol. 66, January.
Mahmud, M. and Y. Sawada (2015), "Happiness in life domains: evidence from Bangladesh based on parametric and non-parametric models", *CIRJE Discussion Paper*, No. 987, Tokyo, Center for International Research on the Japanese Economy (CIRJE), August.
Manski, C. (2000), "Economic analysis of social interactions", *Journal of Economic Perspectives*, vol. 14, No. 3.
Ministry of Social Development (2015), "Encuesta CASEN 2015, Módulo O: trabajo" [online] http://observatorio.ministeriodesarrollosocial.gob.cl/casen-multidimensional/casen/docs/Cuestionario_CASEN_2015.pdf.
MINSAL (Ministry of Health) (2011), "Primera encuesta nacional de empleo, trabajo, salud y calidad de vida de los trabajadores y trabajadoras en Chile (ENETS 2009-2010)" [online] https://www.dt.gob.cl/portal/1629/articles-99630_recurso_1.pdf.
Montero, R. and T. Rau (2016), "Relative income and job satisfaction in Chile", *Handbook of Happiness Research in Latin America*, M. Rojas (ed.), Dordrecht, Springer.
___(2015), "Part-time work, job satisfaction and well-being: evidence from a developing OECD country", *The Journal of Development Studies*, vol. 51, No. 4.
Montero, R. and D. Vásquez (2015), "Job satisfaction and reference wages: evidence for a developing country", *Journal of Happiness Studies*, vol. 16, No. 6, December.
Mumford, K. and P. Smith (2012), "Peer salaries and employee satisfaction in the workplace", *IZA Discussion Paper*, No. 6673, Bonn, Institute of Labor Economics (IZA), June.
Oswald, A., E. Proto and D. Sgroi (2015), "Happiness and productivity", *Journal of Labor Economics*, vol. 33, No. 4, October.
Rojas, M. (2006), "Life satisfaction and satisfaction in domains of life: is it a simple relationship?", *Journal of Happiness Studies*, vol. 7, No. 4, November.
Senik, C. (2007), "Direct evidence on income comparisons and their welfare effects", *IZA Discussion Paper*, No. 3195, Bonn, Institute of Labor Economics (IZA), November.
Sousa-Poza, A. and A. Sousa-Poza (2000), "Well-being at work: a cross-national analysis of the levels and determinants of job satisfaction", *The Journal of Socio-Economics*, vol. 29, No. 6, November.
Stiglitz, J., A. Sen and J. Fitoussi (2009), *Report by the Commission on the Measurement of Economic Performance and Social Progress*, Paris, Commission on the Measurement of Economic Performance and Social Progress.
Stutzer, A. and B. Frey (2008), "Stress that doesn't pay: the commuting paradox", *The Scandinavian Journal of Economics*, vol. 110, No. 2.
Van Praag, B., P. Frijters and A. Ferrer-i-Carbonell (2003), "The anatomy of subjective well-being", *Journal of Economic Behavior & Organization*, vol. 51, No. 1, May.

Constant real expenditure policy: the macroeconomic impacts of budget composition and a primary surplus

Emerson Luís Lemos Marinho and Mauricio Benegas

Abstract

This paper analyses the fiscal policy of constant real expenditure recently adopted by Brazil's fiscal authorities. It also compares the policy of maintaining a primary surplus as a proportion of gross domestic product with that of changing the composition of spending in favour of investment in order to identify which of the two policies is more efficient in promoting economic growth. We investigate the effects of these policies on long- and short-term consumption, investment, labour supply and output and the reaction of the term structure of interest rates. We also analyse the relationship between these fiscal policies and welfare. We use a representative agent model of intertemporal utility maximization subject to budget constraint, with perfect foresight and an infinite horizon.

Keywords

Fiscal policy, public expenditure, economic conditions, consumption, investment, interest rates, social welfare, economic analysis, Brazil

JEL classification

E1, E2, H3

Authors

Emerson Luís Lemos Marinho is a professor with the Department of Finance of the Federal University of Ceará (UFC), Brazil. Email: emarinho@ufc.br.

Mauricio Benegas is a professor with the Department of Economics of the Federal University of Ceará (UFC), Brazil. Email: mauricio_benegas@caen.ufc.br.

I. Introduction

In recent years, Brazil has faced one of its worst recessions since gross domestic product (GDP) began to be measured in the country. Moreover, the government budget deficit has worsened over time, meaning that the country may face serious difficulty in financing this deficit if urgent measures are not adopted.

Statistical analysis shows that during the period of significant growth in the primary deficit, the country's main socioeconomic indicators worsened substantially. According to data from the Institute for Applied Economic Research (IPEA, 2016), from July 2011 to September 2016, primary accounts dropped sharply from a surplus of 3.57% of GDP to a deficit of 3.05% of GDP. The real GDP growth rate of 3.4% in the third quarter of 2011 fell to -4.84% in the fourth quarter of 2015. In the context of this recession, inflation increased from 6.08% to 11.28% between 2011 and 2015.

This situation weighed heavily on families' economic conditions. The unemployment rate, for example, increased from 7.9% in March 2013 to 13.7% in March 2017 and the real wage mass contracted by approximately 10 billion reais between 2015 and 2016.

With a view to addressing this problem, the fiscal authorities recently adopted a policy on constant real public spending for the coming years, according to which the nominal expenditure for a given year shall be, at most, equal to that of the previous year plus inflation in that period.

Considering the difficulties faced, this article aims to analyse the potential consequences of this policy for equilibrium trajectories for long- and short-term consumption, investment and output, and the reaction of the term structure of interest rates. The analysis of the latter is paramount considering its importance in conveying macroeconomic policies.

However, some Brazilian economists have argued that the fiscal authorities should also adopt a policy of maintaining a primary surplus as a proportion of GDP, in order to tackle the fiscal deficit and accelerate economic growth immediately. Meanwhile, other economists in Brazil believe that the government should alter its budget composition to reflect more investment in infrastructure than in expenditure.[1] This infrastructure would enable private companies to increase their productivity, thus contributing to faster economic growth.

The main goal of this article is to determine, on the basis of the assumption that total government spending in real terms remains constant, which of the two fiscal policies suggested is more effective in producing higher levels of output and investment in the long term, and ultimately, produces greater economic growth.

Several papers have focused on the impact of fiscal policies on the term structure of interest rates. With regard to the use of the traditional approach of IS-LM models with some variations, we should mention the works of Blanchard (1981), Turnovsky and Miller (1984) and McCafferty (1986). In a different context that considers the intertemporal optimization behaviour of a representative agent, we should also mention the articles of Cox, Ingersoll and Ross (1985) and Fisher and Turnosvky (1992).

This article is based on the Fisher and Turnovsky model (1992) with two main alterations. The first assumes that real government expenditure is constant through time. The second suggests that the fiscal policy adopted by the government is a primary surplus as a percentage of GDP. This representative agent model employs intertemporal utility maximization subject to budget constraint with perfect foresight and an infinite horizon.

Given that financial portfolio assets may be adjusted instantly and without cost, the real economic performance is independent of the long-term interest rate, while the short-term equilibrium determines

[1] Baxter and King (1993) calibrate a real business cycle model to derive the transitional dynamic response of consumption, investment and employment to changes in the composition of government spending.

the short-term interest rate. As a result, the long-term interest rate is set through arbitrage between short- and long-term equilibria. Therefore, the short-term interest rate responds to fiscal policy shocks immediately, while the long-term rate responds indirectly through the effects of current and future expectations of short-term rates.

In this situation, two types of fiscal policy shock shall be considered: the first is a permanent shock unanticipated by agents; in other words, an immediate shock. The second is a permanent shock anticipated in the future. In this case, the government announces that it will alter the fiscal policy at some point in the future. In addition to the assumption that real government expenditure will remain constant through time, two fiscal policy measures shall be analysed. The first examines how changes in the composition of public expenditure (e.g. more government spending on consumption or on infrastructure) affect investment, private consumption, output, labour supply and long- and short-term interest rates. The second measure, aligned with the first, analyses the impact of growth in the primary surplus as a percentage of GDP.

Finally, this paper discusses the relationship between these fiscal policies and social welfare. The model has been built according to certain specifications in order to obtain objective results. In particular, it is assumed that the representative utility function follows the specification adopted by Christiano, Eichenbaum and Rebelo (2011) and that the technology applied is the Cobb-Douglas production function for public expenditure, as suggested by Barro (1990). With these specifications, fiscal austerity and budget composition policies that maximize social well-being are measured through the total discounted utility. It is therefore demonstrated that under reasonable conditions, a budget composition which maximizes welfare should allocate most resources to infrastructure and that the proportion of GDP allocated to the primary surplus depends on the sensitivity of per capita income to fiscal results.

Including the introduction, this article is divided into six sections. Section II introduces and discusses the applied theoretical model. Section III analyses transactional equilibrium dynamics when the government announces changes in the composition of its expenditure and increases the primary surplus as a proportion of GDP. Section IV discusses the impacts of these fiscal policies on the term structure of interest rates. Section V draws some conclusions on agents' welfare when the government alters the composition of its spending and increases its primary surplus as a percentage of GDP. And lastly, section VI discusses the conclusions. There is also an annex that formally demonstrates the solutions to the model and some of the algebraic equations applied to obtain results.

II. The theoretical model

The model considers a closed economy[2] in which identical agents assumed to have an infinite life make immediate decisions on consumption $c(t)$ and labour $l(t)$, seeking intertemporal maximization of future utility flows $U(c(t),l(t),g_c(t))$ discounted at a rate ρ. The term $g_c(t)$ represents government consumption expenditure. The instant utility function of the agent is defined in the additive form as: $u(c(t),l(t))+v(g_c(t))$, in which, u and v are strictly concave forms with the following properties: $u_c>0$, $u_{cc}<0$, $u_l<0$, $u_{ll}<0$, $v'>0$ and $v''<0$.[3]

Following Barro (1990), the production function shall be defined in the multiplicative form as: $y(t)=f(k(t),l(t))h(g_i(t))$, where $y(t)$ is real output, $k(t)$ is physical capital stock, $l(t)$ is labour supply and $g_i(t)$ is government infrastructure spending. The production function is neoclassical with the following properties: f is linearly homogeneous with $f_k>0$, $f_l>0$, $f_{kk}<0$, $f_{ll}<0$ and $h'>0$, $h''<0$.

[2] See Agénor (2005) for a model based on an open economy.

[3] See Aschauer (1988, 1989 and 1990) for justification of this approach.

In principle, government spending on infrastructure exerts a positive externality on the marginal productivity of private capital. In fact, the marginal productivity of private capital is given by $f_k\ h(g_i)$. Since h is a growing function of infrastructure spending, an increase in infrastructure raises the marginal productivity of capital. The intensity of this positive external effect depends on the specification of the production function. In general, the marginal effects of private capital and of production infrastructure spending depend once again on the specification of the production function and the link between parameters and k and g.

Considering the budget constraint, $y(t)=f(k(t),l(t))h(g_i(t))=c(t)+i(t)+g(t)$. Hence, the capital stock evolves according to the following macroeconomic identity:

$$\dot{k}(t) = f(k(t),l(t))h\left(g_i(t)\right) - c(t) - g(t) \tag{1}$$

in which $g(t)$ represents total real government expenditure and $i(t) = \dot{k}(t)$. The term $\dot{k}(t)$ represents the time-related derivative of $k(t)$.

The budget constraint faced by the government is represented by the differential equation:

$$\dot{b}(t) = rb(t) + g(t) - T(t) \tag{2}$$

where $b(t)$ is the public debt stock, $T(t)$ is the lump-sum tax revenue, r is the real interest rate and $\dot{b}(t)$ is the derivative of $b(t)$ with respect to time.

Total real government spending shall be considered constant through time according to the fiscal policy rule adopted by the government. That said, total spending shall be distributed between government consumption expenditure $-g_c(t)-$ and infrastructure expenditure $-g_i(t)$. In other words, $\overline{g} = g_c(t) + g_i(t)$, where $\overline{g}$ represents the total constant expenditure assuming that $g_c(t) = \alpha\overline{g}$ and that $g_i(t) = (1 - \alpha)\overline{g}$ where $0<\alpha<1$.

Additionally, the fiscal policy adjustment adopted by the government shall be the primary surplus as a percentage of GDP, which means that:

$$T(t) - g(t) = \beta y(t) = \beta f(k(t),l(t))\,h(g_i(t)) \tag{3}$$

where $T(t)-g(t)$ represents the primary surplus and $0<\beta<1$.

Therefore, the problem of the representative agent is formally summarized as:

$$max_{\{c,l\}} \int_0^{\infty} e^{-\rho}\left[u\left(c(t),l(t)\right) + v\left(g_c(\alpha\overline{g})\right)\right]dt \tag{4}$$

subject to restrictions:

$$\dot{k}(t) + \dot{b}(t) = (1 - \beta)f(k(t),l(t))h((1 - \alpha)\overline{g}) + rb(t) - c(t) - \overline{g},\ k(0) = k_0\, b(0) = b_0 \text{ and } b(0) = b0.$$

Observe that this last restriction is generated after the algebraic manipulation of expressions (1), (2) and (3) and from the definitions of $g_i(t)$ and $g_c(t)$. The last two restrictions assume that in the initial state, the economy has a capital stock k_0 and its public debt is equal to b_0.

Hamiltonian first-order conditions of current value associated with the problem (4) are given by:

$$u_c(c(t),l(t)) = \lambda(t) \tag{5}$$

$$u_l\left(c(t),l(t)\right) = -\lambda(t)(1 - \beta)f_l(k(t),l(t))h((1 - \alpha)\overline{g}) \tag{6}$$

$$\lambda(t)(1 - \beta)f_k\left(k(t),l(t)\right)h(1 - \alpha)\overline{g}\right) = \rho\lambda(t) - \dot{\lambda}(t) \tag{7}$$

$$\lambda(t)r = \rho\lambda(t) - \dot{\lambda}(t) \tag{8}$$

$$\lim_{t\to\infty} \lambda(t)e^{-\rho t}k(t) = 0 \tag{9}$$

$$\lim_{t\to\infty} \lambda(t)e^{-\rho t}b(t) = 0 \tag{10}$$

where $\lambda(t)$ is the current marginal utility of wealth. Transversality conditions (9) and (10) are established so that the trajectories of $\lambda(t)$ and $k(t)$ are not explosive.

1. Short-run equilibrium analysis

Solutions targeting consumption $c(t)$ and labour supply $l(t)$ as well as marginal utility of wealth functions $\lambda(t)$ of capital stock $k(t)$ and of policy parameters α and β are obtained from equations (5) and (6). Therefore, we obtain the solutions $c=c(\lambda,k,\alpha,\beta)$ and $l=l(\lambda,k,\alpha,\beta)$, in which the period of time t is no longer included as a function argument for notation simplification effects. In order to analyse the effect of each of the terms λ, k, α and β on c and l, we use the equation systems (5) and (6). The solution to this system provides the signs for the following relations: $\frac{\partial c}{\partial k} = c_k < 0$, $\frac{\partial c}{\partial \lambda} = c_\lambda < 0$, $\frac{\partial c}{\partial \alpha} > 0$, $\frac{\partial c}{\partial \beta} = c_\beta > 0$, $\frac{\partial l}{\partial k} = l_k > 0$, $\frac{\partial l}{\partial \lambda} = l_\lambda > 0$, $\frac{\partial l}{\partial \alpha} = l_\alpha < 0$, and $\frac{\partial l}{\partial \beta} = l_\beta < 0$.

In the annex, we formally demonstrate how the expressions and respective signs of the above equations are obtained. The short-run impact of capital stock variations and the marginal utility of wealth on consumption and labour supply are as expected. Meanwhile, according to the expressions of $\frac{\partial c}{\partial k}$ and $\frac{\partial l}{\partial k}$ obtained in the system solutions, when the primary surplus as a percentage of GDP increases (β growth), both the increase in private consumption and the decline in labour supply slow down.

Growth in government expenditure allocated to consumption (α growth) implies an increase in private consumption and a decrease in labour supply. These two outcomes are less sensitive to increases in the percentage of GDP allocated to the primary surplus (β growth).

Finally, the growth in the primary surplus percentage leads to an increase in private consumption and a decrease in the labour supply. With regard to the increase in private consumption, the rise in β affects consumption through an income effect and a predominant substitution effect. Consequently, expressions (6) and (7) give rise to the expression $r=(1-\beta)f_k k$. In these terms, $dr/d\beta < 0$. Therefore, the β growth of triggers a fall in interest rates, causing individuals to reduce savings and increase private consumption.

2. Long-run equilibrium analysis

Steady-state equilibrium dynamics are obtained by replacing the function solutions $c=c(\lambda,k,\alpha,\beta)$ and $l=l(\lambda,k,\alpha,\beta)$ in differential equations (5) and (6). Therefore, we obtain the following system of differential equations:

$$\dot{k} = f\big(k, l(\lambda,k,\alpha,\beta)\big)h\big((1-\alpha)\overline{g}\big) - c(\lambda,k,\alpha,\beta) - \overline{g} \tag{11}$$

$$\dot{\lambda} = [\rho - (1-\beta)f_k\big(k(\lambda,k,\alpha,\beta), l(\lambda,k,\alpha,\beta)\big)h\big((1-\alpha)\overline{g}\big)]\lambda \tag{12}$$

Applying $\dot{k} = \dot{\lambda} = 0$ in the system above, we can obtain the steady-state equilibrium. Therefore, we have that $f\left(\tilde{k}, l\left(\tilde{\lambda}, \tilde{k}, g, \alpha, \beta\right)\right)h\left((1-\alpha)\overline{g}\right) = c\left(\tilde{\lambda}, \tilde{k}, g, \alpha, \beta\right) + \overline{g}$ and $(1-\beta)f_k\left(\tilde{k}, l\left(\tilde{\lambda}, \tilde{k}, g, \alpha, \beta\right)\right)$ $h\left((1-\alpha)\overline{g}\right) = \rho$, where the solution to the above system helps to establish equilibrium variables. The variables with a tilde (~) represent values in a steady state. Long-run impacts of fiscal policy parameters α and β on capital stock and the long-run marginal utility of wealth are given by the following relations[4]: $\partial\tilde{k}/\partial\alpha < 0$, $\partial\tilde{k}/\partial\beta < 0$, $\partial\tilde{\lambda}/\partial\alpha > 0$ and $\partial\tilde{\lambda}/\partial\beta > 0$.

Therefore, increases in α and β reduce the capital stock and improve the marginal utility of wealth (reduction of long-run private consumption).

The system dynamics analysis is easier following the linearization of equations (11) and (12) around their steady-state equilibrium. Consequently, we obtain the following dynamics:

$$\dot{k} = w_{11}\left(k - \tilde{k}\right) + w_{12}\left(\lambda - \tilde{\lambda}\right) \tag{13}$$

$$\dot{\lambda} = -\tilde{\lambda}\ (1-\beta)w_{21}\ \left(k - \tilde{k}\right) - \tilde{\lambda}(1-\beta)w_{22}\left(\lambda - \tilde{\lambda}\right) \tag{14}$$

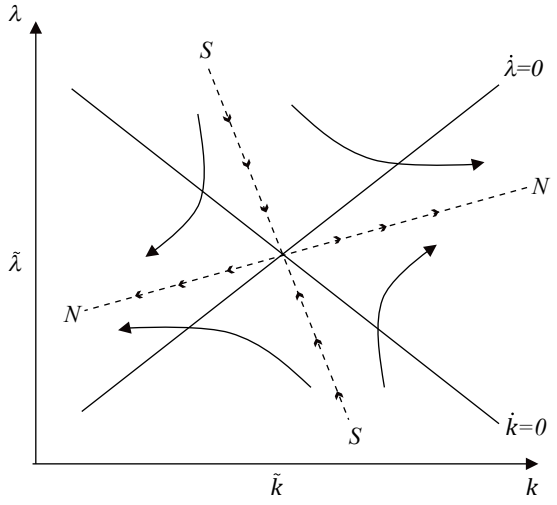
where $w_{11}=(f_k l_k h - c_k)>0$, $w_{12}=(f_l l_\lambda h - c_\lambda)>0$, $w_{21}=(f_{kk}+f_k l_k)h<0$ and $w_{22}=f_k l_k h>0$.

In the annex, we formally demonstrate that long-run equilibrium is a saddle-point type and that stable and unstable arm equations are respectively represented by: $\lambda = \tilde{\lambda} + \frac{(\mu_1 - w_{11})}{w_{12}}\left(k - \tilde{k}\right)$ and $\lambda = \tilde{\lambda} + \frac{(\mu_2 - w_{11})}{w_{12}}\left(k - \tilde{k}\right)$, where μ_1 and μ_2 are eigenvalues of the equation system matrixes (13) and (14). Since equilibrium is a saddle-point type, we assume, without loss of generality, that $\mu_1<0$ and $\mu_2>0$.

As demonstrated in the annex, the straight line of the stable arm presents a negative inclination while that of the unstable arm is positively inclined but with a lower inclination than the stable arm.

Designing these straight lines in the space $\lambda \times k$ considering the equilibrium characteristics of the saddle point and the properties of the stable and unstable arms, we obtain the phase diagram of this system as shown in figure 1. The SS and NN straight lines represent the stable arm and the unstable arm, respectively.

