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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.

Industrial policy, economic growth and international engagement: a comparison of selected countries

Nádia Campos Pereira Bruhn, Cristina Lelis Leal Calegario and Michelle da Silva Borges

Abstract

The current debate on industrial policies is no longer focused on whether such policies are necessary, but on how best to implement them and on the lessons that can be learned (and transferred) from successful industrialization experiences. Accordingly, the aim of this paper is to analyse the impact of different configurations of industrial policies on the growth and international engagement of nine Latin American economies. This impact is measured by analysing autoregressive integrated moving average (ARIMA) models and intervention models for 1966–2014. The results show that the interventions analysed did not significantly modify the behaviour of the time series studied, except in the case of the economic growth series. For the other variables, the interventions were quite self-contained, and it was impossible to identify any behavioural pattern associated with the intervention periods analysed.

Keywords

Industrial policy, industrialization, development policy, economic liberalization, economic growth, economic history, econometric models, Latin America

JEL classification

F2, F23, L5, N16

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I. Introduction

In recent years, there has been a revival of interest in the importance of industrial policies in the Latin American countries. According to Devlin and Moguillansky (2012), this shift towards accepting a more proactive stance occurred partly in response to the great global recession of 2008–2009, and partly through disillusion with the policies implemented under the Washington Consensus. These entailed adjustments based on macroeconomic balances and market-oriented institutional reforms that strongly discouraged State intervention in productive activities. It is in this context that, according to the aforementioned authors, Latin American countries began to show an emerging interest in State interventions, implemented through proactive and systemic industrial policies aimed at leading the private sector to overcome structural constraints in terms of innovation, productive restructuring and export promotion. In fact, the perception of a more proactive industrial policy has become a reasonable goal in Latin American countries, since the "visible hand" of public interventions can be discerned in a number of successful initiatives in Asia, Oceania, Europe and even North America (Stiglitz and Lin, 2013).

While there is renewed confidence in the market's ability to perform a wide range of economic functions, there is also a recognition of its shortcomings in providing the ideal supply and demand conditions needed to ensure socially optimal investment in innovative and welfare-generating economic activities, which are seen as the main drivers of a country's wealth. This combination is causing national governments to reassess their policies and recognize that their competitive advantages are increasingly based on the assets and capabilities that they develop, and not merely on their natural factor endowments (Dunning and Lundan, 2008).

Based on these findings, the question underlying this research is: what is the relationship between the different configurations and intensities of State intervention (through industrial policy) on the domestic structural conditions and international engagement of Latin American economies?

To answer this question, this article analyses the effects of different configurations and intensities of State intervention, through industrial policy, on the characteristics that define: (i) the domestic structural conditions prevailing in the Latin American countries; and (ii) their international engagement.

The article starts by recognizing that, in the broadest sense of the term, industrial policies embrace a wide range of elements, traditionally comprising not only trade and investment policies, but also policies on science and technology, the promotion of micro, small and medium-sized enterprises, human resource training and regional development. In other words, governments can change the shape and behaviour of economic agents through different types of industrial policy instruments, including trade policy measures, capital controls, regulation, antitrust and competition policy and foreign direct investment (FDI) (Spar, 2009). The concept of industrial policy in this study is based on Rodrik (2008), which views it as encompassing all policies of economic restructuring towards more dynamic activities, whether or not in the industrial sector as such.

As the international community resets the goals for a post-2015 development agenda, it is crucial to ensure that effective industrial policy instruments are available that are consistent with the trajectory, current situation and specific features of the Latin American countries, which serve as mechanisms capable of achieving the proposed goals and make it possible to advance the development agenda in the countries of the region (UNCTAD, 2014).[1]