Figure 1
System phase diagram



Source: Prepared by the authors.

[4] These long-run relations are obtained by solving the equation systems $\dot{\lambda} = 0$ and $\dot{k} = 0$.

III. Anticipated and unanticipated permanent fiscal shocks

In this section we analyse the consequences of two fiscal shock cases. In the first, the government announces that it will increase spending on infrastructure to the detriment of government consumption expenditure. This implies a reduction of the fiscal policy parameter α. In the second case, the government announces a policy of growth in the primary surplus as a percentage of GDP. This results in an increase in parameter β.

In both cases, we consider that these fiscal policy announcements are not anticipated; the policy change takes place immediately. When policy changes are anticipated, the government announces that they will take place at a future time T. Moreover, the fiscal shocks are permanent.

The main goal is to identify which of the two fiscal policies is better for economic growth. The secondary goals are to analyse the effects of these changes on the trajectories of capital stock $k(t)$, the marginal utility of wealth $\lambda(t)$ and the term structure of interest rates. The annex includes a formal description of the solutions to the model and of how equilibrium displacements occur.

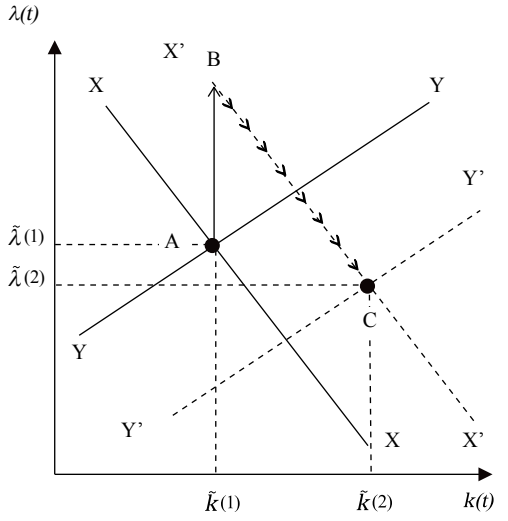
1. Permanent fiscal shock in α

Initially, we consider the unanticipated fiscal policy of an increase in infrastructure expenditure (reduction in α) announced by the government in the present. Since $\partial\tilde{k}/\partial\alpha < 0$ and $\partial\tilde{\lambda}/\partial\alpha > 0$, the new long-run equilibrium shall have a bigger capital stock (higher investment levels) and a lower marginal utility of wealth, which implies higher private consumption than the initial equilibrium.

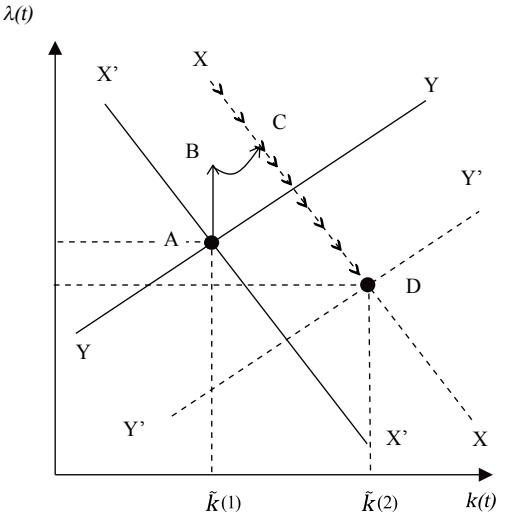
Observe in figure 2A that the immediate announcement of a cut in α causes displacements in the lines of the stable arm XX and the unstable arm YY. Both straight lines are displaced to the right, originating a new steady-state equilibrium represented by point C. Therefore, there is a displacement of the initial equilibrium A to a new long-run equilibrium C.

Figure 2

A. Unanticipated shock



B. Anticipated shock



Source: Prepared by the authors.

In the short run, right after the announcement of a cut in α, the marginal utility of wealth $\lambda(0)$ jumps directly to the stable arm (point B in the straight line X'X'). This results in a decline in private wealth, causing a reduction in private consumption and an increase in labour supply. The increase in labour supply leads to an improvement in the marginal productivity of capital, which results in an increase in the short-term interest rate.

At the same time, the marginal productivity of capital increases more than that of the steady-state equilibrium. According to the equilibrium equation (7) this makes $\dot{\lambda}(t) < 0$, implying that the marginal utility of wealth should decrease, while private consumption should grow. However, note that the time spent by both to reach a new steady-state equilibrium according to equation (14) increases as the primary surplus as a percentage of GDP rises (higher for β).

We can still note that the fall in initial private consumption levels improves savings, thus resulting in an accumulation of physical capital. In this context, the economy follows a trajectory from B to C. Private consumption, capital stock (investment), output and labour supply are higher in this new equilibrium than in the initial equilibrium.

In the case of an anticipated shock, when the government announces a reduction of α at a future date T, provided agents discount the change in the future, the jump in the marginal utility of wealth should be lower. In the annex, we show that the more distant the time of the policy change, the lower the $\lambda(t)$ jump. Therefore, $\lambda(t)$ jumps from A to B, as shown in figure 2B.

As in the unanticipated case, the capital stock in the new equilibrium shall be higher and the marginal utility of wealth lower, and consequently, private consumption shall grow. The main difference is the lower $\lambda(0)$ jump, which results in a smaller decline in private wealth. Therefore, labour supply increases while output grows and private consumption falls, but to a lesser extent.

In the short term the adverse effects of an anticipated policy are more limited than in the case of the same policy announced immediately. For example, the reduction in consumption in the first case is more limited than in the second. It therefore appears advisable for the government to adopt anticipated policies in the short term.

At the same time, as the labour supply increases, the marginal productivity of capital improves, causing short-term interest rates to rise. This also makes $\dot{\lambda}(t) > 0$, in line with the equilibrium equation (7). This result, combined with the savings increase, causes $\lambda(t)$ and $k(t)$ to follow the unstable trajectory BC until they reach the stable arm X'X'. In fact, the change in α takes place in period T. The displacement of $\lambda(t)$ and $k(t)$ in this trajectory is conveyed in figure 2A.

As from this point, $\lambda(t)$ and $k(t)$ follow their trajectories on the stable arm until they reach the new long-run equilibrium, represented by point D in figure 2B. Private consumption, capital stock (investment) and output are also higher compared to the initial equilibrium.

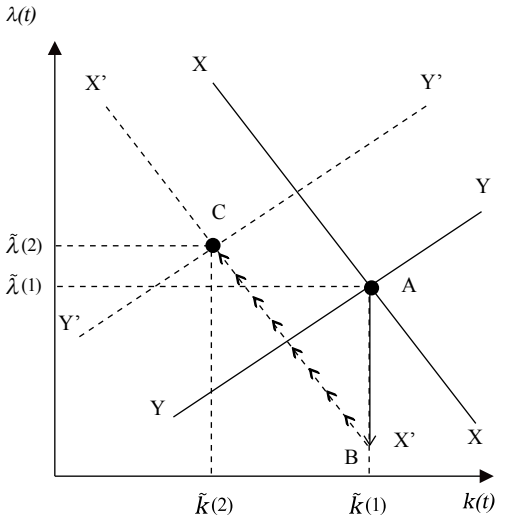
Note also that the effects of an increase in government consumption spending on private consumption, investment and output are not symmetrical to those in the case of an increase in infrastructure spending, regardless of the announcement being anticipated or not.

2. Permanent fiscal shock in β

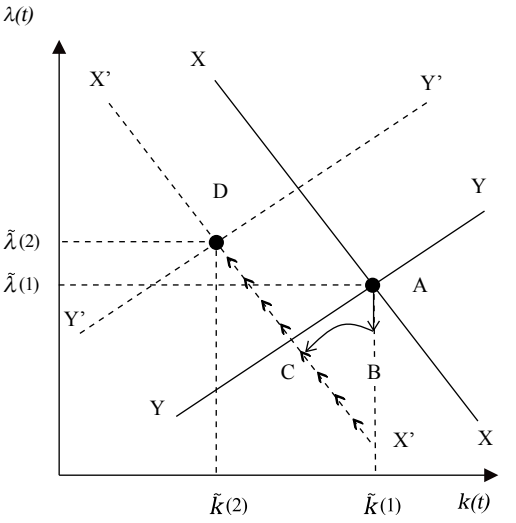
In this case, the government announces in the present (unanticipated fiscal policy) that it will increase the primary surplus as a percentage of GDP (increase in β). According to the signs of $\partial\tilde{k}/\partial\beta < 0$ and $\partial\tilde{\lambda}/\partial\beta > 0$, in the long-run equilibrium scenario the capital stock shall be lower than the marginal utility of wealth compared to the initial equilibrium. In fact, in figure 2C, the increase in β displaces the stable arm from XX to X'X' and the unstable arm from YY to Y'Y'. The new steady-state equilibrium (long-run) is represented by point C.

Figure 2

C. Unanticipated shock



D. Anticipated shock



Source: Prepared by the authors.

Following the announcement, the marginal utility of wealth $\lambda(0)$ immediately jumps from an initial equilibrium A to reach the stable arm X'X' at point B. The growth in private wealth owing to the decline in $\lambda(t)$ is short-term and results in a reduction in labour supply, which in turn leads to a decrease in the marginal productivity of capital and therefore, in short-term interest rates.

At the same time, the decrease in the marginal productivity of capital below the long-run equilibrium causes the marginal utility of wealth to grow again in order to maintain the equilibrium equation (7). This is followed by a fall in private consumption. Meanwhile, the initial improvement in consumption (savings decrease) generates a reduction in physical capital. In this context, the trajectories of $\lambda(t)$ and $k(t)$ move from point B to a new long-run equilibrium represented by point C. In this new long-run equilibrium, private consumption, physical capital stock and output are lower and labour supply is higher compared to the initial equilibrium.

The effects of the announcement of a policy change that will occur at a future date *T* (anticipated fiscal policy) are similar to those in the case of an unanticipated announcement. The main difference is that the jump in $\lambda(0)$ is smaller because agents anticipate that policy changes will only occur at a future time *T*.

In the short term, anticipated policies produce fewer adverse effects than unanticipated policies. For example, the decline in private consumption when an anticipated policy is applied is smaller than when an unanticipated policy is implemented. This result indicates that policies anticipated in the short term are preferable to unanticipated policies.

According to figure 2D, in the case of an anticipated shock, the marginal utility of wealth falls from A to B, which means that private wealth should grow. The higher the T value, the lower $\lambda(0)$ the jump. In the short run, the marginal productivity of capital diminishes, implying a fall in short-term interest rates but to a lesser extent. Considering the equilibrium equation (7) we can conclude that the fall in the marginal productivity of capital implies that $\dot{\lambda}(t) > 0$. Consequently, private consumption must decrease in order to maintain the marginal utility of wealth equilibrium. At the same time, growth in the initial consumption generates a reduction in savings, thus discouraging investments. Therefore, the economy follows a trajectory from C to D, when it reaches a new long-term equilibrium.

In this new equilibrium, private consumption, capital stock, output and labour supply are similar to the levels seen in unanticipated cases when comparing the initial and final equilibria. The effects of a cut in the primary surplus (β fall) are clearly symmetrical to the effects of a primary surplus increase.

To sum up, in terms of generating economic growth, the fiscal policy of infrastructure spending is more effective than the policy of maintaining a primary surplus as a proportion of GDP. Therefore, this infrastructure spending policy, combined with the constant real expenditure policy, are more effective in promoting economic growth and reducing the fiscal deficit. In this case, the levels of output and private investment in the final long-run equilibrium are greater than in the initial equilibrium, regardless of whether the shocks are anticipated or unanticipated. On the other hand, in the case of the primary surplus policy, the levels of output and private investment in the final long-run equilibrium are lower than in the initial equilibrium, regardless of the type of shock.

IV. Term structure of interest rates

We assume that perpetual bonds pay a long-term interest rate through a single periodic coupon with the value set in a given monetary unit. If $P(t)$ is the bond price and $R(t)$ is its internal return rate, we have that $R(t) = \frac{1}{P(t)}$.

In efficient and risk-free markets, through arbitrage, the short-term rate $r(t)$ shall be equal to the long-term rate plus capital $\frac{\dot{P}(t)}{P(t)}$. Therefore, $r(t) = \frac{1}{P(t)} + \frac{\dot{P}(t)}{P(t)}$, which originates the differential equation $\dot{P}(t) - rP(t) = -1$.

The solution to this equation for $P(t)$ looking into the future, as shown in the annex, results in the following expression: $P(t) = \int_t^\infty e^{-\int_t^s r(w)dw} ds$. Provided that $R(t) = \frac{1}{P(t)}$, the long-term interest rate may be defined as $R(t) = \frac{1}{\int_t^\infty e^{-\int_t^s r(w)dw} ds}$, defining $P(t,s) = e^{-\int_t^s r(w)dw}$ as the price of a zero-coupon bond in a period t that matures on date s, so we have that $P(t,s) = e^{-\int_t^s r(w)dw}$.

However, according to our hypothesis, the long-term bond has a unitary face value, which shall have to be equal to the sum of short-term rates considering the price for a period t of a zero-coupon bond that matures on date s. In other words, $\int_t^\infty r(s)P(t,s)ds = 1$.

Consequently, the long-term interest rate $R(t)$ may be expressed as:

$$R(t) = \frac{\int_t^\infty r(s)P(t,s)ds}{\int_t^\infty P(t,s)ds} \quad (15)$$

In other words, the long-term interest rate is a weighted average of short-term interest rates perfectly foreseen for the future.

From equilibrium conditions (7) and (8) we obtain that $r = (1-\beta)f_k(K, l(\lambda, K))h[(1-\alpha)\overline{g}]$. Linearizing this expression around the steady-state equilibrium, we find that its trajectory follows

the expression: $r(t) = \tilde{r} + (1 - \beta)w_{21}\left(k(t) - \tilde{k}\right) + (1 - \beta)w_{22}\left(\lambda(t) - \tilde{\lambda}\right)$, where $\tilde{r} = \rho$. Therefore, the short-term interest rate dynamic is obtained by differentiating the expression $r(t)$ above.[5]

Consequently,

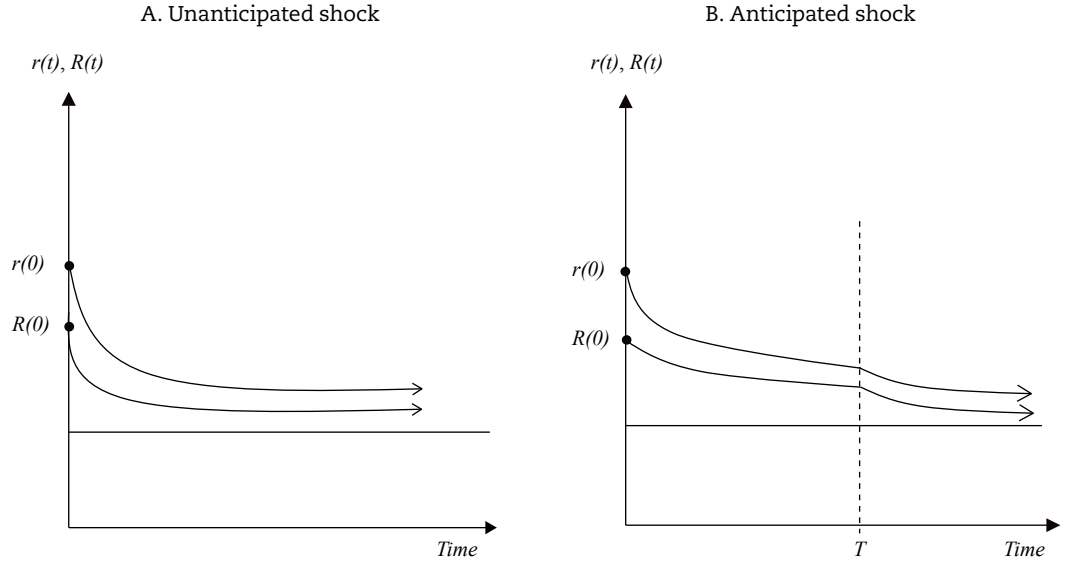
$$\dot{r}(t) = (1 - \beta)w_{21}\dot{k}(t) + (1 - \beta)w_{22}\dot{\lambda}(t) \tag{16}$$

As $R(t)$ is a weighted average, the short-term interest rate is perfectly foreseen for the future. According to (expression 15), the dynamics are established from the analysis of (16).

1. Permanent shocks of α on short- and long-term interest rates

Initially, we consider the case of an unanticipated fiscal policy in which the fiscal authority immediately announces an increase in permanent infrastructure spending (fall in α). According to the analysis developed in subsection III.1, $\lambda(t)$ immediately jumps to the stable arm X'X'. This growth in $\lambda(t)$ causes an increase in the marginal productivity of capital that, at the same time, increases short-term interest rates. Therefore, the short-term interest rate also jumps, followed by a gradual decrease through time, as shown in figure 3A.

Figure 3



Source: Prepared by the authors.

Since the dynamics of the rate $r(t)$ are governed by equation (16), and as after the jump of $\lambda(t)$, $k(t)$ follows a growing trajectory $(\dot{k}(t) > 0)$ and $\lambda(t)$ follows a decreasing trajectory $(\dot{\lambda}(t) < 0)$, the short-term interest rate shall decrease through time until it reaches its steady-state equilibrium ρ.

The long-term interest rate is expressed as a weighted average of the short-term interest rates perfectly foreseen for the future according to expression (15). The long-term interest rate also jumps from its initial equilibrium ρ to then decrease through time, always lagging the trajectory of $r(t)$, until converging again to its initial equilibrium level. As shown in expression (16), short- and long-term interest rate convergences slow down as the primary surplus as a percentage of GDP rises (increase in β).

[5] Seeking the dynamics of $R(t)$, provided that $\dot{R} = R\left[R - (1 - \beta)f_K(K, I(\lambda, K))\right]$, and linearizing this expression with the steady-state equilibrium, we obtain that: $\dot{R}(t) = \rho\left[\left(R(t) - \tilde{R}\right) - (1 - \beta)w_{21}\left(k(t) - \tilde{k}\right) - (1 - \beta)w_{22}\left(\lambda(t) - \tilde{\lambda}\right)\right]$ in which $\dot{R} = \rho$.

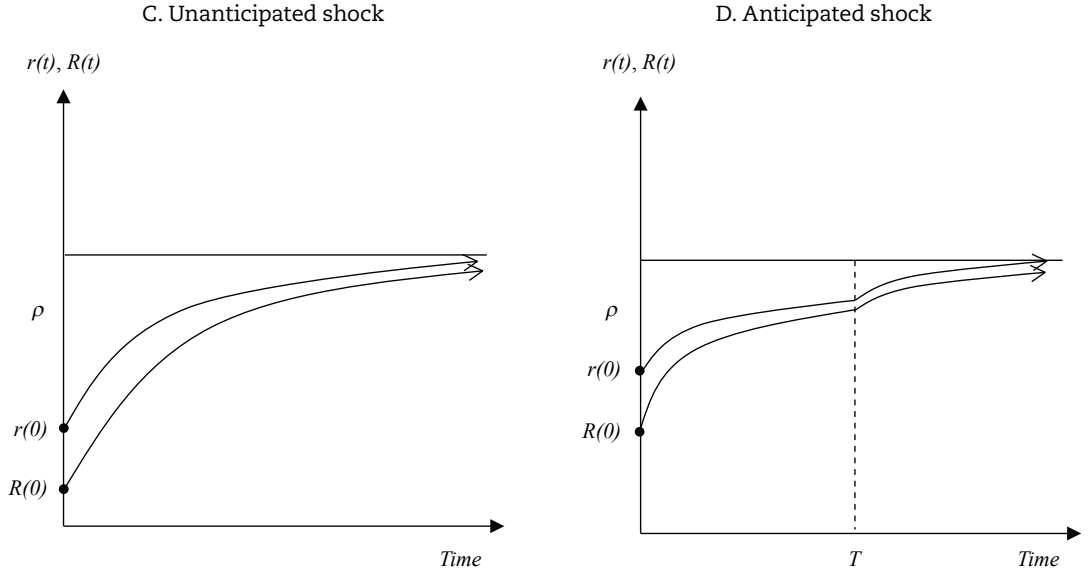
In the case of an announcement of the increase in infrastructure expenses at a future date T (anticipated fiscal policy) the convergence trajectories of interest rates are similar to those seen in the previous case but with subtle differences. These trajectories are illustrated in figure 3B. First, their initial jumps are more limited, as agents anticipate that the changes shall only take place at a future time T. Second, after the jump of $\lambda(t)$ to B in figure 2B, $k(t)$ and $\lambda(t)$ follow a decreasing unstable trajectory to the stable arm X'X', when the policy change occurs at time T. According to expression (16), in this same period of time, the interest rate $r(t)$ decreases, albeit to a lesser extent $\lambda(t)$ as shown in figure 3B. On the basis of time T, as $k(t)$ grows and $\lambda(t)$ decreases, the short-term interest rate converges more rapidly towards its initial equilibrium than in its previous trajectory.

2. Permanent β shocks on short- and long-term interest rates

Initially, we considered the case in which the government announces an immediate increase in the primary surplus as a percentage of GDP (unanticipated fiscal policy). As seen before, this implies an increase in the fiscal policy parameter β.

In figure 2C of subsection III.2, an increase in β causes a small jump in the short-term interest rate in the moment the change of policy is announced owing to a fall in the marginal utility of wealth. After the initial fall of $\lambda(t)$, the capital stock $k(t)$ starts to decrease and $\lambda(t)$ grows. According to the equation dynamics in (16), the short-term rate begins to rise through time until it returns to its long-term equilibrium ρ, as shown in figure 3C.

Figure 3



Source: Prepared by the authors.

Since the long-term interest rate is a weighted average of short-term interest rates perfectly foreseen for the future, it also suffers a larger initial fall than in the case of short-term rates. After this initial fall, it reflects a growing trajectory, but always below the short-term rate, until it reaches its initial equilibrium level ρ. Figure 3C illustrates this convergence very clearly.

Once again, it is important to highlight that the increase in β intensity delays the convergence of both interest rates further.

When primary surplus growth occurs at a future date T (anticipated fiscal policy), the movements of the short- and long-term interest rates are not very different. The same is true in the case of unanticipated fiscal policy: both interest rates decline but to a lesser extent. Ultimately, agents discount the fact that there will only be a policy change at a future date (see figure 3D). As from these jumps, both interest rates start to grow through time, but the long-term rate is always lower than the short-term rate. Figure 2D shows that after the initial $\lambda(t)$ jump, the capital stock and the marginal utility of wealth follow unstable trajectories (from B to C) until C is reached, when there is in fact growth in the primary surplus. This happens in a period of time T. In these trajectories, as $k(t)$ and $\lambda(t)$ decrease through time, we can conclude from equation (16) that the short-term interest rate must increase although the decline in $\lambda(t)$ limits growth.

As from point C, $k(t)$ continues its declining trajectory while $\lambda(t)$ starts to increase. The result is that the short-term interest rate, after the period of time T, continues to rise more rapidly than in the previous period. The long-term interest rate reflects the same movement, but its trajectory towards initial equilibrium always remains lower than that of the short-term interest rate. Ultimately, it is simply a weighted average of short-term rates perfectly foreseen by agents.

In this case, the intensity of the fiscal policy parameter β slows down the convergence of both interest rates towards their final equilibrium.

V. Fiscal policy and welfare

The analysis of the effects of changes in fiscal policy parameters on welfare considers the total utility discounted from agents. For this purpose, we use the instant utility stable trajectory linearized around its steady state.[6] According to Fisher and Turnovsky (1995) and Turnovsky (1995) the utility of agents $U(c(t), l(t), g_c(t))$ may be broken down as: $U(t) \cong \tilde{U} + (U(0) - \tilde{U})e^{\mu_1 t}$, in which, for simplification purposes, we adopt: $U(t)=U(c(t), l(t),g_c(t))$.

Denoting the total discounted utility that measures agent welfare by W, $W = \int_0^\infty \left[\tilde{U} + \left(U(0) - \tilde{U}\right)e^{\mu_1 t}\right]e^{-\rho t}dt$

which implies that: $W = \frac{\tilde{U}}{\rho} + \frac{\left(U(0) - \tilde{U}\right)}{\rho - \mu_1}$.

In the expression above, the term $\tilde{U}/\rho$ represents the instant welfare discounted by the intertemporal rate ρ. This term expresses the resulting welfare level if the long-term equilibrium is reached immediately. The term $\frac{\left(U(0) - \tilde{U}\right)}{\rho - \mu_1}$ represents the adjustment until long-term equilibrium is achieved, as in an economy with capital accumulation, the steady state is gradually reached.[7]

The main goal of this section is to find a budget policy that maximizes social well-being. Specifically, we intend to obtain expressions for $\hat{\alpha}$ and $\hat{\beta}$, such that:

$$\left(\hat{\alpha}, \hat{\beta}\right) = \underset{\alpha,\beta \in [0,1]}{argmax}\, W \qquad (17)$$

Unfortunately, it is not possible to obtain a general solution for (17) once the dependency of $U(0)$ and $\tilde{U}$ in parameters α and β is implicitly given by the representative agent utility function and the production technology. Therefore, in search of a better solution to the problem, we shall highlight some specifications:

[6] This paper does not analyse the optimality of the policies presented. See Chari and Kehoe (1999) for a detailed discussion of the optimality of fiscal and monetary policies.

[7] See Stockman (2001) for a discrete-time version of that approach.

Initially, problem (17) may be replaced by the equivalent problem:

$$\left(\widehat{\alpha},\widehat{\beta}\right) = \underset{\alpha,\beta\in[0,1]}{argmax}\,\overline{W} \tag{18}$$

where $\overline{W} = \rho W$, such that $\overline{W} = \tau U(0) + (1-\tau)\tilde{U}$ with $\tau = \rho/(\rho + |\mu_1|)$. It is assumed that τ is independent of α and β.

In addition to the assumptions above, functional forms for the utility of a representative consumer and for production technology shall be adopted. According to Christiano, Eichenbaum and Rebelo (2011) it is assumed that the (instant) utility function of a representative consumer is:

$$U(c,l,\overline{\alpha g}) = \frac{\left(c^{\gamma}(1-l)^{1-\gamma}\right)^{1-\sigma} - 1}{1-\sigma} + \varphi \ln \overline{\alpha g} \text{ se } \sigma \neq 1 \tag{19}$$

so that all parameters of this utility function are non-negative with $0<\gamma<1$.

The production function, at the same time, follows the suggestion of Barro (1990) on productive public expenditure, such that:

$$F(k,l,(1-\alpha)\overline{g}) = Ak^{\delta}l^{1-\delta}\left((1-\alpha)\overline{g}\right)^{\eta}$$

where all parameters of the specified function above are positive and $0<\delta<1$. Observe that parameter η measures product elasticity with regard to infrastructure expenditure.

Finally, it is assumed that the taxation scheme in $t=0$ and that in the steady state they shall be treated as parameters. This means that if we consider $y(t)$ as the per capita output of the economy, for each austerity policy β, we will have that: $\beta y(0) = T(0) - \overline{g} = s_0$ and $\beta\tilde{y} = \tilde{T} - \overline{g} = \tilde{s}$.

Hence, the assumption above means that in problem (18), s_0 and $\tilde{s}$ shall be treated as parameters.

With the above specifications, it is possible to obtain explicit solutions for the endogenous variables of the model using the initial data, as well as for the steady state. According to proposition 1 in the annex, solutions for labour supply and private consumption for $t=0$ are respectively: (a) $l(0) = \left[\frac{s_0}{\beta A k_0^{\delta}\left((1-\alpha)\overline{g}\right)^{\eta}}\right]^{\frac{1}{1-\delta}}$ and (b) $c(0) = \frac{\gamma(1-\delta)s_0(1-l(0))}{\beta(1-\gamma)l(0)}$.

In the steady state, solutions for consumption, labour supply and capital stock are equal to: (c) $\tilde{l} = \frac{(1-\gamma)(\tilde{s}-\beta\overline{g})}{(1-\gamma)(\tilde{s}-\beta\overline{g}) + \gamma(1-\delta)(1-\beta)\tilde{s}}$, (d) $\tilde{c} = \frac{\tilde{s}-\beta\overline{g}}{\beta}$ and (e) $\tilde{k} = \frac{(1-\beta)\delta\tilde{s}}{\rho\beta}$.

Replacing these solutions (a, b, c, d and e) in (19), after some algebraic manipulations, we obtain the following expressions for $U(0)$ and $\tilde{U}$:

$$U(0) = \left[\frac{\gamma(1-\delta)}{\beta(1-\gamma)}\right]^{-\gamma(1-\sigma)} \frac{s_0^{\frac{-\gamma\delta(1-\delta)}{1-\delta}}\left[\phi(\alpha)^{\frac{1}{1-\delta}} - s_0^{\frac{1}{1-\delta}}\right]^{1-\delta}}{\phi(\alpha)^{\frac{(1-\gamma)(1-\sigma)}{1-\sigma}}} + \varphi \ln \overline{\alpha g} - \frac{1}{1-\sigma} \tag{20}$$

$$\tilde{U} = \frac{(1-\gamma)^{(1-\gamma)(1-\sigma)}(\tilde{s}-\beta\overline{g})^{(1-\sigma)}}{\beta^{\gamma(1-\delta)}(1-\delta)\left[(1-\gamma)(\tilde{s}-\beta\overline{g}) + \gamma(1-\delta)(1-\beta)\overline{s}\right]} + \varphi \ln \overline{\alpha g} - \frac{1}{1-\sigma} \tag{21}$$

where $\phi(\alpha) = \beta A k_0^{\delta}\left((1-\alpha)\overline{g}\right)^{\eta}$.

Before investigating first-order conditions for this problem (18), it is important to verify whether there are corner solutions, as they must be restricted to the unitary interval. Initially, solutions $\beta=0$ and

$\alpha=1$ may be ruled out as the objective function is discontinued, thus making the use of first-order conditions impossible. We can also note that the objective function depends on α, which tends to be more finite when α is close to zero. Therefore, the solution $\alpha=0$ cannot be optimal.

The solution $\beta=1$ cannot be ruled out immediately. However, if this was the case, the economy would develop a trajectory in which assets would be destroyed, as there would be no accumulation. Consequently, the problem shall be treated as a maximization problem without restriction and first-order conditions shall be analysed if $\beta=1$ satisfies these conditions.

Using the equations (20) and (21), the first-order conditions in (18) for α and β are respectively given by:[8]

$$\left[\frac{\tau\eta(1-\sigma)}{1-\sigma}\right]\left[\frac{\gamma(1-\delta)s_0}{\widehat{\beta}(1-\gamma)}\right]^{\gamma(1-\sigma)}\frac{\left[\phi(\widehat{\alpha})^{\frac{1}{1-\sigma}}-s_0^{\frac{1}{1-\delta}}\right]^{-\sigma}\left[\gamma\phi(\widehat{\alpha})^{\frac{1}{1-\delta}}+(1-\gamma)s_0^{\frac{1}{1-\delta}}\right]}{\phi(\widehat{\alpha})^{\frac{(1-\gamma)(1-\sigma)}{1-\delta}}}=\frac{1-\widehat{\alpha}}{\widehat{\alpha}} \qquad (22)$$

and

$$-\tau\left[\frac{\gamma(1-\delta)}{(1-\gamma)}\right]^{\gamma(1-\sigma)}\gamma\widehat{\beta}^{-[1+\gamma(1-\sigma)]}s_0^{-\frac{\delta\gamma(1-\sigma)}{1-\delta}}\frac{\left[\phi(\widehat{\alpha})^{\frac{1}{1-\delta}}-s_0^{\frac{1}{1-\delta}}\right]^{1-\sigma}}{\varphi(\widehat{\alpha})^{\frac{(1-\gamma)(1-\sigma)}{1-\delta}}}+(1-\tau)\frac{(1-\gamma)^{(1-\gamma)(1-\sigma)}\widehat{\beta}^{-\gamma(1-\sigma)}\left(\tilde{s}-\widehat{\beta}\,\overline{g}\right)^{-\sigma}}{(1-\sigma)\left[(1-\sigma)\left(\tilde{s}-\widehat{\beta}\,\overline{g}\right)+\delta\sigma(1-\widehat{\beta})\tilde{s}\right]^{(1-\gamma)(1-\sigma)}}x$$

$$x\left\{-\gamma(1-\sigma)\widehat{\beta}^{-1}\left(\tilde{s}-\widehat{\beta}\,\overline{g}\right)+\frac{[(1-\gamma)\delta\sigma\tilde{s}-\gamma(1-\sigma)\overline{g}]\left(\tilde{s}-\widehat{\beta}\,\overline{g}\right)-\delta\sigma(1-\widehat{\beta})\overline{g}}{(1-\sigma)\left(\tilde{s}-\widehat{\beta}\,\overline{g}\right)+\delta\sigma(1-\widehat{\beta})\tilde{s}}\right\}=0 \qquad (23)$$

Observe that an explicit solution for (22) and (23) is possible only in very special cases (some of which shall be analysed later on). However, it is possible to reach some qualitative conclusions on optimal austerity rules and budget composition without the need for explicit solutions.

Using equation (22), proposition 2 in the annex affirms that if $\eta>\left[\left(\frac{1-\gamma}{\gamma}\right)^{\gamma(1-\sigma)}\right]/\tau(1-\sigma)$, then any valid solution for α must be such that $\hat{\alpha}<0.5$ This leads to the following conclusion: if the output elasticity with regard to infrastructure expenditure is high enough and if the employment volume on the initial date represents more than half of the available workforce, the socially optimal solution prescribes that the largest portion of public budget should be allocated to investments (infrastructure expenditure). In order to have an idea of the magnitude of η necessary to validate proposition 2, let us consider a numeric example. Suppose that leisure and consumption are equally weighted in the utility of the representative agent and that the elasticity of intertemporal substitution is equal to 2. In this case, we have that $\gamma=0.5$ and $\sigma=0$, such that the condition for output elasticity with regard to public spending on infrastructure is $\eta>1/\tau$. This implies that the lesser the importance of the utility today in a long-term relation, the higher the η level necessary to have as a social optimum that $\hat{\alpha}<0.5$.

The result above deserves some consideration. The inverse relationship between output elasticity and short-term welfare means that first and foremost, $\eta>1$, which means that in order to grant an optimal social condition, we need to allocate the largest portion of the budget to investment. The economic output must be elastic with regard to investment, because as specified by the Cobb-Douglas production function, both private and public capital represent some level of substitution,[9] so that the higher the η value, the lower the substitution. Consequently, in the composition of economic output, public and private capital shall complement each other.

[8] The details of the process are available in the annex.

[9] Specifically, the marginal rate of technical substitution between private and public capital is given by $\frac{\delta(1-\alpha)\tilde{g}}{\eta k}$.

The arguments above add to the analysis of fiscal shocks to long-term equilibrium. As seen in section III, an increase in the percentage of spending allocated to infrastructure always raises capital stock in a steady state. Therefore, considering long-term effects, the higher the value of η, the stronger the impact on output resulting from an increase in infrastructure expenditure, as both private and public capital shall grow complementarily.

Finally, a lower τ value means a higher η, which implies that the long-term importance in the composition of welfare shall increase, thus reinforcing the arguments in favour of private and public capital complementing each other more.

Note that the result $\hat{\alpha} < 0.5$ is independent of the value of β in the socially optimal situation. Hence, in this case the expression $\widetilde{\beta} = \frac{\widetilde{T} - \widetilde{g}}{\widetilde{y}} = \frac{\tilde{s}}{\widetilde{y}}$ is sufficient to determine the optimal fiscal austerity rule, where $\widetilde{y}$ is the output in the steady state that is obtained by applying proposition 1.

Note that although the solution proposed for $\widetilde{\beta}$ is implicit, its scale clearly depends on the size of the primary surplus (tax burden) desired by the fiscal authority and the size of the output in long-term equilibrium. Specifically, through an implicit differentiation, it may be proved that the sign of $d\widetilde{\beta}/ds$ depends on $1-\varepsilon_{y,s}$, where $\varepsilon_{y,s}$ is the output elasticity in relation to the magnitude of the primary surplus determined by the fiscal authority (both in long-term conditions). As this elasticity is always positive (by definition) the sign of $d\widetilde{\beta}/ds$ depends on the magnitude of $\varepsilon_{y,s}$.

More specifically, if the output is inelastic with regard to the primary surplus, then the larger the primary surplus, the larger the magnitude of $\widehat{\beta}$. This is an intuitive result and at first sight, is the only possible one. However, the model creates a possibility for an increase in s that may be accompanied by a reduction in β. To that end, it is enough for economic output to be elastic in relation to the primary surplus, which means that if $\varepsilon_{y,s}>1$, the sign of the $d\widetilde{\beta}/ds$ derivative is negative.

What is the reason for this result? Initially, it seems reasonable to assume that the magnitude of $\varepsilon_{y,s}$ depends on the influence of the government on the economy (measured by the ratio $\bar{g}/y$) as follows: the bigger the influence of the government on the economy, the more intense the impact of fiscal results on output. That said, it may be theorized that in economies in which $\bar{g}/y$ is large enough, we have that $\varepsilon_{y,s}>1$. Naturally, this conjecture has not been proven through a general proposition or empirical regularity. In any case, both analyses are beyond the scope of this research.[10]

VI. Concluding remarks

In the case of unanticipated fiscal policy, the announcement of an immediate and permanent increase in infrastructure expenditure causes a short-term fall (jump) in private wealth, thus resulting in a decline in consumption and growth in the labour supply. From that point onward, a dynamic of initial equilibrium is initiated for a new long-run equilibrium (steady-state equilibrium). As in the initial moment, there is a fall in private consumption and the capital stock starts to increase towards a new long-run equilibrium. Simultaneously, the marginal utility of wealth starts declining after its initial growth. However, the time that the marginal utility of wealth, private consumption and labour supply take to reach a new steady-state equilibrium is longer as the primary surplus grows as a percentage of GDP.

In the final long-run equilibrium, private consumption, capital stock (investment), output and labour supply are higher than in the initial equilibrium state.

[10] The point may be introduced less dramatically if the relationship between the magnitudes of $\varepsilon_{y,s}$ and $\overline{g}/y$ is assumed to be probabilistic. Specifically, by using notation $G = \bar{g}/y$, it may be accepted that $Pr\left[\varepsilon_{y,s} > \frac{1}{G}\right]$ is a growing G function.

In the case of anticipated fiscal policy, the effects of the increase in infrastructure expenditure on output, consumption and capital stock are similar to those seen in the case of unanticipated fiscal policy. The main difference is the more limited jump in the marginal utility of wealth in the short term.

We should also note that the effects of an increase in government consumption spending on output, private consumption, investment and labour supply are symmetrical to those in the case of an increase in infrastructure expenditure, regardless of whether the announcement is anticipated or unanticipated.

In the case of unanticipated fiscal policy related to the increase in the short-term primary surplus, consumption improves and labour supply decreases, resulting in a decline in the marginal productivity of labour. In the long run, output, private consumption and capital stock are lower and the labour supply grows in comparison to the initial equilibrium.

In summary, we conclude that in terms of generating economic growth, the fiscal policy of increasing government spending on infrastructure is more effective than the policy of maintaining a primary surplus as a proportion of GDP. Therefore, this infrastructure spending policy combined with the constant real spending policy that tackles the fiscal deficit are more effective in promoting economic growth.

As for the term structure of interest rates, the unanticipated fiscal policy of increasing infrastructure expenses causes an immediate jump in the short-term interest rate, followed by a decreasing trajectory towards long-term equilibrium. Since the long-term interest rate is a weighted average of short-term rates perfectly foreseen for the future, it also jumps, but to a lesser extent, before quickly converging to steady-state equilibrium. However, the higher the primary surplus goal, the longer both interest rates shall take to reach their new equilibria.

In the case of anticipated fiscal policy, in which the increase in the primary surplus shall take place at a future date, short- and long-run movements are similar to the previously described situation. This is also the case with unanticipated policy, as both interest rates also fall, but do so less dramatically. In the end, agents discount that there will only be a policy change in the future. After falling, both interest rates start to rise again through time, but with the trajectory of the long-term rate always lagging that of the short-term rate. From the moment the policy change takes place, both rates begin rising more rapidly compared to the previous period.

In this case, the magnitude of the primary surplus slows down the convergence of both interest rates towards their final long-term equilibria.

Lastly, fiscal and budgetary policy outcomes that maximize social well-being suggest that if output is sufficiently sensitive to infrastructure expenditure or if the short run is not very relevant in the total discounted utility considered, the largest portion of public resources must be allocated to investment spending, provided the total of employed workers is higher than 50% of the available workforce. The percentage of GDP allocated to the primary surplus depends on per capita income elasticity with regard to the economy's fiscal performance. Specifically, if per capita income is elastic with regard to the primary surplus, even if the fiscal authority decides on an absolute increase in this surplus, the allocated percentage of GDP may end up being lower.

Bibliography

Agénor, P. (2005), "Fiscal adjustment and labor market dynamics in an open economy", *Journal of Development Economics*, vol. 76, No. 1, February.

Aschauer, D. (1990), "Why is infrastructure important?", *Is There a Shortfall in Public Capital Investment?*, A. Munnell (ed.), Conference Series, No. 34, Boston, Federal Reserve Bank of Boston.

___(1989), "Is public expenditure productive?", *Journal of Monetary Economics*, vol. 23, No. 2, March.

___(1988), "The equilibrium approach to fiscal policy", *Journal of Money, Credit and Banking*, vol. 20, No. 1, February.

Barro, R. (1990), "Government spending in a simple model of endogenous growth", *Journal of Political Economy*, vol. 98, No. 5.

Baxter, M. and R. King (1993), "Fiscal policy in general equilibrium", *The American Economic Review*, vol. 83, No. 3, June.

Blanchard, O. (1981), "Output, the stock market, and interest rates", *The American Economic Review*, vol. 71, No. 1, March.

Chari, V. and P. Kehoe (1999), "Optimal fiscal and monetary policy", *NBER Working Paper*, No. 6891, Cambridge, National Bureau of Economic Research (NBER), January.

Christiano, L., M. Eichenbaum and S. Rebelo (2011), "When is the government spending multiplier large?", *Journal of Political Economy*, vol. 119, No. 1, February.

Cox, J., J. Ingersoll and S. Ross (1985), "A theory of the term structure of interest rates", *Econometrica*, vol. 53, No. 2, March.

De la Fuente, A. (2000), *Mathematical Methods and Models for Economists*, New York, Cambridge University Press.

Fisher, W. and S. Turnovsky (1995), "The composition of government expenditure and its consequences for macroeconomic performance", *Journal of Economic Dynamics and Control*, vol. 19, No. 4, May.

___(1992), "Fiscal policy and the term structure of interest rates: an intertemporal optimizing analysis", *Journal of Money, Credit and Banking*, vol. 24, No. 1, February.

Hirsch, M. and S. Smale (1974), *Differential Equations, Dynamical Systems, and Linear Algebra*, New York, Academic Press.

IPEA (Institute for Applied Economic Research) (2016), "Ipeadata" [online] http://www.ipeadata.gov.br.

Marinho, E. and M. Benegas (2006), "Ajuste fiscal no Brasil: por que adotar o regime de superávit primário ou o de déficit nominal zero?" [online] http://www.tesouro.fazenda.gov.br/premio/Premio_TN/XIpremio/divida/1afdpXIPTN/1premio_afdp.pdf.

McCafferty, S. (1986), "Aggregate demand and interest rates: a macroeconomic approach to the term structure", *Economic Inquiry*, vol. 24, No. 4.

Stockman, D. (2001), "Balanced-budget rules: welfare loss and optimal policies", *Review of Economic Dynamics*, vol. 4, No. 2, April.

Turnovsky, S. (1995), *Methods of Macroeconomic Dynamics*, Cambridge, MIT Press.

Turnovsky, S. and M. Miller (1984), "The effects of government expenditure on the term structure of interest rates", *Journal of Money, Credit and Banking*, vol. 16, No. 1, February.

Woodford, M. (1996), "Control of the public debt: a requirement for price stability?", *NBER Working Paper*, No. 5684, Cambridge, National Bureau of Economic Research (NBER), July.

Annex A1

1. Short-run comparative statics

Equations (5) and (6) in section II help to find solutions for consumption $c(t)$ and labour supply $l(t)$ as functions of marginal utility of wealth $\lambda(t)$, of capital stock $k(t)$ and of policy parameters α and β. Therefore, differentiating (5) and (6), we find that:

$$U_{cc}dc + U_{cl}dl = dk$$

$$U_{lc}dc + \left(U_{ll} + \lambda(1-\beta)f_{ll}h\right)dl = -\lambda(1-\beta)f_{kl}dk - (1-\beta)f_l h d\lambda + \lambda(1-\beta)h'\bar{g}d\alpha + \lambda f_l h d\beta$$

The solution to the system above originates the following short-run relations, as introduced in subsection II.1:

$$\frac{dc}{dk} = \frac{\lambda(1-\beta)f_{lk}U_{cl}h}{\Delta} < 0, \quad \frac{dl}{dk} = -\frac{\lambda(1-\beta)f_{lk}U_{cc}h}{\Delta} > 0, \quad \frac{dc}{dl} = \frac{U_{ll} + \lambda(1-\beta)f_{ll}h + (1-\beta)f_l h}{\Delta} < 0,$$

$$\frac{dl}{d\lambda} = -\frac{(1-\beta)f_l U_{cc}h + U_c}{\Delta} > 0, \quad \frac{dc}{d\alpha} = -\frac{\lambda(1-\beta)f_l U_{cl}h\bar{g}}{\Delta} > 0, \quad \frac{dc}{d\beta} = -\frac{\lambda f_l U_{cl}h}{\Delta} > 0 \text{ and } \frac{dl}{d\beta} = \frac{\lambda f_l U_{cc}h}{\Delta} < 0.$$

2. Demonstration that long-run equilibrium is a saddle point

The system of linearized equations (13) and (14) around the steady state may be written in matrix form as:

$$\dot{k} = w_{11}(k - \tilde{k}) + w_{12}(\lambda - \tilde{\lambda})$$

$$\dot{\lambda} = -(1-\beta)\tilde{\lambda}w_{12}(k - \tilde{k}) - (1-\beta)\tilde{\lambda}w_{22}(\lambda - \tilde{\lambda})$$

In order to demonstrate that the system equilibrium is a saddle-point type, we still need to prove that the determinant of the system above is negative. Indeed, the determinant sign is $-\tilde{\lambda}(1-\beta)[w_{11}w_{22} - w_{21}w_{12}] < 0$, $w_{11} > 0$, $w_{22} > 0$, $w_{12} > 0$, $w_{21} < 0$ and $0 < \beta < 1$. Besides, as $-\tilde{\lambda}(1-\beta)[w_{11}w_{22} - w_{12}w_{21}] = \mu_1\mu_2$, where μ_1 and μ_2 are the eigenvalues associated with the system matrix above, we shall admit without loss of generality that $\mu_1 < 0$ and $\mu_2 > 0$.

3. Stable and unstable arms of saddle-point equilibrium, determination of trajectories of $k(t)$ and $\lambda(t)$ and (t) jump

It is accepted that the government can announce today a change in the fiscal policy at a future time $T > 0$. In other words, the policy change is anticipated by agents. Initially, the solution for $k(t)$ and $\lambda(t)$ in the period $0 \leq t < T$ is as follows:

$$k(t) = \tilde{k}_1 + A_1 e^{\mu_1 t} + A_2 e^{\mu_2 t}$$

$$\lambda(t) = \tilde{\lambda}_1 + A_1\left(\frac{\mu_1 - w_{11}}{w_{12}}\right)e^{\mu_1 t} + A_2\left(\frac{\mu_2 - w_{11}}{w_{12}}\right)e^{\mu_2 t}$$

For the period $t \geq T$, the solutions for $k(t)$ and $\lambda(t)$ are:

$$k(t) = \tilde{k}_2 + A_1' e^{\mu_1 t} + A_2' e^{\mu_2 t}$$

$$\lambda(t) = \tilde{\lambda}_2 + A_1' \left(\frac{\mu_1 - w_{11}}{w_{12}} \right) e^{\mu_1 t} + A_2' \left(\frac{\mu_2 - w_{11}}{w_{12}} \right) e^{\mu_2 t}$$

In order to meet the transversality condition (9), we consider that $A'_2 = 0$. Imposing this restriction on the two previous equations, we have the stable arm of the saddle-point equilibrium:

$$\lambda(t) = \tilde{\lambda}_2 + \left(\frac{\mu_1 - w_{11}}{w_{12}} \right) \left(k(t) - \tilde{K} \right)$$

where the angular coefficient of this straight line is negative, as $w_{11} > 0$, $w_{12} > 0$, $\mu_1 < 0$.

The unstable arm is obtained by replacing the stable root μ_1 with the unstable root μ_2 in the prior straight-line equation. Consequently,

$$\lambda(t) = \tilde{\lambda}_2 + \left(\frac{\mu_2 - w_{11}}{w_{12}} \right) \left(k(t) - \tilde{K} \right)$$

The angular coefficient of the unstable arm line is positive, as according to the eigenvalue properties $\left(\frac{\mu_2 - w_{11}}{w_{12}} \right) = \left(\frac{-\tilde{\lambda}(1-\beta) w_{21}}{\mu_2 + \tilde{\lambda}(1-\beta) w_{22}} \right)$, considering that $w_{21} < 0$, $w_{22} > 0$ and $\mu_2 > 0$.

In order to obtain the trajectories of $k(t)$ and $\lambda(t)$, we need to determine the constants A_1, A_2 and A'_1 as $A'_2 = 0$. For this purpose we have developed two additional hypotheses: the first is that the initial capital stock (date t=0) is equal to the initial steady-state capital stock, which is $k(0) = \tilde{k}_1$; the second is that on the date of the policy change ($t = T$) there is a continuity of solutions, which means that they must be similar for this period of time.

Therefore, on the basis of the first hypothesis, $k(0) = \tilde{k}_1 + A_1 + A_2$ which implies that $A_1 + A_2 = 0$ or $A_1 = -A_2$. The second hypothesis originates the following equation system:

$$(A_1' - A_1) \left(\frac{\mu_1 - w_{11}}{w_{12}} \right) e^{\mu_1 t} + A_2 \left(\frac{\mu_2 - w_{11}}{w_{12}} \right) e^{\mu_2 T} = \tilde{\lambda}_2 - \tilde{\lambda}_1$$

$$\left(A_1' - A_1 \right) e^{\mu_1 T} + A_2 e^{\mu_2 T} = \tilde{k}_2 - \tilde{k}_2$$

Therefore, the solution to the system above, besides using the restriction $A_1 = -A_2$ produces the following solutions:

$$A_1 = \frac{e^{\mu_1 T} \left[\left(\frac{\mu_1 - w_{11}}{w_{12}} \right) (\tilde{k}_2 - \tilde{k}_2) - (\tilde{\lambda}_2 - \tilde{\lambda}_1) \right]}{\Delta}$$

$$A_1' = \frac{e^{\mu_1 T} \left[\left(\frac{\mu_1 - w_{11}}{w_{12}} \right) (\tilde{k}_2 - \tilde{k}_2) - (\tilde{\lambda}_2 - \tilde{\lambda}_1) \right] + e^{\mu_2 T} \left[(\tilde{\lambda}_2 - \tilde{\lambda}_1) - \left(\frac{\mu_2 - w_{11}}{w_{12}} \right) (\tilde{k}_2 - \tilde{k}_1) \right]}{\Delta}$$

where $\Delta = e^{(\mu_1 + \mu_2) T} \left(\frac{\mu_2 - \mu_1}{w_{12}} \right) > 0$.

Thus, replacing A_1, A_2 and A'_1 in the expressions of $k(t)$ and $\lambda(t)$ for each of the periods $0 \leq t < T$ and $t \geq T$, we fully determine the trajectories of $k(t)$ and $\lambda(t)$.

In determining the solution for this model type, it is generally admitted that one of the variables may jump with each new measure announced by the government while the other will continuously evolve through time. For this article, the first variable shall be the marginal utility of wealth $\lambda(t)$. The variable $k(t)$ shall be the predetermined variable that continuously evolves through time.

In order to calculate the dimension of this jump, it is sufficient to have t=0 in the equation of $\lambda(t)$ for a period $0 \leq t < T$ observing that $A_1 = -A_2$. Hence, we find that:

$$\lambda(0) = \tilde{\lambda}_1 + A_2\left(\frac{\mu_2 - \mu_1}{w_{12}}\right)$$

Replacing the value of A_2 in this last expression, we obtain the expression for the $\lambda(t)$ jump:

$$\lambda(0) - \tilde{\lambda}_1 = e^{-\mu_2 T}[(\tilde{\lambda}_2 - \tilde{\lambda}_1) - (\frac{\mu_1 - w_{11}}{w_{12}})(\tilde{k}_2 - \tilde{k}_1)]$$

Regardless of the sign of the expression between brackets in the previous equation, the longer the time *T*, in other words the more distant the policy change announced, the lower the resulting $\lambda(t)$ jump.

When the policy change occurs immediately (today), which means that it is not anticipated by agents, the $\lambda(t)$ jump is calculated by making $T=0$. Hence, we have that:

$$\lambda(0) = \tilde{\lambda}_2 - \left(\frac{\mu_1 - w_1}{w_{12}}\right)(\tilde{k}_2 - \tilde{k}_1)$$

which is just the stable arm expression. This implies that when the policy announcement is not anticipated, $\lambda(t)$ immediately jumps to the straight line of the stable arm saddle-point equilibrium.

The essential characteristic of solutions in this type of model is that the dynamics involve three phases. An announcement today on a policy alteration at a future time *T* generates an immediate jump in $\lambda(t)$. The further in the future the policy change, the weaker the intensity of the jump. Immediately afterward, these variables follow unstable trajectories until meeting the stable arm saddle-point equilibrium in a period *T*. As from this point, these variables continue on the stable arm until reaching the new steady-state equilibrium.

When the policy change announcement and its implementation are immediate, the marginal utility of wealth jumps immediately to the stable arm and is then followed by $k(t)$ and $\lambda(t)$ in its trajectory through the stable arm towards the new steady-state equilibrium.

4. Formal solution to the equation $\dot{P}(t) - r(t)P(t) = -1$ looking into the future

The general solution for this differential equation is given by the following expression:

$$P(t) = e^{\int_0^s r(t)dt}A - \int_0^t e^{-\int_0^t r(s)ds}ds$$

where A is a constant to be determined. In order to ensure that this constant is endogenously established, Sargent and Wallace (1973) proposed the application of the terminal condition instead of the initial condition. The terminal condition is that the price level should remain limited when $t \to \infty$. For this purpose, we must have that:

$$A = \lim_{t\to\infty}\int_0^t e^{-\int_0^t r(s)ds}ds = \int_0^\infty e^{-\int_0^t r(s)ds}ds$$

Replacing this last result in the expression $P(t)$, we find that:

$$P(t) = e^{\int_0^s r(t)dt}[\int_t^\infty e^{-\int_0^t r(w)dw}ds] = \int_t^\infty e^{-\int_t^s r(w)dw}ds$$

Provided $R(t) = \frac{1}{P(t)}$, we finally find that:

$$R(t) = \frac{1}{\int_t^\infty e^{-\int_t^s r(w)dw}ds}$$

5. Demonstration of proposition 1

Proposition 1: *suppose that conditions* (17) – (19) are met. Then:

(a) $l(0) = \left[\dfrac{s_0}{\beta A k_0^{\delta} \left((1 - \alpha) \overline{g} \right)^{\eta}} \right]^{\frac{1}{1-\delta}}$;

(b) $c(0) = \dfrac{\gamma(1-\delta)s_0\left(1 - l(0)\right)}{\beta(1-\gamma)l(0)}$;

(c) $\tilde{c} = \dfrac{\tilde{s} - \beta\overline{g}}{\beta}$;

(d) $\tilde{l} = \dfrac{(1-\gamma)(\tilde{s} - \beta\overline{g})}{(1-\gamma)(\tilde{s} - \beta\overline{g}) + \gamma(1-\delta)(1-\beta)\tilde{s}}$;

(e) $\tilde{k} = \dfrac{(1-\beta)\delta\tilde{s}}{\rho\beta}$.

Demonstration:

(a) In $t=0$, we have that:

$$\beta A k_0^{\delta} l(0)^{1-\delta} \left((1 - \alpha) \overline{g} \right)^{\eta} = s_0 \tag{A.1}$$

Resolving A.1 for $l(0)$, we obtain the desired result.

(b) Using the utility and technology utility functions, equations (5) and (6) may be written as:

$$\gamma c^{\gamma(1-\sigma)-1} \left(1 - l\right)^{(1-\gamma)(1-\sigma)} = \lambda \tag{A.2}$$

$$(1-\gamma)c^{\gamma(1-\sigma)}(1-l)^{(1-\gamma)(1-\sigma)-1} = \lambda(1-\delta)Ak^{\delta}l^{(1-\delta)-1}\left((1 - \alpha) \overline{g} \right)^{\eta} \tag{A.3}$$

Combining (A.2) and (A.3) in $t=0$ and using the definition of y, we have that:

$$\left(\frac{1-\gamma}{\gamma}\right)\frac{l(0)c(0)}{\left(1 - l(0)\right)} = (1-\delta)y(0) \tag{A.4}$$

The result is demonstrated by considering the assumption that $y(0)=s_0/\beta$ and item (a) in equation (A.4).

In this situation, first-order conditions (5) and (6) together with the equations that describe the steady-state equilibrium produce the following system:

$$(1-\beta)\tilde{y} = \tilde{c} + \overline{g}$$

$$(1-\beta)\delta\tilde{y} = \rho\tilde{k}$$

$$\left(\frac{1-\gamma}{\gamma}\right)\frac{\tilde{l}\,\tilde{c}}{(1-\tilde{l})} = (1-\beta)(1-\delta)\tilde{y}$$

$$\tilde{y} = \frac{\tilde{s}}{\beta}$$

The solution to the system above results in the proposition results described in items (c), (d) and (e).

6. First-order conditions to the problem (18)

By definition, first-order conditions for α and β in problem (18) respectively determine that:

$$\tau\frac{\partial U(0)}{\partial \alpha}+(1-\tau)\frac{\partial \tilde{U}}{\partial \alpha}=0 \tag{A.5}$$

$$\tau\frac{\partial U(0)}{\partial \beta}+(1-\tau)\frac{\partial \tilde{U}}{\partial \beta}=0 \tag{A.6}$$

Consequently, in order to set equations (20) and (21), it is sufficient to find derivatives appointed in (A.5) and (A.6). Using the expression for $U(0)$, we have that:

$$\frac{\partial U(0)}{\partial \alpha}=\left[\frac{\gamma(1-\delta)}{\beta(1-\gamma)}\right]^{\gamma(1-\sigma)} s_0^{\frac{\gamma\delta(1-\sigma)}{1-\delta}}$$

$$\frac{\partial U(0)}{\partial \alpha}=\left[\frac{\gamma(1-\delta)}{\beta(1-\gamma)}\right]^{\gamma(1-\delta)} s_0^{\frac{\gamma\delta(1-\sigma)}{1-\delta}}\frac{\left(\frac{1-\sigma}{1-\delta}\right)\left[\phi(\alpha)^{\frac{1}{1-\delta}}-s_0^{\frac{1}{1-\delta}}\right]^{-\sigma}\phi(\alpha)^{\frac{(1-\gamma)(1-\sigma)}{1-\delta}}\phi'(\alpha)\left[\gamma\phi(\alpha)^{\frac{1}{1-\delta}}+(1-\gamma)s_0^{\frac{1}{1-\delta}}\right]}{\phi(\alpha)^{2\frac{(1-\gamma)(1-\sigma)}{1-\delta}}}+\frac{\varphi}{\alpha}$$

It is easy to verify that $\phi'(\alpha)=-\eta\phi(\alpha)/(1-\alpha)$. Using this fact in the expression above we arrive at:

$$\frac{\partial U(0)}{\partial \alpha}=-\left[\frac{\gamma(1-\delta)s_0}{\beta(1-\gamma)}\right]^{\gamma(1-\delta)}\frac{\eta\left(\frac{1-\sigma}{1-\delta}\right)\left[\phi(\alpha)^{\frac{1}{1-\delta}}-s_0^{\frac{1}{1-\delta}}\right]^{-\sigma}\left[\gamma\phi(\alpha)^{\frac{1}{1-\delta}}+(1-\gamma)s_0^{\frac{1}{1-\delta}}\right]}{(1-\alpha)\phi(\alpha)^{\frac{(1-\gamma)(1-\sigma)}{(1-\delta)}}}+\frac{\varphi}{\alpha} \tag{A.7}$$

On the other hand:

$$\frac{\partial \tilde{U}}{\partial \alpha}=\frac{\varphi}{\alpha} \tag{A.8}$$

Replacing (A.7) and (A.8) in (A.5), we obtain equation (20). Proceeding likewise with regard to β, we have that:

$$\frac{\partial U(0)}{\partial \beta}=-\gamma\beta^{-1}\left[\frac{\gamma(1-\delta)}{\beta(1-\gamma)}\right]^{\gamma(1-\sigma)} s_0^{\frac{\gamma\delta(1-\sigma)}{(1-\delta)}}\frac{\left[\phi(\alpha)^{\frac{1}{(1-\delta)}}-s_0^{\frac{1}{(1-\delta)}}\right]^{1-\sigma}}{\phi(\alpha)^{\frac{(1-\gamma)(1-\sigma)}{(1-\sigma)}}} \tag{A.9}$$

We also have that:

$$\frac{\partial \tilde{U}}{\partial \beta}=-\frac{\gamma(1-\sigma)(1-\gamma)^{(1-\gamma)(1-\sigma)}\beta^{-\gamma(1-\sigma)}(\tilde{s}-\beta\bar{g})^{(1-\sigma)}}{(1-\sigma)\left[(1-\gamma)(\tilde{s}-\beta\bar{g})+\gamma(1-\delta)(1-\beta)\tilde{s}\right]}+$$

$$+\frac{(1-\gamma)^{(1-\gamma)(1-\sigma)}\beta^{\gamma(1-\sigma)}(1-\sigma)(\tilde{s}-\beta\bar{g})^{-\sigma}\left[(1-\sigma)(\tilde{s}-\beta\bar{g})+\delta\sigma(1-\beta)\tilde{s}\right]^{(1-\gamma)(1-\sigma)-1}}{(1-\sigma)}\times \tag{A.10}$$

$$\frac{\left\{\left[(1-\gamma)\delta\sigma\tilde{s}-\gamma(1-\sigma)\overline{g}\right]\left(\tilde{s}-\beta\overline{g}\right)-\delta\sigma(1-\beta)\tilde{s}\,\overline{g}\right\}}{\left[(1-\sigma)\left(\tilde{s}-\beta\,\overline{g}\right)+\delta\sigma\left(1-\beta\right)\tilde{s}\right]^{2(1-\gamma)(1-\sigma)}}$$

Replacing (A.9) and (A.10) in (A.6), after some algebraic manipulations we obtain equation (21).

7. Demonstration of proposition 2

Proposition 2: If $\eta > \left|\left(\frac{1-\gamma}{\gamma}\right)^{\gamma(1-\sigma)}\right| / \tau(1-\sigma)$ and $l(0) > (0.5)^{1-\delta}$, then $\widehat{\alpha} < 0.5$.

Demonstration:

It is enough to prove that in the enunciation conditions, the left side (22) is higher than one. Initially, observe that the term $[\frac{\tau\eta(1-\sigma)}{(1-\delta)}]\left[\frac{\gamma(1-\delta)s_0}{\widehat{\beta}(1-\gamma)}\right]^{\gamma(1-\sigma)}$ is higher than one.

This occurs because of the assumption that $\eta > \left|\left(\frac{1-\gamma}{\gamma}\right)^{\gamma(1-\sigma)}\right| / \tau(1-\sigma)$ and the fact that $\frac{s_0}{\beta} = y_0 > 1$. Therefore, the result is established if we can prove that:

$$\frac{\left[\phi(\alpha)^{\frac{1}{1-\delta}} - s_0^{\frac{1}{1-\delta}}\right]^{-\sigma}\left[\gamma\phi(\widehat{\alpha})^{\frac{1}{1-\delta}} + (1-\gamma)s_0^{\frac{1}{1-\delta}}\right]}{\phi(\widehat{\alpha})^{\frac{(1-\gamma)(1-\sigma)}{(1-\delta)}}} > 1$$

Applying a reduction ad absurdum, let us assume this affirmation is not valid. In this case we have that:

$$[\gamma\phi(\widehat{\alpha})^{\frac{1}{1-\delta}} + (1-\gamma)s_0^{\frac{1}{1-\delta}}] \leq \left[\phi(\widehat{\alpha})^{\frac{1}{1-\delta}} - s_0^{\frac{1}{1-\delta}}\right]^{\sigma}\phi(\widehat{\alpha})^{\frac{(1-\gamma)(1-\sigma)}{1-\delta}} \qquad \text{(A.10)}$$

As $l(0)<1$, we can easily demonstrate that $\varphi(\widehat{\alpha}) > s_0$. Following some manipulations, the inequality in (A.10) may be rewritten as:

$$s_0^{\frac{1}{1-\delta}} < \left[1 - \left(\frac{s_0}{\phi(\widehat{\alpha})}\right)^{\frac{1}{1-\delta}}\right]^{\sigma}\phi(\widehat{\alpha})^{\frac{1-\gamma(1-\sigma)}{1-\delta}}$$

or even:

$$\left(\frac{s_0}{\phi(\widehat{\alpha})}\right)^{\frac{1}{1-\delta}} < \left[1 - \left(\frac{s_0}{\phi(\widehat{\alpha})}\right)^{\frac{1}{1-\delta}}\right]^{\sigma}\phi(\widehat{\alpha})^{\frac{1-\gamma(1-\sigma)}{1-\delta}} \qquad \text{(A.11)}$$

Given that $\frac{s_0}{\phi(\widehat{\alpha})} = l(0)$, equation (A.11) may be rewritten as:

$$l(0)^{\frac{1}{1-\delta}} < \left[1 - l(0)^{\frac{1}{1-\delta}}\right]^{\sigma} \phi(\widehat{\alpha})^{\frac{-\gamma(1-\sigma)}{1-\delta}} \tag{A.12}$$

For $\sigma<1$, it is evident that $\left[1 - l(0)^{\frac{1}{1-\delta}}\right]^{\sigma} < 1 - l(0)^{\frac{1}{1-\sigma}}$. In this case, equation (A.12) implies that: $\frac{l(0)^{\frac{1}{1-\delta}}}{\left(1 - l(0)^{\frac{1}{1-\delta}}\right)} < \phi(\widehat{\alpha})^{\frac{-\gamma(1-\sigma)}{1-\delta}}$

Given the proposition conditions and using the definition of $\phi(\alpha)$, we have that: $\frac{l(0)^{\frac{1}{1-\delta}}}{\left(1 - l(0)^{\frac{1}{1-\delta}}\right)} < \phi(\widehat{\alpha})^{\frac{-\gamma(1-\sigma)}{1-\delta}}$. That contradiction produces the desired result.

Nationalism and development: an alternative for Mexico

Gaspar Núñez Rodríguez and
José Antonio Romero Tellaeche

Abstract

The most developed countries have generally had an active State, a driving, regulatory and protectionist State, among other roles, although the most consolidated concept seems to be that of a developmental State. In this paper, a social accounting matrix of Mexico is constructed in order to design a dynamic-recursive applied general equilibrium model to analyse and quantify the impact of policies that were promoted by the State; in particular, policies aimed at increasing private savings and subsidies for the consumption of domestic inputs. The implementation of these simple policies was found to have a substantial positive impact overall, from which important economic policy elements for a development strategy emerge.

Keywords

Nationalism, economic development, social development, economic policy, development strategies, econometric models, social accounting, Mexico

JEL classification

C68, D58, E16, O21, O41, O54

Authors

Gaspar Núñez Rodríguez is a researcher with the Economic Analysis Programme of Mexico (PRAEM) of the Center for Economic Studies (CEE) at El Colegio de México. Email: gaspar.nunez@colmex.mx.

José Antonio Romero Tellaeche is a Research Professor with the Center for Economic Studies (CEE) at El Colegio de México. Email: jromero@colmex.mx.

I. Introduction

The economic stagnation and growing inequality that Mexico has experienced over the last three decades have led many scholars to propose simplistic solutions to help the country catch up, as illustrated by the idea that has been reiterated of forging a fair and inclusive Mexico (CCO Noticias, 2015). However, countries that have achieved rapid growth have motivated their populations to work harder and make greater sacrifices on the basis of a fierce nationalism.

Hirschman (1958) identifies nationalism as the "binding agent" of East Asian development in the context of "late development"; it is not an unjustified nationalism, but one that emerged as a reaction to war and imperialism, and which manifested itself in different ways: communism in China and the Democratic People's Republic of Korea and the capitalist developmental State in Japan, the Republic of Korea and Taiwan Province of China. This is also why the East Asian developmental States have more in common with the late-developing European nations of the nineteenth century, such as Germany, and less in common with contemporary developing societies in Latin America and other regions (Greenfeld, 1993; Hirschman, 1958 and 1968; Johnson, 1982; Woo-Cumings, 1999).

Nationalism helps to provide the initial impetus for development and is, in turn, strengthened by that development. To grow, Mexico must once again resort to nationalism and boost its self-esteem; it must aspire to be more than just a fairer and more inclusive country (CCO Noticias, 2015). Most countries that have achieved economic well-being have not set it as a goal, but have achieved it as a by-product of development. Mexico has the size and the elements to become a middle power; with a population of just over 100 million, it can aspire to play a leading role in the international community, on the same level as countries such as Japan, the Russian Federation or Germany, all of which have populations similar in size to Mexico's. To achieve this, planning for development should be undertaken, as successful countries have done.

It is not necessary to invent something new for this. One need only look at countries that managed to develop in a few decades, as Germany did in the nineteenth century (Lee, 1991; Pierenkemper and Tilly, 2004), Japan in the early twentieth century, the Republic of Korea and Taiwan Province of China in the second half of the twentieth century, China in the late twentieth and early twenty-first centuries and, more recently, Viet Nam. Studying these countries reveals that they all had a genuine intention to develop and that they planned their economies to accelerate development and catch up with the leading countries within a few decades. All of them adopted a developmental State model, defined as seeking accelerated capitalist development through planning by means of a consensual rational plan, which combines private property with State control, in other words, managed capitalism (Amsden, 1992; Chibber, 2014; Evans, 1995; Kasahara, 2013; Kim, 1999; Kristof and WuDunn, 2000; Leftwich, 1994 and 1995; Maman and Rosenhek, 2011; Minns, 2001; Nabi and Shivakumar, 2001; Öniş, 1991; Polidano, 2001; Thompson, 1996; Vogel, 1991; Wade, 2003; Wan, 2008; Weiss, 2000; Wong, 2004; Woo-Cumings, 1999).

The stylized components of this strategy include: (i) a strong State; (ii) a nationalism capable of leading the population to make sacrifices now for the country's future development; (iii) an efficient bureaucracy and, within it, an elite body with broad economic and social planning powers;[1] (iv) policies to encourage saving

[1] In Japan, after the Second World War, a strong link was re-established between the government and big business. The civil service and the private sector worked together to establish this link, through which the government implemented an administrative management system with key government departments, such as the Ministry of International Trade and Industry and the Ministry of Finance, which actively participated in protecting and subsidizing companies whose activities were in line with national priorities. The equivalent of Japan's Ministry of International Trade and Industry in the Republic of Korea was the Ministry of Trade and Industry, which helped to create and implement the government's industrial policies in the latter country (Chen, 1995).

(or discourage consumption);[2] (v) not allowing foreign investment or only allowing highly regulated foreign investment, as in the case of China (Alfaro and Charlton, 2013; Chang, 2003; Rodriguez and Rodrik, 1999; Paul, 1979); (vi) a strong, State-controlled financial system to channel national savings and foreign loans to strategic sectors (Skocpol, 1985; Chandrasekhar, 2013; Rashid, 2013; Woo-Cumings, 1999; Johnson, 1987; Zysman, 1983);[3] (vii) selecting strategic sectors according to their capital intensity, increasing returns,[4] learning and innovation economies, among other characteristics,[5] and high income elasticity of demand;[6] (viii) key sectors with tariff protection, access to foreign exchange and financial support based on their performance (Aoki, Kim and Okuno-Fujiwara, 1998); (ix) educational and scientific and technological policies based on these objectives;[7] and (x) using the exchange rate to make the economy more competitive (Rodrik, 2007).

None of the aforementioned components can be considered in isolation, rather they are part of the overall strategy; no policy makes sense on its own, its importance lies in the fact that it contributes to achieving the ultimate goal, which is the greatness of the nation.

To analyse the potential effects of adopting a developmental State model in Mexico, we designed a recursive dynamic computable general equilibrium (CGE) model, which is based on a social accounting matrix, constructed from the 2012 input-output matrix, published by the National Institute of Statistics and Geography (INEGI, 2016), and additional information from the national accounts. The model considers consumers, the government, factors, productive sectors and the external sector. Consumers and the government consume domestic and imported goods and also save. Businesses use labour, capital and intermediate goods to produce the final good. Intermediate goods are domestic and imported. The price system and the level of income motivate the decisions of all economic agents. The model's prime characteristic is the inclusion of increasing returns, which is the core that gives meaning to the developmental State model strategy.

The model assumes a strong and legitimate government, robust nationalism, an efficient civil service and government control of the financial system, allowing it to channel resources to strategic sectors by mandate. The CGE model allows us to analyse the effects of different trade policies (tariffs on or subsidies for certain types of imports, taxes on or subsidies for certain exports), changes in the exchange rate, or the use of taxes or subsidies to limit or expand overall consumption (to reduce or increase private savings) or certain types of products. Similarly, the CGE model can simulate restrictions on the entry of aggregate foreign investment and could be modified to analyse the effects of selective regulation of foreign investment by industry.

The CGE model is used to simplify and at the same time illustrate the possibilities of the developmental model, as it allows the effects of only two policies to be analysed. Specifically, it is

[2] Much of the Asian countries' success is attributed to the traditional Confucian ethics, which prizes qualities such as diligence, frugality, family solidarity and group harmony, and puts an emphasis on education. For other developing countries, these examples serve as a reminder that if they want to apply the lessons of East Asia's experiences, it is not enough to merely imitate the economic and institutional aspects of those experiences, they must also factor in the cultural aspects that played a key role in East Asia's achievements. This is not to say that other developing countries need to adopt Confucian tradition. Rather, it is to remind them of the beneficial effects that certain, country-specific cultural traits bring and to take advantage of them and cultivate them to achieve the desired purposes (Liang, 2010). Similarly, the launch of a pension plan in Singapore, based on individual contributions, led to significant increases in savings (Monetary Authority of Singapore, 1991).

[3] In this regard, Skocpol (1985) states that "All these sorts of questions must be asked in any study of state capacities. [...] A state's means of raising and deploying financial resources tell us more than could any other single factor about its existing (and immediately potential) capacities to create or strengthen state organizations, to employ personnel, to coopt political support, to subsidize economic enterprises and to fund social programmes" (p. 17).

[4] See Young (1928) for an excellent explanation of the importance of increasing returns.

[5] See Kim and Nelson (2000), Nelson (1996), Rasgotra (2013), Taylor (2016) and Shin and Chang (2003) for explanations of the importance of sectors' technological innovation capacities.

[6] See analysis of sector selection in Felipe (2015) and Falck, Gollier and Woessmann (2011).

[7] The complementarity between education and other factors is commonly seen as the driving force behind economic growth and efficiency in East Asia. East Asian education systems are formed and extended in close relation to the stages of economic development: the higher the level of economic development, the greater the demand for better and higher education systems (Permani, 2009).

assumed that: (i) subsidies for the use of national inputs are provided to key sectors, but not the remaining sectors; and (ii) the population can be motivated to save more, not through consumption taxes —as in the Republic of Korea (Liang, 2010) or Singapore (Huff, 1995)— and that the government can channel these increased savings towards key sectors (those with above-average indices of power of dispersion (backward linkages) and sensitivity of dispersion (forward linkages)).[8]

Protectionist measures and efforts to promote exports are not mutually exclusive. The Asian growth model has been presented as one in which growth is achieved through exports, as opposed to the unsuccessful Latin American model of import substitution. This misguided dichotomy contrasted a protectionist and inefficient Latin America with Asian economies that opened their borders to international competition and benefited from growing international demand through trade based on their comparative advantages. Analysis of the success stories of Japan in the nineteenth and twentieth centuries, the Republic of Korea and Taiwan Province of China in the twentieth century, and, more recently, China and Viet Nam, and the role played by foreign trade or foreign direct investment (FDI), shows that this is not a linear relationship.

The respective governments of these countries offered interesting incentives at the time, such as preferential loans, licences that limited domestic and external competition, and tariffs or access to foreign currencies at advantageous official prices, but at the same time they set export targets in order to reduce current account deficits. The mandatory export targets would, over time, have a greater benefit than balancing the external sector. The targets forced the business owners of these countries to perform well in a market that was not managed and, consequently, in which they did not have privileges, unlike their domestic markets. Making profits in a market where licences eliminated the possibility of competition did not produce an inefficient productive fabric; on the contrary, German (*karteles*), Japanese (*zaibatsu*), Korean (*chaebol*) or Chinese conglomerates could artificially lower export prices, below their own costs, in order to achieve the given export target and offset these losses with the bumper profits made in their domestic market. Foreign markets thus allowed and still allow the local dangers of industrial policy incentives to be corrected (Berasaluce and Romero, 2018).

For our proposed CGE model, it is assumed that in some sectors there are increasing returns to scale. These increasing returns are internal to an industry, but external to a firm, allowing the perfect competition assumption to be maintained (Helpman and Krugman, 1985). Because we work with increasing returns, the model does not reach a stable state. Ten time periods are used and the CGE model has 47 sectors.

This paper is organized as follows: in section II, the function used of increasing returns to scale is explained in detail and substantiated; in section III, the database, the construction of the social accounting matrix and the selection of key sectors are described; in section IV, the proposed CGE model is described (see the mathematical model in annex A3); in section V, the proposed simulation is carried out and the results are analysed; and lastly, in section VI, the paper concludes with some final comments and reflections.

II. Increasing returns[9]

Although increasing returns to scale may have several causes, the division of labour has traditionally been cited as the main one. According to Sánchez (2011), Adam Smith's ideas on this subject were later improved upon by Young (1928) and then indirectly by a number of development economists —Rosenstein-Rodan (1943), Nurkse (1952), Hirschman (1958), Myrdal (1971) and Prebisch (1959), among others— for whom industry was the engine of growth, either because of increasing returns to scale or because of its productive linkages.

[8] The CGE model can perfectly simulate this objective through consumption taxes, but we consider that the assumption that the increase in savings is a voluntary measure, taken for non-economic reasons, induced a national sentiment, which goes beyond individualism and with a view to achieving a strong and powerful nation, is more consistent with the developmental model.

[9] This section is based on Young (1928).

More recently, other authors have made important conceptual additions, most notably the works of Krugman (The Nobel Prize, 2020) and Helpman and Krugman (1985), on which the concept of increasing returns to scale used in this research is based.

A huge body of empirical work has been developed at the international level to test the hypothesis of increasing returns to scale in real economies and to estimate parameters that account for the amounts. For example, Antweiler and Trefler (2000) found that "the Helpman-Krugman framework provides a remarkable lens for viewing the scale elasticities encoded in trade flows. In particular, we find that a third of all goods-producing industries are characterized by scale. (The modal range of scale elasticities for this group is 1.10–1.20 and the economy-wide scale elasticity is 1.05)".

In the specific case of Mexico, studies have also been carried out that show that the potential effects on the country are significant. Castañeda and Garduño (2000) estimate a returns to scale index for Mexican manufacturing industries, in a paper that finds considerable evidence of increasing returns to scale, and they conclude that, considering the results of the pooled data, six sectors comprising 21 industries present evidence of increasing returns to scale. In two-digit estimates, 19 industries show increasing returns to scale.

Sánchez (2011) analyses the stagnation in Mexico's relationship with manufacturing and increasing returns using a Kaldorian approach. Using a series of econometric models, he tests Kaldor's three growth laws and finds, among other results, that the estimate of the law using Kaldor's specification indicates that the degree of increasing returns is around 2.98 in the Mexican regions, the Wald test indicates that this value is statistically significant.

Meanwhile, increasing returns to scale have also been used in applied theoretical works to demonstrate empirical implications in applied general equilibrium models, as López-de-Silanes, Markusen and Rutherford (1992) do in the case of Mexico.

In accordance with the papers previously referred to for this research, based on the proposal of Helpman and Krugman (1985) for a production function with increasing returns to scale $Y = g(Y)\tilde{f}(v)$, where v is the input vector, we propose a function of increasing returns to scale with the specific functional form $g = \left(\frac{Y_t}{Y_{t-1}}\right)^{\mu}$, where Y_t is the current production level and Y_{t-1} the previous one; μ can be specified at different levels to achieve more or less high degrees of increasing returns to scale; in the main simulation, we specified μ = 1.5 for 12 key sectors, which is consistent with the results of Sánchez (2011) and Castañeda and Garduño (2000) for Mexico. For the remaining 35 sectors, we specified μ = 0 (in other words, they do not develop increasing returns to scale). It should be noted that this is a very conservative assumption, as economic growth would also generate increasing returns, to some degree, in non-key sectors; in simulations with a greater for either of the two groups (or for both), as expected, the results obtained are always higher as μ increases.

III. Data and social accounting matrix

A social accounting matrix is built on the concept of the circular flow of the economy, able to capture all these flows with greater or lesser disaggregation; in turn, the social accounting matrix is the standard database that underpins the CGE model.

Households own the factors of production, which businesses pay them for and then use to produce goods and services that they sell to households. It is assumed that, in each productive cycle, the economy reaches an equilibrium that allows agents to optimize their behaviour, and that the factor and goods markets are cleared.

The government collects taxes from households and businesses to provide services and, lastly, the country's economy exchanges goods with the rest of the world.

The circular flow of the economy generates, in turn, a circular flow of income with a counter-flow of goods and factors. When firms pay for capital and labour, they generate an income for households, which they use to buy the goods produced; firms in turn use that income to rehire capital and labour, and so on.

To prepare the social accounting matrix that is the database that underpins the design, calibration and implementation of the model, the national symmetric input-output tables, published by INEGI for 2012 (INEGI, 2016) (aggregated to 47 productive activities), were used as a starting point, together with national accounts data to close the accounts. We also used the imports origin-destination matrix (INEGI, 2016), a novel feature of our model, which allows the constant elasticity of substitution (CES) combination of domestic and foreign inputs used in each case (compound inputs) to be broken down in detail.

To determine which sectors benefit from an active domestic input subsidy policy (with the effect of increasing domestic content), we used key sector analysis based on Rasmussen's (1956) indices[10] (see annex A1). Twelve sectors were selected, namely: electric power generation; food manufacturing; paper manufacturing; petroleum and coal products manufacturing; chemical manufacturing; plastics and rubber products manufacturing; primary metal manufacturing; fabricated metal product manufacturing; machinery manufacturing; computer, communications and other equipment manufacturing; electrical equipment, appliance and component manufacturing; and transportation equipment manufacturing.[11]

IV. Recursive dynamic computable general equilibrium (CGE) model

This section provides an intuitive description of the model. Annex A2 contains the list of parameters and variables as a reference for the subsequent specification of the mathematical model. Table A2.1 in annex A2 describes the parameters to be calibrated with the economy's data from the social accounting matrix. Similarly, table A2.2 describes the variables in the model. The mathematical model is specified in annex A3.

1. Households

In the social accounting matrix, Mx12, households are aggregated into an account that concentrates all private income in the first row of the matrix and all expenditure in the first column. In the economy represented by the social accounting matrix, households earn income from capital income, wages and salaries, government transfers and transfers from the rest of the world (RoW) (remittances).

Meanwhile, households pay taxes and the rest of their disposable income is used for savings (future consumption) and consumption of goods and services (present consumption). In turn, consumption of goods and services is broken down into two groups, a national aggregate good and an imported aggregate good.

[10] Rasmussen's (1956) indices consist of calculating the average magnitudes of the power of dispersion (backward linkages) and sensitivity of dispersion (forward linkages) for each of the productive sectors and comparing them with the global average, in order to identify the "key sectors", which are those whose forward and backward linkages are above the average. In this paper we use them to define the sectors that benefit from a specific public policy and, at the same time, to identify the sectors with increasing returns to scale.

[11] See Castañeda and Garduño (2000) for a study finding positive economies of scale in Mexico.

2. Government

The government collects taxes: on income, on products and on production. It uses these to makes transfers to households (programmes to combat poverty and other issues), saves a proportion and devotes the rest to the purchase of domestic and imported goods.

3. Savings and investment

The savings and investment account gathers together the savings of economic agents: households, firms, government and the rest of the world (balance-of-payments current account, which is equivalent to net lending from the rest of the world), to finance the purchase of capital goods (gross fixed capital formation, including changes in stocks). Some capital goods come from the total domestic supply and some from the rest of the world.

4. Productive factors

The economy has an initial undifferentiated capital endowment and a labour endowment, that is also uniform. This implies full factor mobility among productive activities, which in turn suggests a long-term time horizon, that is to say that, eventually capital can be transformed and transferred from one activity to another depending on the stimuli generated by changes in relative prices. The same applies to labour.

5. Production

The production of the total supply of goods and services in the economy is modeled through the following nesting: first the value added is produced through a Cobb-Douglas function; at the same level, a composite input (domestic and imported inputs) is generated through a CES function; at the next level, the total supply production is estimated with a Leontief function.

Given its complexity, nesting production is standard practice for the design and implementation of computable general equilibrium models, otherwise it would be unmanageable in terms of both the mathematical specification of the models and their computational implementation (see, for example, Lofgren, Harris and Robinson, 2002).

6. Rest of the world (RoW)

The rest of the world receives income from imported inputs and capital goods, as well as from direct imports by the public and private sectors, and also takes a share of capital income, mainly as payment for property rents. The expenses incurred by the rest of the world are transfers to households (remittances); payment for labour (documented); exports; and savings (net lending from the rest of the world).

7. Macroeconomic closures

The macroeconomic closures specified in the simulations are:

(i) fixed marginal propensity to save and variable investment;

(ii) fixed tax rates and variable receipts; and

(iii) fixed exchange rate and variable income from the rest of the world.

8. Recursive dynamics

Dixon and Parmenter (1996) consider four dynamic modelling cases. In this model, we followed the first case, in which investment is exogenous, consistent with expectations of limited scope, savings rates are given and savings are equal to investment in each period. The population (labour) is growing at a constant rate g_0. For the recursive dynamics, we used external growth projections for the economically active population (EAP), on average 1.6% per period (Partida, 2008).

V. Simulations and results

We simulate a growth-enhancing policy based on two elements: an increase in households' marginal propensity to save as a result of moralistic exhortations (such as the message disseminated in the Republic of Korea: "spend what is left after saving" (Park, 1979) or through direct consumption taxes and subsidies on the use of domestic inputs. As mentioned above, it is assumed that 12 key sectors show increasing returns to scale in both the baseline scenario and the simulations.

1. Baseline scenario

To obtain the baseline scenario over a time horizon divided into 10 periods, we started from the capital accumulation rate observed in year zero (initial balance) and, as indicated above, from labour factor growth of 1.6% on average, in accordance with the projections of Partida (2008).

The input-output matrices published by INEGI (2016), which is the source used, include all wages paid in the economy, including those in the informal sector. For the purposes of this analysis, it is not necessary to disaggregate wages by formal and informal sector; it should be noted, however, that in the manufacturing sector virtually all work is formal (see table 1).

Table 1
Composition of total value added and of the labour factor
(Millions of constant 2012 pesos)

Gross value added *(basic prices)*	15 106 358.629
Total compensation of employees	4 216 575.358
Salaries	782 354.771
Wages	3 010 643.774
Actual social security contributions	317 929.494
Other social benefits	105 647.319
Net taxes on production	84 631.434
Gross operating surplus	10 805 151.837

Source: National Institute of Statistics and Geography (INEGI), "Sistema de cuentas nacionales de México: fuentes y metodología, año base 2013", 2017 [online] https://www.inegi.org.mx/contenidos/programas/mip/2013/metodologias/SCNM_Metodo_MIP_B2013.pdf.

2. Simulations

Once the results of the baseline scenario were obtained, the following combined simulation was carried out: an increase from 10% to 20% in the marginal propensity of households to save, and a 20% subsidy for the purchase of domestic inputs for key sectors.[12]

Subsidies are paid for from government revenues. Logically, by having to devote an increasing percentage to this subsidy (given that 20% is specified for a growing economy), government revenues and, therefore, spending decrease. But this is more than offset by the boost to real household consumption and by the increase in household income, as a result of the growth in capital stocks, because savings are building up.

Figures 1 and 2 contain the results for labour productivity in two groups of sectors. As can be seen in figure 1, the electric power, food and petroleum and coal derivatives sectors barely react to the increase in savings and the price subsidy for domestic inputs; in contrast, the productivity of the paper, chemical and plastics and rubber products manufacturing industries increase by between 84% and 98% above what would be achieved in the absence of any policy.

Although the two policies considered here are relatively simple, the parallel and serial effects triggered by their implementation are very complex because of the numerous interrelations that take place among the productive sectors and among these and the other economic agents, as well as all the effects of second and subsequent loops. In general, the development of a particular industry, as well as its productivity, will depend on several factors, mainly the magnitude of the forward linkages (in this case, the subsidy on domestic inputs), its growing importance as an input supplier for other industries and its capital-labour ratio.

Figure 2 shows the second recipient group. In this case, there is a notable increase in the productivity of primary metal manufacturing industries and manufacturers of fabricated metal products, machinery, computer, communication and other equipment, of electrical appliances, and of transport equipment (automotive industry). The sector with the lowest productivity growth is transport equipment, with 52%, while primary metal manufacturing industries saw the highest increase, tripling their productivity in just 10 years.

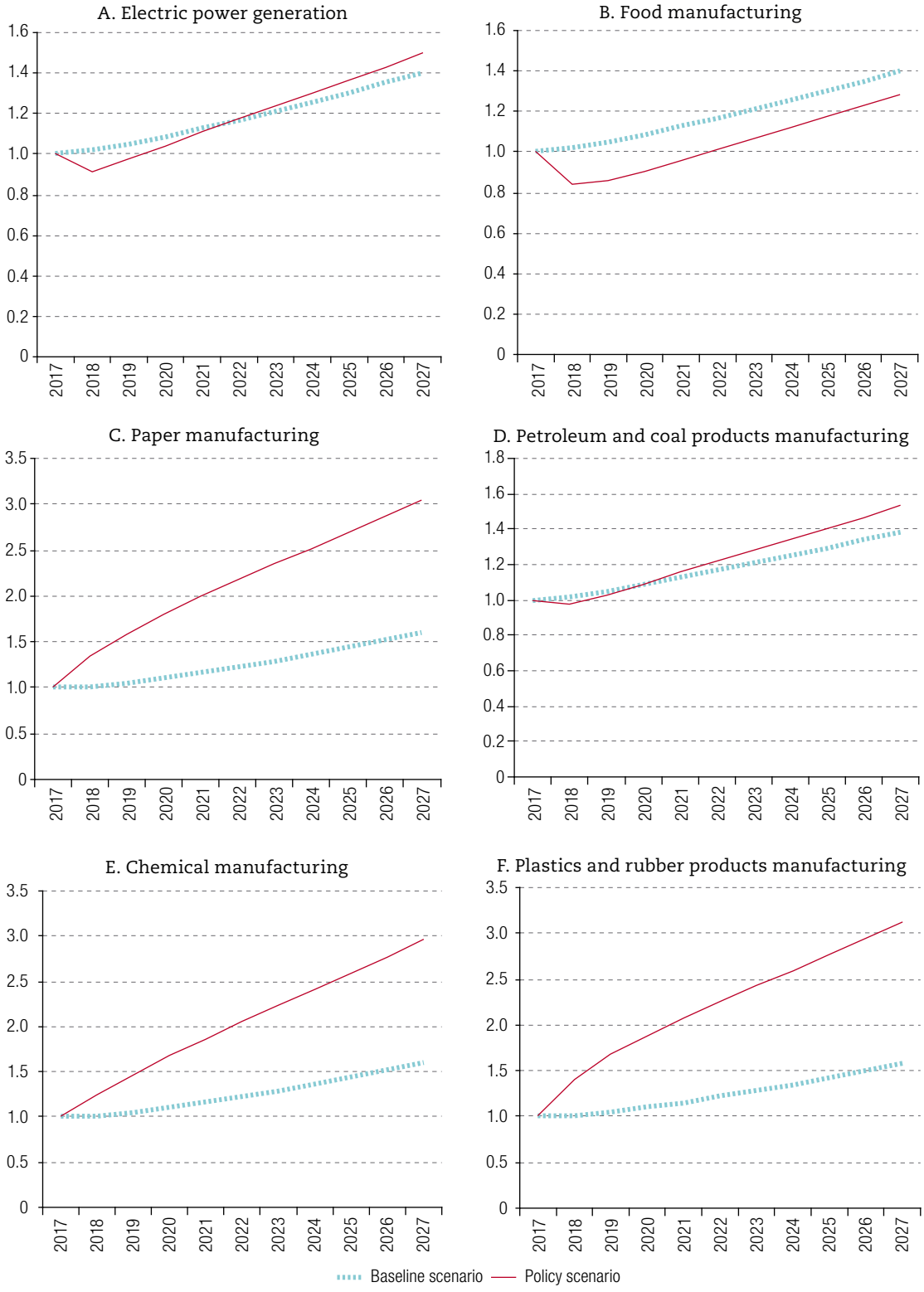
There are also positive effects on the economy as a whole. Total labour productivity in the tenth year is 7% higher than in the baseline scenario. Figure 3 shows the labour productivity growth index (period $0=1$), grouping productive activities into six major sectors: (i) agriculture; (ii) oil and mining; (iii) electricity and gas; (iv) construction; (v) manufacturing; and (vi) services (see annex A4).

In the policy scenario, the agricultural sector increases its productivity by 2% in the tenth year over the baseline scenario, the oil sector does so by 26.56%, electricity and gas by only 3.63%, construction by 39.8% and manufacturing by 37.14%, while productivity in the services sector in the tenth year is 4.3% lower than in the baseline scenario.

These changes mean that the manufacturing sector's share of GDP in the tenth year increases from 19.6% in the baseline scenario to 21.95% in the policy scenario, an increase of 2.35 percentage points in just 10 years (see figure 4).

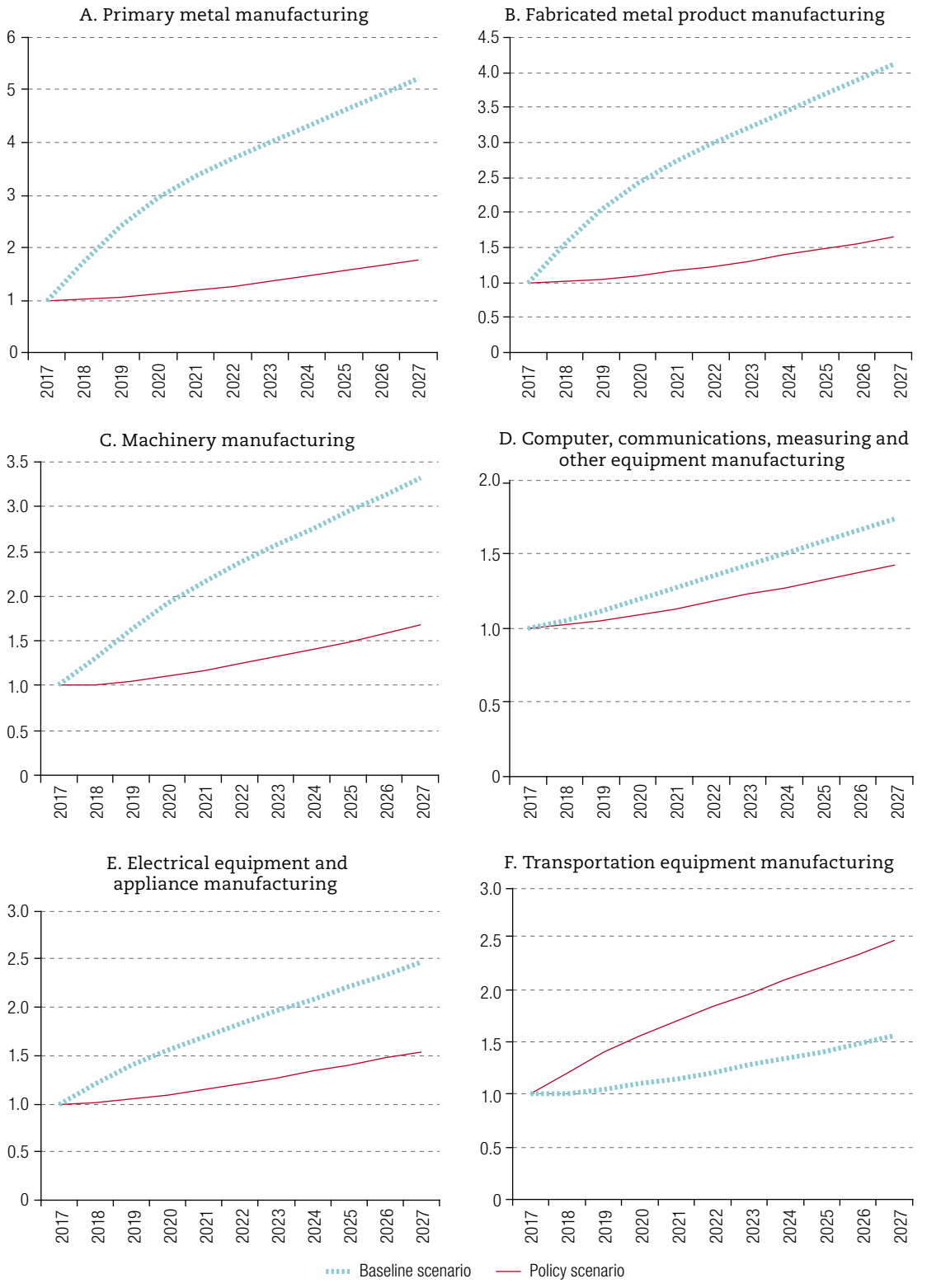
[12] In addition to economies of scale, the Solow residual can also be affected by increases in total factor productivity and by the introduction of technological improvements.

Figure 1
Comparison of labour productivity growth: baseline scenario versus the policy scenario, low-response sectors
(Index, base year 2017 = 1)



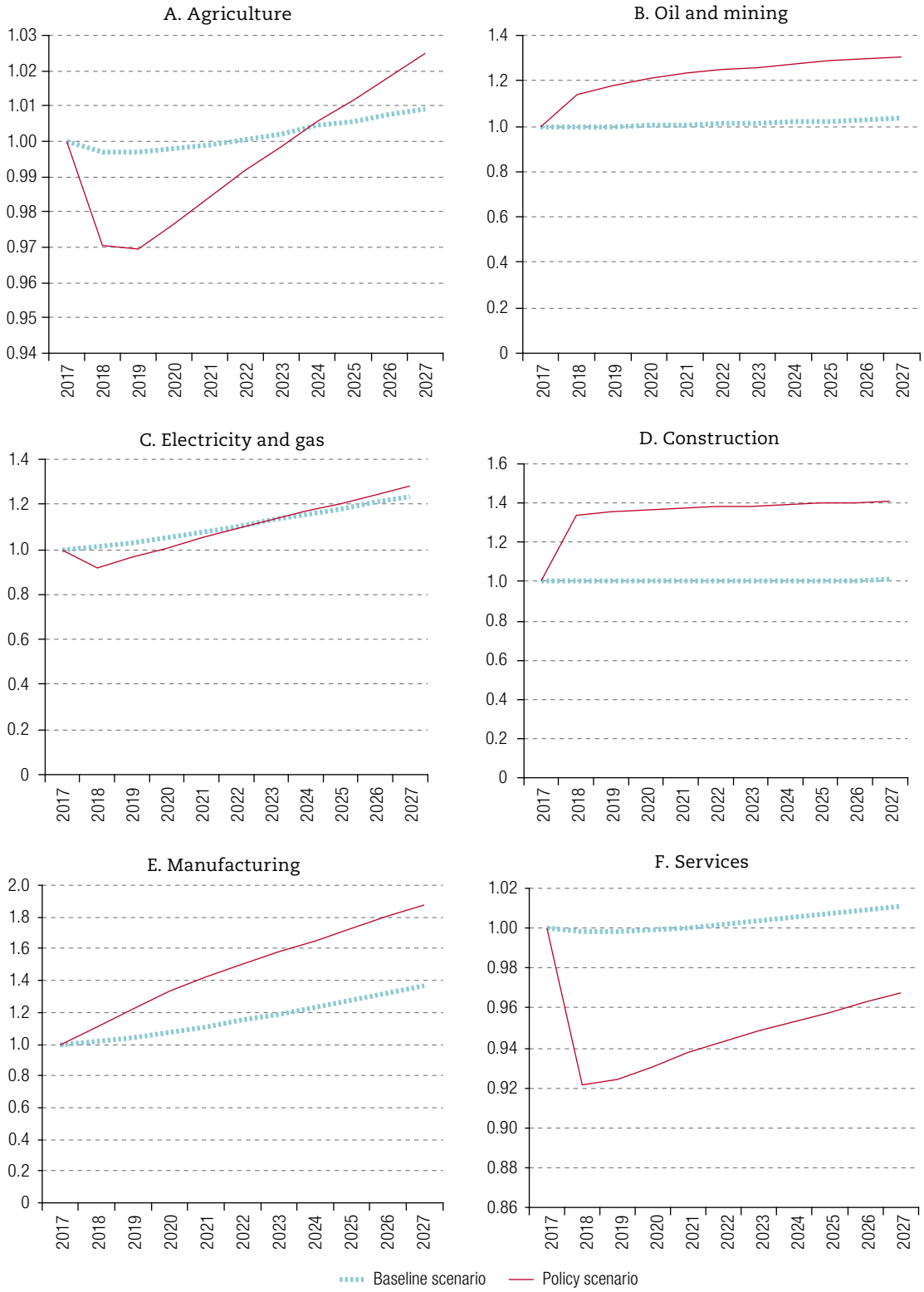
Source: Prepared by the authors.

Figure 2
Comparison of labour productivity growth: baseline scenario versus the policy scenario, high-response sectors
(Index, base year 2017 = 1)



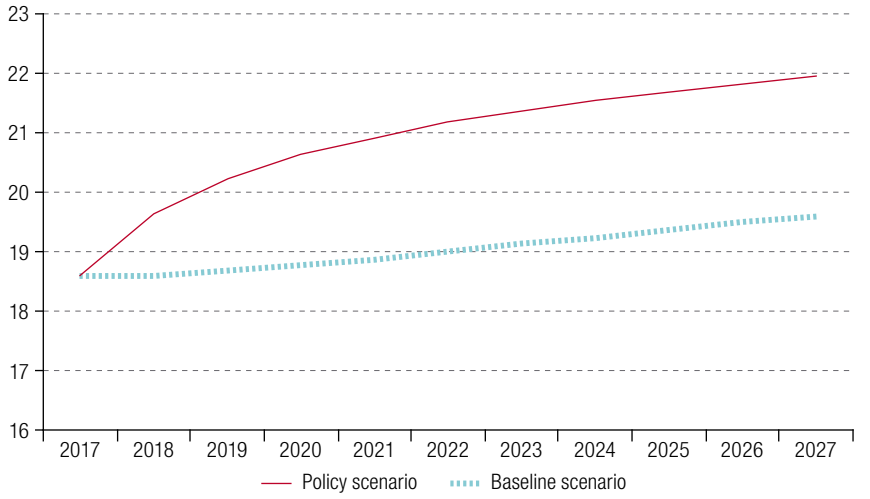
Source: Prepared by the authors.

Figure 3
Productivity index by sector, baseline scenario and policy scenario
(Index, base year 2017 = 1)



Source: Prepared by the authors.

Figure 4
Manufacturing sector's share of national GDP, baseline scenario and policy scenario
(Percentages)

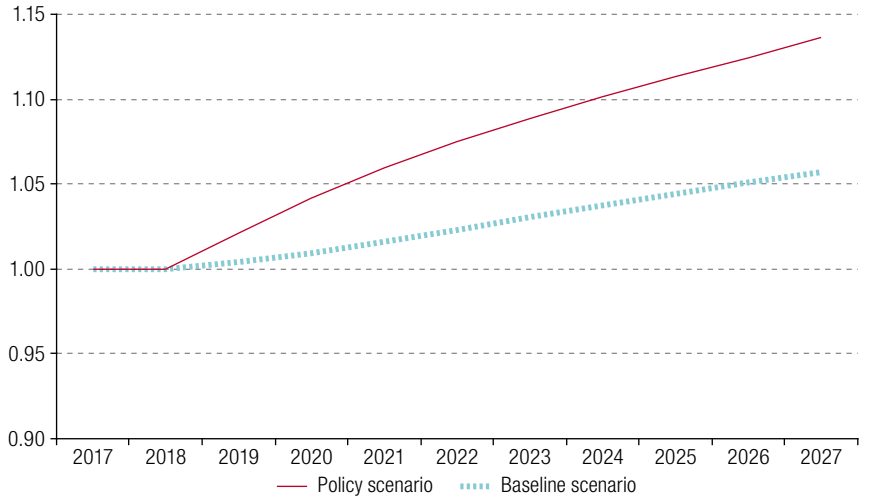


Source: Prepared by the authors.

As Coatsworth (1990) points out, per capita income, despite its limitations, is the best indicator of well-being; if a country's per capita income increases as a result of an economic policy, this indicates that it is potentially better off than before. Under the "compensation test" it can be assumed that, if per capita income increases, the winners could compensate potential losers and keep a remainder. A country's per capita income is closely related to average labour productivity in the economy.[13]

Therefore, in order to know how per capita income will evolve, labour productivity trends must be identified. Figure 5 shows the labour productivity results.

Figure 5
Labour productivity index
(Base year 2017 = 1)

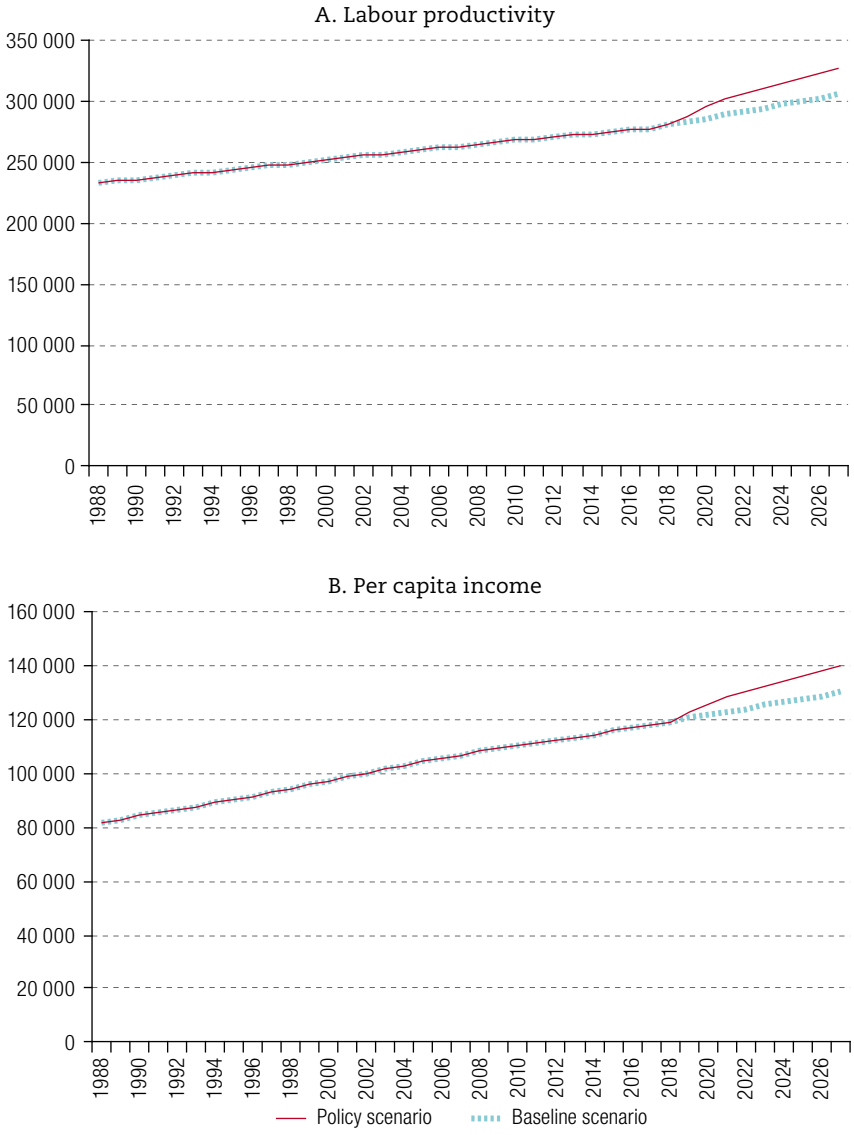


Source: Prepared by the authors.

[13] Per capita GDP *(GDP/P)* can be disaggregated into average labour productivity *(GDP/E)*, the labour force participation rate *(L/P)* and the employment rate *(E/L)*, where GDP: gross domestic product; P: population; L: labour force; and E: employment. This is: $\frac{PIB}{P}=\left(\frac{PIB}{E}\right)\left(\frac{L}{P}\right)\left(\frac{E}{L}\right)$. This equation shows that the observed variations in per capita GDP are due to factors related to labour productivity and socioeconomic trends, and the level of economic activity.

Using data from the statistical annexes of the *Informes de Gobierno* from several years, on GDP, employment and population, the trajectory of labour productivity and per capita GDP was projected for the period 1988–2027 (see figure 6).

Figure 6
Labour productivity and per capita income, 1988–2027
(Thousands of constant 2008 pesos)



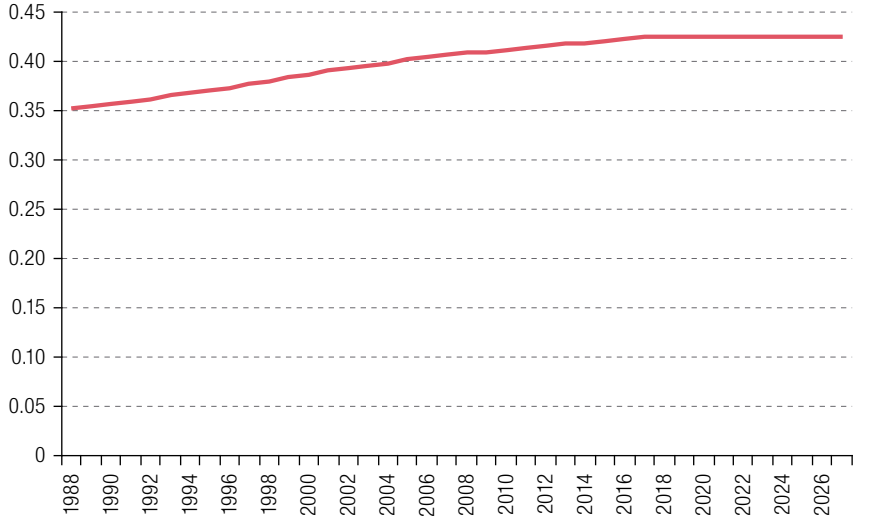
Source: Prepared by the authors, on the basis of Mexico, *Informe de Gobierno: anexo estadístico*, Mexico City, various years.

To put this in perspective, labour productivity between 1988 and 2017 only increased by 19%, whereas if the suggested policies are implemented productivity would see growth of 18% within 10 years. Or put another way, with the suggested reforms, labour productivity in another 10 years would be 18% higher than it was in 2017, instead of 10%, which is how much it would increase if these reforms are not implemented.

Meanwhile in the baseline scenario, the per capita income growth rate would be 0.95% over the same period, while it would be 1.67% under the policy scenario. This result alone would justify adopting a State-led growth strategy, as even between 1988 and 2017, per capita GDP growth was

less, reaching an average of 1.27%. This was not due to higher productivity (which increased during that period at a rate of just 0.61%), but rather to a notable growth in the proportion of the population that joined the labour market, up 0.66% (that is, the difference between 1.27% and 0.61%)[14] (see figure 7).

Figure 7
Employed population as a share of the total population, 1988–2026



Source: Mexico, *6.° Informe de Gobierno: anexo estadístico*, Mexico City, 2000; *5.° Informe de Gobierno: anexo estadístico*, Mexico City, 2000; *4.° Informe de Gobierno: anexo estadístic*o, Mexico City, 2010, and *6.° Informe de Gobierno: anexo estadístico*, Mexico City, 2018.

This result can be interpreted as follows. If the proportion of the population participating in the labour force remains the same as the trend observed from 1988 to 2017, the average per capita income growth rate for the period 2017–2026 would be 0.62%, compared to 1.67% if the proposed policies were implemented from 2017 onwards. Looked at another way, if the share of the population in employment continues to trend upwards, the per capita income growth rate would easily exceed 2% per year in the policy scenario, compared to the 1.27% rate recorded from 1988 to 2017.

VI. Some conclusions and final comments[15]

Mexico's economy has been stagnating for more than 30 years, leading us to consider the possibility of breaking a "consensus" that does not even exist in Washington.[16] This leads us, in turn, to review carefully the economic strategies followed by other countries that have managed to accelerate their economic growth and improve the well-being of their inhabitants in a few decades. These strategies, based on an economy with a strong private sector, but managed by the State, have come to be known as developmental State strategies.

[14] Assuming full employment, the per capita GDP growth rate can be expressed as the sum of the growth rate of average labour productivity and the growth rate of the share of the population in employment: $\left(\frac{PIB}{Pob}\right)^{o} = \left(\frac{PIB}{Emp}\right)^{o} + \left(\frac{Emp}{Pob}\right)^{o}$ where 0 indicates the growth rates.

[15] The objective of this paper has been to analyse the results arising from two policies or two simple changes that the government can introduce. The social accounting matrix we used does not disaggregate all households in the economy, which would allow a differentiated analysis of the various spending (and savings) patterns of these different types of households, according to their consumption patterns. This could be an important future addition for the model, allowing a more complete analysis of the implications for savings and actual consumption.

[16] The Washington Consensus refers to a set of 10 economic policy recommendations made in 1989 by John Williamson, for developing countries to help them overcome the debt crisis of the early 1980s. These recommendations include fiscal discipline; capital and foreign exchange market liberalization; international trade liberalization; elimination of barriers to the entry of foreign direct investment; privatization of public enterprises; and protection of property rights, including intellectual property (Williamson, 1990).

As Rodrik (2009) points out, "the Asian experience highlights a deeper point: a sound overall development strategy that produces high economic growth is far more effective in achieving integration with the world economy than a purely integrationist strategy that relies on openness to work its magic".

In order to envisage how a developmental State, as described in the introduction to this article, could be established in Mexico, a CGE model was prepared using just two measures from the strategy's powerful arsenal. We simulated the effects on the Mexican economy of a 20% subsidy for national inputs granted to 12 of 47 sectors considered key, and an increase in savings from 10% to 20%. By adopting these two measures alone, it would be possible to almost double the per capita income growth rate and thus prevent, or at least contain, the increasing social disintegration. If other measures were added to the CGE model described in this paper, growth rates would be considerably higher.

The purpose of this exercise is to illustrate what the country could do to shake off economic stagnation by adopting a new strategy. It is obviously not easy to change strategy. There are many internal and external vested interests, which prefer the status quo and are opposed to change and experimentation.

Bibliography

Alfaro, L. and A. Charlton (2013), "Growth and the quality of foreign direct investment", *The Industrial Policy Revolution I: The Role of Government Beyond Ideology*, J. Stiglitz and J. Lin (eds.), London, Palgrave MacMillan.

Amsden, A. (1992), "Getting relative prices 'wrong': a summary", *Asia's Next Giant: South Korea and Late Industrialization*, New York, Oxford University Press.

Antweiler, W. and D. Trefler (2000), "Increasing returns and all that: a view from trade", *NBER Working Paper*, No. 7941, Cambridge, National Bureau of Economic Research (NBER), October.

Aoki, M., H. Kim and M. Okuno-Fujiwara (eds.) (1998), *The Role of Government in East Asian Economic Development: Comparative Institutional Analysis*, Clarendon Paperbacks, Oxford, Oxford University Press.

Berasaluce, J. and J. Romero (2018), "La política económica exterior coreana (1948-presente): apertura bajo una estrategia nacional", *Cambio de la época de Corea y la revisión de su relación con América Latina*, W. Suk-Kyun and J. Ramírez (eds.), Mexico City, El Colegio de México, in press.

Böhm-Bawerk, E. (1891), *The Positive Theory of Capital*, New York, Pantianos Classics.

Castañeda, A. and G. Garduño (2000), "Rendimientos crecientes a escala en la manufactura mexicana", *El Trimestre Económico*, vol. 67, No. 266.

CCO Noticias (2015), "Tener un México más moderno, próspero, justo e incluyente es una responsabilidad compartida: EPN (video)", 1 April [online] https://corporacioncomunicativaojeda.wordpress.com/2015/04/01/tener-un-mexico-mas-moderno-prospero-justo-e-incluyente-es-una-responsabilidad-compartida-epn-video/.

Chandrasekhar, C. (2013), "Financialization as an obstacle to industrialization", *The Industrial Policy Revolution II: Africa in the 21st Century*, J. Stiglitz, J. Lin and E. Patel (eds.), London, Palgrave MacMillan.

Chang, H. (2003), *Globalisation, Economic Development and the Role of the State*, London, Third World Network, Zed Books.

Chen, M. (1995), *Asian Management Systems: Chinese, Japanese and Korean Styles of Business*, London, Routledge.

Chibber, V. (2014), "The developmental State in retrospect and prospect: lessons from India and South Korea", *The End of the Developmental State?*, M. Williams (ed.), New York, Routledge.

Coatsworth, J. (1990), *Los orígenes del atraso: nueve ensayos de historia económica de México en los siglos XVIII y XIX*, Mexico City, Alianza Editorial.

Dixon, P. and B. Parmenter (1996), "Computable general equilibrium modelling for policy analysis and forecasting", *Handbook of Computational Economics*, vol. 1, H. Amman, D. Kendrick and J. Rust (eds.), Amsterdam, North-Holland.

Evans, P. (1995), *Embedded Autonomy: States and Industrial Transformation*, Princeton, Princeton University Press.

Falck, O., C. Gollier and L. Woessmann (eds.) (2011), *Industrial Policy for National Champions*, CESifo Seminar Series, Cambridge, MIT Press.

Felipe, J. (ed.) (2015), *Development and Modern Industrial Policy in Practice: Issues and Country Experiences*, Cheltenham, Asian Development Bank (ADB), Edward Elgar Publishing.

Greenfeld, L. (1993), *Nationalism: Five Roads to Modernity*, Cambridge, Harvard University Press.

Helpman, E. and P. Krugman (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*, Cambridge, MIT Press.

Hennings, K. (1990), "Roundabout methods of production", *Capital Theory*, The New Palgrave, J. Eatwell, M. Milgate and P. Newman (eds.), London, Palgrave Macmillan UK.
Hirschman, A. (1968), "The political economy of import-substituting industrialization in Latin America", *The Quarterly Journal of Economics*, vol. 82, No. 1, February.
___(1958), *The Strategy of Economic Development*, New Haven, Yale University Press.
Huff, W. (1995), "The developmental State, government, and Singapore's economic development since 1960", *World Development*, vol. 23, No. 8, August.
INEGI (National Institute of Statistics and Geography) (2016), "Matriz de Insumo Producto 2012 – actualización. Base 2008" [online] https://www.inegi.org.mx/programas/mip12/2008/default.html#Documentacion.
Johnson, C. (1987), "Political institutions and economic performance: the government-business relationship in Japan, South Korea, and Taiwan", *The Political Economy of the New Asian Industrialism*, F. Deyo (ed.), Ithaca, Cornell University Press.
___(1982), *MITI and the Japanese Miracle: the Growth of Industrial Policy, 1925-1975*, Stanford, Stanford University Press.
Kasahara, S. (2013), "The Asian developmental State and the flying geese paradigm", *Discussion Papers*, No. 213 (UNCTAD/OSG/DP/2013/3), Geneva, United Nations Conference on Trade and Development (UNCTAD), November.
Kim, L. and R. Nelson (eds.) (2000), *Technology, Learning, & Innovation: Experiences of Newly Industrializing Economies*, Cambridge, Cambridge University Press.
Kim, Y. (1999), "Neoliberalism and the decline of the developmental State", *Journal of Contemporary Asia*, vol. 29, No. 4.
Kristof, N. and S. WuDunn (2000), *Thunder from the East: Portrait of a Rising Asia*, New York, Alfred A. Knopf.
Lee, K. (2013), *Schumpeterian Analysis of Economic Catch-up: Knowledge, Path-Creation, and the Middle-Income Trap*, Cambridge, Cambridge University Press.
Lee, W. (ed.) (1991), *German Industry and German Industrialisation: Essays in German Economic and Business History in the Nineteenth and Twentieth Centuries*, New York, Routledge.
Leftwich, A. (1995), "Bringing politics back in: towards a model of the developmental State", *The Journal of Development Studies*, vol. 31, No. 3, February.
___(1994), "The developmental State", *Working Paper*, No. 6, York, University of York.
Liang, M. (2010), "Confucianism and the East Asian Miracle", *American Economic Journal: Macroeconomics*, vol. 2, No. 3, July.
Lofgren, H., R. Harris and S. Robinson (2002), *A standard computable general equilibrium (CGE) model in Gams*, Microcomputers in Policy Research, Washington, D.C., International Food Policy Research Institute (IFPRI).
López-de-Silanes, F., J. Markusen and T. Rutherford (1992), "Complementarity and increasing returns in intermediate inputs: a theoretical and applied general-equilibrium analysis", *NBER Working Paper*, No. 4179, Cambridge, National Bureau of Economic Research (NBER).
Malerba, F. and others (2016), *Innovation and the Evolution of Industries: History-Friendly Models*, Cambridge, Cambridge University Press.
Maman, D. and Z. Rosenhek (2011), "The institutional dynamics of a developmental State: change and continuity in State-economy relations in Israel", *Working Paper Series*, No. 5, Raanana, Open University of Israel.
Mexico (2017), *5.° Informe de Gobierno 2016-2017: anexo estadístico*, Mexico City.
Minns, J. (2001), "Of miracles and models: the rise and decline of the developmental State in South Korea", *Third World Quarterly*, vol. 22, No. 6, December.
Monetary Authority of Singapore (1991), *Savings-Investment Balances in Singapore: Determinants and Medium-Term Outlook*, Singapore.
Myrdal, G. (1971), *Economic Theory and Underdeveloped Regions*, New York, Harper & Row.
Nabi, I. and J. Shivakumar (2001), *Back from the Brink: Thailand's Response to the 1997 Economic Crisis*, Washington, D.C., World Bank.
Nelson, R. (2005), *Technology, Institutions and Economic Growth*, Cambridge, Harvard University Press.
___(1996), *The Sources of Economic Growth*, Cambridge, Harvard University Press.
Nurkse, R. (1952), "Some international aspects of the problem of economic development", *The American Economic Review*, vol. 42, No. 2, May.
Öniş, Z. (1991), "The logic of the developmental State", *Comparative Politics*, vol. 24, No. 1, October.
Partida, V. (2008), *Proyecciones de la población económicamente activa de México y de las entidades federativas, 2005–2050*, Mexico City, National Population Council (CONAPO).

Park, C. (1979), *Korea Reborn: A Model for Development*, Englewood Cliffs, Prentice-Hall.
Paul, S. (1979), "Transnational corporations and developing countries: some issues in industrial policy", *Economic and Political Weekly*, vol. 14, No. 30/32, August.
Permani, R. (2009), "The role of education in economic growth in East Asia: a survey", *Asian-Pacific Economic Literature*, vol. 23, No. 1, May.
Pierenkemper, T. and R. Tilly (2004), *The German Economy during the Nineteenth Century*, New York, Berghahn Books.
Polidano, C. (2001), "Don't discard State autonomy: revisiting the East Asian experience of development", *Political Studies*, vol. 49, No. 3, August.
Prebisch, R. (1959), "Commercial policy in the underdeveloped countries", *The American Economic Review*, vol. 49, No. 2, May.
Rasgotra, M. (ed.) (2013), *Science and Technology in China: Implications and Lessons for India*, New Delhi, SAGE Publications India.
Rashid, H. (2013), "Does financial market liberalization promote financial development?: evidence from Sub-Saharan Africa", *The Industrial Policy Revolution II: Africa in the 21st Century*, J. Stiglitz, J. Lin and E. Patel (eds.), London, Palgrave Macmillan.
Rasmussen, P. (1956), *Studies in Inter-Sectoral Relations*, Copenhagen, Einar Harcks.
Rodríguez, F. and D. Rodrik (1999), "Trade policy and economic growth: a skeptic's guide to the cross-national evidence", *NBER Working Paper*, No. 7081, Cambridge, National Bureau of Economic Research (NBER), April.
Rodrik, D. (2009), "Trading in illusions", *Foreign Policy*, November 18 [online] https://foreignpolicy.com/2009/11/18/trading-in-illusions/.
___(2007), "The real exchange rate and economic growth: theory and evidence", *Working Paper*, Boston, Weatherhead Center for International Affairs.
Rosenstein-Rodan, P. (1943), "Problems of industrialisation of Eastern and South-Eastern Europe", *The Economic Journal*, vol. 53, No. 210/211.
Sánchez, I. (2011), "Estancamiento económico en México, manufacturas y rendimientos crecientes: un enfoque kaldoriano", *Investigación Económica*, vol. 70, No. 277.
Shin, J. and H. Chang (2003), *Restructuring Korea Inc*., London, RoutledgeCurzon.
Skocpol, T. (1985), "Bringing the State back in: strategies of analysis in current research", *Bringing the State Back In*, P. Evans, D. Rueschemeyer and T. Skocpol (eds.), Cambridge, Cambridge University Press.
Taylor, M. (2016), *The Politics of Innovation: Why some Countries are Better than Others at Science and Technology*, New York, Oxford University Press.
The Conference Board (2019), "Total Economy Database™ - Key Findings" [online database] http://www.conference-board.org/data/economydatabase/.
The Nobel Prize (2020), "The increasing returns revolution in trade and geography" [online] https://www.nobelprize.org/prizes/economic-sciences/2008/krugman/lecture/.
Thompson, M. (1996), "Late industrialisers, late democratisers: developmental States in the Asia-Pacific", *Third World Quarterly*, vol. 17, No. 4.
Vogel, E. (1991), *The Four Little Dragons: The Spread of Industrialization in East Asia*, Cambridge, Harvard University Press.
Wade, R. (2003), "What strategies are viable for developing countries today? The World Trade Organization and the shrinking of 'development space'", *Review of International Political Economy*, vol. 10, No. 4.
Wan, M. (2008), *The Political Economy of East Asia: Striving for Wealth and Power*, Washington, D.C., CQ Press.
Weiss, L. (2000), "Developmental States in transition: adapting, dismantling, innovating, not 'normalising'", *The Pacific Review*, vol. 13, No. 1.
Williamson, J. (ed.) (1990), "What Washington means by policy reform", *Latin American Adjustment: How Much Has Happened?*, Washington, D.C., Peterson Institute for International Economics.
Wong, J. (2004), "The adaptive developmental State in East Asia", *Journal of East Asian Studies*, vol. 4, No. 3, December.
Woo-Cumings, M. (1999), "Introduction: Chalmers Johnson and the politics of nationalism and development", *The Developmental State*, M. Woo-Cumings (ed.), Ithaca, Cornell University Press.
W Radio (2017), "Quinto Informe de Gobierno de EPN", 2 September [online] http://wradio.com.mx/radio/2017/09/01/nacional/1504292661_444049.html.
Young, A. (1928), "Increasing returns and economic progress", *The Economic Journal*, vol. 38, No. 152, December.
Zysman, J. (1983), *Governments, Markets, and Growth: Financial Systems and the Politics of Industrial Change*, Ithaca, Cornell University Press.

Annex A1

Key activities of the Mexican economy

In accordance with Rasmussen's indices, the key activities of the Mexican economy, for the 2012 social accounting matrix with 47 sectors, developed as part of this research, are those presented in table A1.1.

Table A1.1
Key sectors according to backward and forward linkages

	Description	Backward linkages	Forward linkages
A6	Electric power generation, transmission and distribution	1.155	1.422
A10	Food manufacturing	1.124	1.174
A16	Paper manufacturing	1.317	1.573
A18	Petroleum and coal products manufacturing	1.316	4.196
A19	Chemical manufacturing	1.125	4.349
A20	Plastics and rubber products manufacturing	1.310	1.389
A22	Primary metal manufacturing	1.210	2.349
A23	Fabricated metal product manufacturing	1.360	1.448
A24	Machinery manufacturing	1.387	1.636
A25	Computer, communications, measuring and other electronic equipment, components and products	2.032	2.892
A26	Electrical equipment, appliance and component manufacturing	1.576	1.324
A27	Transportation equipment manufacturing	1.481	1.473

Source: Prepared by the authors.

Annex A2

Parameters and variables of the recursive dynamic computable general equilibrium (CGE) model

Table A2.1
CGE-Mx12 parameters

Parameter	Description	Parameter	Description
Factors			
Captotecon	Total capital in the economy		
Labtotoecon	Total labour in the economy		
Households			
$\tau^{caphous}$	Share of households in *captotecon*		
MPSHOUS	Marginal propensity to save		
σcp	Constant elasticity of substitution	Production	Cobb-Douglas value added
δcp	Consumer preference parameter	αcap_j	Share of capital
Government		αlab_j	Share of labour
τ^{ithous}	Household income tax rate	$aescva_j$	Scale parameter
τ^{itcap}	Company income tax rate		CES combined input
$\tau^{IThousNAT}$	Domestic consumption tax	$\sigma ic_{i,j}$	Elasticity of substitution
$\tau^{IThousRoW}$	Tax on imported consumer goods	$\delta ic_{i,j}$	Share of factors
τ_j^{IP}	Production tax by activity	$\Phi ic_{i,j}$	Scale parameter
t^{invrow}	Capital import tax		Leontief total supply
$a_{trgovhous}$	Share of transfers in public expenditure	$uirc_{i,j}$	Unitary input requirement
a_{savgov}	Share of savings in public expenditure	$urva_j$	Unitary requirement of value added
$a_{conspubrow}$	Share of imports in public expenditure		Aggregate goods for private final consumption
$a_{conspubnat}$	Share of consumption in public expenditure	$urcp_i$	Unitary requirements for the final good
$\beta_{CONSPUBi}$	Share of each good in public expenditure	*RoW*	
Investment		τ^{caprow}	Share of RoW in *captotecon*
t^{deprec}	Depreciation rate	α_{LABROW}	Share of labour in RoW expenditure
t^{reinv}	Reinvestment rate	α_{TRROW}	Share of remittances in RoW expenditure
α_{INVRoW}	Share of capital imports in total investment	α_{SAVROW}	Share of savings in expenditure
α_{INVNAT}	Share of domestic investment in total investment	α_{EXPORT}	Share of exports in RoW expenditure
β_{INVi}	Share of each good in domestic investment	$\beta_{EXPORTi}$	Share of each good in exports

Source: Prepared by the authors.
Note: IT: income tax; CES: constant elasticity of substitution; RoW: rest of the world.

Table A2.2
CGE-Mx12 endogenous variables

Variable	Description	Variable	Description
	HOUSEHOLDS		GOVERNMENT
DISPINC	Household disposable income	*ITREV*	Income tax revenue
HOUSSAV	Household savings	*PRODTAXREV*	Product and production tax revenue
MPSHOUS	Marginal propensity to save	*IMPINVREV*	Capital import tax revenue
PRIVCONSNAT	Private consumption of national goods	*GOVREV*	Government revenue
PRIVCONSRoW	Private consumption of imported goods	*ITRATEHOUS*	Household income tax rate
IPCES	CES index	*TRGOVHOUS*	Social transfers
	SAVINGS-INVESTMENT	*SAVGOV*	Public savings
INVRoW	Investment in imported capital	*CONSPUBi*	Government consumption
INVNATi	Investment in domestic capital	*CONSPUBRoW*	Government imports
SAVTOT	Total savings in the economy	*GOVSURP*	Public surplus
	PRODUCTION		
$DEMCAP_j$	Demand for capital		PRICES
$DEMLAB_j$	Demand for labour	*Pcap*	Price of capital
VA_j	Value added	*Plab*	Price of labour
$DEMINPNAT_{i,j}$	Demand for domestic inputs	Pva_j	Price of value added
$DEMINPEXT_{i,j}$	Demand for imported inputs	$Pinpcombi_i$	Price of combined inputs
$DEMINPCOMBI_{i,j}$	Demand for combined inputs	Pts_i	Price of total supply
$TOTSUP_i$	Total supply by activity	*Pcp*	Price of aggregate private consumption goods
$DEMCPGDS_i$	Goods for private consumption	*ER*	Exchange rate
	REST OF WORLD	$Prow_i$	Price of imported inputs
REVROW	RoW revenue	*ProwCF*	Import price for final consumption
TRROWHOUS	Transfers from RoW		
SAVRoW	RoW savings		
LABROW	Labour hired by the RoW		
EXPORTi	Exports by activity		

Source: Prepared by the authors.
Note: IT: income tax; CES: constant elasticity of substitution; RoW: rest of the world.

Annex A3

Mathematical model

A. Households

$$DISPINC=[\ \tau^{caphous}*[captotecon*(1-\tau^{itcap}-\tau^{deprec}-\tau^{reinv})]*Pcap + (labtotecon - LABRoW)*Plab\ ]*(1-\tau^{ITHOUS})+LABRoW*ProwCF*ER + TRGOVHOUS + TRRoWHOUSE*ER \quad (1)$$

$$PRIVCONSNAT = \frac{(DISPINC-HOUSSAV)*\delta_{CP}^{\sigma^{CP}}*[Pcp*(1+\sigma^{IThousNAT})]^{-\sigma^{CP}}}{IPCES} \quad (2)$$

$$PRIVCONSRoW = \frac{(DISPINC-HOUSSAV)*(1-\delta_{CP})^{\sigma^{CP}}*[ProwCF*ER*(1+\sigma^{IThousNAT})]^{-\sigma^{CP}}}{IPCES} \quad (3)$$

$$IPCES=\delta_{CP}^{\sigma^{CP}}*[Pcp*(1+\sigma^{IThousNAT})]^{1-\delta_{CP}} + (1-\delta_{CP})^{\sigma^{CP}}*[ProwCF*ER*(1+\sigma^{IThousNAT})]^{1-\delta_{CP}} \quad (4)$$

$$HOUSSAV = MPSHOUS*DISPINC \quad (5)$$

B. Government

$$ITREV = [\tau^{caphous}*captotecon*(1-\tau^{itcap}-\tau^{deprec}-\tau^{reinv})*Pcap + (labtotecon - LABRoW)*Plab]*\tau^{ITHOUS}+\tau^{itcap}*captotecon*Pcap \quad (6)$$

$$PRODTAXREV = \sigma^{IDhousNAT}*PRIVCONSNAT*Pcp + \sigma^{IThogRoW}*PRIVCONSRoW*ProwCF*ER + \sum_j[VA_j*Pva_j+\sum_i DEMINSCOMBI_{i,j}*Pinpcombi_{i,j}]*\tau_j^{IP} \quad (7)$$

$$IMPINVREV = \tau^{invrow}*(INVRoW*ProwCF*ER) \quad (8)$$

$$GOBREV = ITREV + PRODTAXREV + IMPINVREV \quad (9)$$

$$TRGOVHOUS = \alpha^{trgovhous}*GOVREV \quad (10)$$

$$SAVGOB = \alpha^{savgov}*GOVREV \quad (11)$$

$$CONSPUB_i = \frac{\beta_i^{conspub}*\alpha^{conspubnat}*GOBREV}{Pts_i} \quad (12)$$

$$CONSPUBRoW = \frac{\alpha^{conspubrow}*GOBREV}{ProwCF*ER} \quad (13)$$

$$GOVSURP = GOVREV - TRGOVHOUS - GOVSAV - CONSPUBRoW*P_{RoW}CF*ER - \sum_i CONSPUB_i*Pts_i \quad (14)$$

C. Savings-investment

$$TOTSAV=HOUSSAV+GOVSAV+SAVRoW*ER+ (\tau^{deprec}+\tau^{reinv})*captotecon*Pcap \quad (15)$$

$$INVRoW=\frac{\alpha^{invrow}*SAVTOT}{ProwCF*ER*(1+\tau^{invrow})} \quad (16)$$

Two proposals for savings-investment closures are included in the section on macroeconomic closures.

D. Production factors

See the section on macroeconomic closures.

E. Production

Cobb-Douglas production function applied to value added. To produce the value added (compound factor), we used a Cobb-Douglas aggregation of constant returns to scale, where minimizing total cost generates optimal demands:

$$DEMCAP_J=\frac{\alpha cap_j*VA_j*Pva_j}{Pcap} \quad (17)$$

$$DEMLAB_J=\frac{\alpha lab_j*VA_j*Pva_j}{Plab} \quad (18)$$

With $\alpha cap_j + \alpha lab_j = 1$. And the assumption of perfect competition:

$$VA_j=aescva_j*DEMCAP_j^{\alpha cap_j}*DEMLAB_j^{\alpha lab_j} \quad (19)$$

In accordance with section II, for each productive sector j, we use the functional form:

$$Y_t=\left(\frac{VA_t}{VA_{t-1}}\right)^{\mu}aescva_t*DEMCAP_t^{\alpha cap_j}*DEMLAB_t^{\alpha lab_j}$$

where $\mu = 1.5$ for the key activities and $\mu = 0$ for all other activities.

CES production of combined inputs. By minimizing the cost, the optimal demands are:

$$DEMINPNAT_{i,J}=\frac{DEMINPCOMBI_{i,J}}{fiic_{i,j}}*\frac{\delta ic_{i,j}^{\sigma ic_{i,j}}*Pts_i^{-\sigma ic_{i,j}}}{[\delta ic_{i,j}^{\sigma ic_{i,j}}*Pts_i^{-\sigma ic_{i,j}}+(1-\delta ic_{i,j})^{\sigma ic_{i,j}}*(Prow_i*ER)^{1-\sigma ic_{i,j}}]^{\sigma ic_{i,j}/(\sigma ic_{i,j}-1)}} \quad (20)$$

$$DEMINPEXT_{i,J}=\frac{DEMINPCOMBI_{i,J}}{fiic_{i,j}}*\frac{(1-\delta ic_{i,j})^{\sigma ic_{i,j}}*(Prow_i*ER)^{-\sigma ic_{i,j}}}{[\delta ic_{i,j}^{\sigma ic_{i,j}}*Pts_i^{-\sigma ic_{i,j}}+(1-\delta ic_{i,j})^{\sigma ic_{i,j}}*(Prow_i*ER)^{1-\sigma ic_{i,j}}]^{\sigma ic_{i,j}/(\sigma ic_{i,j}-1)}} \quad (21)$$

And the assumption of perfect competition:

$$Pinscombi_{i,j} = \frac{1}{fiic_{i,j}} * [\delta ic_{i,j}^{\sigma ic_{i,j}} * Pts_i^{1-\sigma ic_{i,j}} + (1 - \delta ic_{i,j})^{\sigma ic_{i,j}} * (Prow_i * ER)^{1-\sigma va_{i,j}}]^{1/(1-\sigma ic_{i,j})} \quad (22)$$

Leontief production function of total supply (total gross production). By minimizing the cost, the optimal demands are:

$$VA_j = ruva_j * TOTSUP_j \quad (23)$$

$$DEMINPCOMBI_{i,j} = uirc_{i,j} * TOTSUP_j \quad (24)$$

And the assumption of perfect competition:

$$Pts_j = [urva_j * Pva_j + \sum_i uirc_{i,j} * Pinpcombi_{i,j}] * (1+\tau_j^{IP}) \quad (25)$$

Leontief production function of national aggregate goods for private final consumption:

$$DEMCPGDS_i = PRIVCONSNAT * urcp_i \quad (26)$$

$$Pcp = \sum_i Pts_i * urcp_i \quad (27)$$

F. Rest of the world (RoW)

At RoW prices.

$$REVROW = [PRIVCONSRoW + CONSPUBRoW + INVRoW] * ProwCF + \sum_i \sum_j DEMINSEXT_{i,j} * Prow_i + \tau^{caprow} * captotecon\ (1 - \tau^{itcap} - \tau^{deprec} - \tau^{reinv})\ \frac{P_{CAP}}{ER} \quad (28)$$

$$TRROWHOUS = \alpha_{trrow} * REVROW \quad (29)$$

$$SAVROW = \alpha_{SAVrow} * REVROW \quad (30)$$

$$LABROW = \alpha_{labrow}\ \frac{REVROW}{P_{RoW}CF} \quad (31)$$

$$EXPORT_i = \beta export_i * \alpha_{export}\ \frac{REVROW}{Pts_i/ER} \quad (32)$$

Small country scenario:

$$ProwCF = 1 \quad (33)$$

$$Prow_i = 1 \quad (34)$$

G. Macroeconomic closures

The sum of capital (labour) demands in each activity is equal to the total capital (labour) of the economy (full employment).

$$\sum_j DEMCAP_j = captotecon \quad (35)$$

$$\sum_j DEMLAB_j = labtotecon - LABRoW \quad (36)$$

Assuming that households' propensity to save does not vary significantly in the face of relatively small changes:

$$[SAVTOT - INVRoW * ProwCF * ER(1 + \tau^{invrow})]\beta inv_i = INVNAL_i * Pts_i \quad (37a)$$

By fixing investment, the marginal propensity to save remains variable:

$$HOUSSAV = \sum_i INVNAT_i * Pts_i + INVRoW * ProwCF * ER(1 + \tau^{invrow}) - SAVGOV - (\tau^{deprec} + \tau^{reinv}) * captotecon * P_{CAP} - SAVRoW * ER \quad (37b)$$

Lastly, the total demand for goods has to be equal to the total supply:

$$TOTSUP_i = \sum_j DEMINPNAT_{i,j} + DEMCPGDS_i + CONSPUB_i + INV_i + EXPORT_i \quad (38)$$

H. Recursive dynamics

The exercise was carried out across 10 time periods (t = 1, 2,..., 10). As noted above, labour is updated in each period according to the (constant) growth rate of the economically active population (EAP).

With regard to capital, its real return (ktr_t) is given by the total value of income divided by total savings, multiplied by the growth rate g_t. Looked at another way: $g_t = (SAVTOT_t * ktr_t) / (Pcap_t * captotecon_t)$, which means that savings multiplied by their return and divided by total income gives the growth rate, as savings are the difference between the income of two periods. Accordingly, capital is updated for each period as follows:

$$captotecon_{t+1} = (1+g_t) * captotecon_t$$

$$g_t = SAVTOT_t * ktr_t / (Pcap_t * captotecon_t)$$

Annex A4

Activities and their aggregate in large sectors

Large sector	Number	Activity
Agriculture	1	Agriculture
	2	Animal breeding and production; forestry; fishing, hunting and trapping; services related to agricultural and forestry activities
Oil and mining	3	Oil and gas extraction
	4	Metallic and non-metallic ore mining, except oil and gas
	5	Services related to mining
Electricity and gas	6	Electric power generation, transmission and distribution
	7	Water and gas supply through mains to the final consumers
Construction	8	Construction
	9	Civil engineering construction works; specialized construction works
Manufacturing	10	Food industry
	11	Beverage and tobacco industries
	12	Textile inputs manufacturing and textiles finishing, and textile products manufacturing, except apparel
	13	Apparel manufacturing
	14	Leather and hide tanning and finishing, and manufacturing of leather, hide and allied products
	15	Wood product manufacturing
	16	Paper manufacturing
	17	Printing and related support activities
	18	Petroleum and coal products manufacturing
	19	Chemical manufacturing
	20	Plastics and rubber products manufacturing
	21	Non-metallic mineral product manufacturing
	22	Primary metal manufacturing
	23	Fabricated metal product manufacturing
	24	Machinery manufacturing
	25	Computer, communications, measuring and other equipment manufacturing
	26	Electrical equipment, appliance and component manufacturing
	27	Transportation equipment manufacturing
	28	Miscellaneous manufacturing
Services	29	Retail trade
	30	Transportation
	31	Postal, parcel and warehousing services
	32	Mass media information
	33	Central bank, non-stock exchange credit and financial intermediation institutions, and stock market, currency exchange and financial investment activities
	34	Surety, insurance and pension companies
	35	Real estate services
	36	Rental and leasing of tangible goods, and rental services of trademarks, patents and franchises
	37	Professional, scientific and technical services
	38	Corporate services
	39	Business support services, and waste management and remediation services
	40	Educational services
	41	Outpatient medical services and related services
	42	Hospitals; social assistance and health care residential facilities; other social assistance services
	43	Cultural and sporting recreation services and other recreational services
	44	Temporary accommodation services
	45	Food and beverage preparation services
	46	Other services, except government activities
	47	Legislative, governmental and justice administration activities, and activities of international and extraterritorial organizations

Source: Prepared by the authors.

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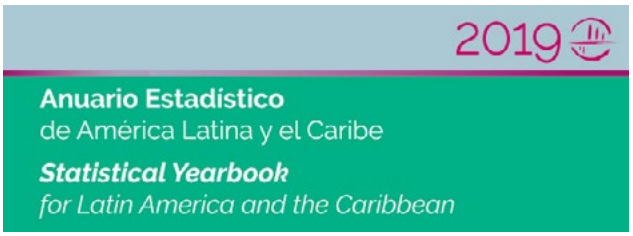

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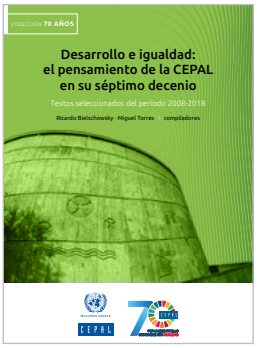

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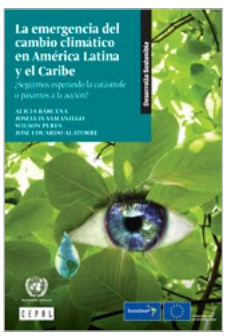

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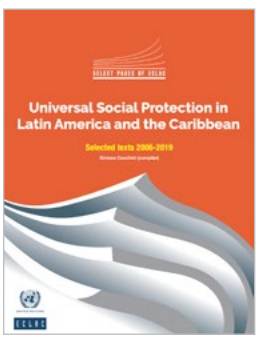

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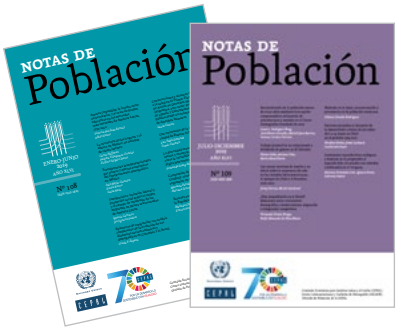

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