[1] "If macroeconomic policy is tacking uncomfortably close to the 'business-as-usual' strategy of the precrisis years, the discussions now under way on a post-2015 development agenda are tending to break with the past […] The international community faces three principle challenges in fashioning this new approach. The first is aligning any new goals and targets to a policy paradigm that can help raise productivity and per capita incomes everywhere, generate enough decent jobs on a scale to meet a rapidly growing and urbanizing global labour force, establish a stable international financial system that boosts productive investment, and deliver reliable public services that leave no one behind, particularly in the most vulnerable communities. […] The second challenge to consider in formulating a new development agenda is the massive rise in inequality, which has accompanied the spread of market liberalism.[…] The third challenge is ensuring that effective policy instruments are available to countries to enable them to achieve the agreed goals and advance the development agenda. Restoring a development model that favours the real economy over financial interests, puts sustainability ahead of short-term gains and truly seeks to achieve prosperity for all will almost certainly require adding more instruments to the policy toolkit than is currently contemplated by economic orthodoxy" (UNCTAD, 2014, pp. VI–VII).

Regardless of a country's political and economic orientations, and whatever the precise role played, the State is indispensable for competing in regional and global markets (Haar, 2015). Regardless of the origin of the issues surrounding the industrial policy debate, in the case of Latin America, the State has played a decisive role in development. The key question is no longer "whether" an industrial policy should be adopted, but "with what instruments" and "how" it should be adopted (Devlin and Moguillansky, 2012; Haar, 2015; Rodrik, 2008).

This article is divided into five sections, including this introduction and the conclusions. Section II sets out theoretical foundations for the domestic structural conditions and international engagement of the Latin American countries in recent years. Section III describes the procedures used to select the countries, the data source and the assumptions underlying the time series fit and the intervention analysis. The fourth section reports the results and analysis, while the fifth and final section presents the conclusions.

II. International engagement and economic growth: the renewed interest in industrial policy in Latin American

The developed countries adopted a range of industrial policies during their industrialization period and continued to do so after World War II. Industrial policy also became a priority on the agenda of many developing country governments, which saw industrialization as a key to unlocking hitherto underutilized resources and addressing structural and technological weaknesses (UNCTAD, 2014).

According to Bielschowsky (1998), the 1960s were characterized by industrialization-oriented reforms, which included a process of international engagement by the developing countries (especially those of Latin America), marked by the dependency and vulnerability of the least developed countries. The author argues that, in that period, the structural conditions of economic growth, technical progress and employment in those countries were characterized by lack of impetus, dependency and structural heterogeneity, giving rise to reformist political agendas.

The 1970s witnessed a reorientation of the development styles of Latin American countries. According to Bielschowsky (1998), the international engagement of these countries was characterized by dependency, indebtedness and insufficient exports; while the structural conditions of economic growth, technical progress and employment reflected an industrialization process that combined policies oriented towards the domestic market and exports, but with limited capacity to sustain economic growth weighed down by the debt burden.

In response to the first oil shock of 1973–1974, the subsequent oil crisis of 1978–1979 and the debt crisis of the 1980s, Latin American countries, which had maintained protectionist policies through the 1950s and 1960s, started to liberalize their economies as a development strategy (Biglaiser and DeRouen, 2006). Governments in the region began to integrate their economies more fully into the global economy, by lowering trade barriers, privatizing State-owned enterprises, and eliminating controls on prices and capital accounts (Hernández and Parro, 2008; Williams, 2015).

The phases defined in the preceding paragraphs are grouped into three intervention periods (see table 1). The first, encompassing the 1960s, 1970s and 1980s, corresponds to the period in which industrial policies implemented in Latin America were based on "inward-looking development" strategies (see table 1).

Table 1
First intervention and period of "inward-looking development"

Phase	International engagement	Domestic structural conditions
Reforms adopted in the 1960s, and industrial policies implemented to facilitate industrialization.	Dependency, international policy to reduce vulnerability in less developed countries (periphery).	Lack of impetus, dependency and structural heterogeneity that pointed to reformist political agendas.
Reorientation of development styles and industrial policies for greater export diversification.	Dependency, indebtedness and export insufficiency.	Industrialization, combining the domestic market and export promotion. Limited capacity to sustain economic growth under the debt burden.
1980s and overcoming the external debt crisis through policies to foster adjustment with growth.	Fiscal crisis that highlighted the need to liberalize markets.	Adjustment with growth. Need for foreign direct investment (FDI) inflow policies and stabilizing shocks. Debt crisis resulting in macroeconomic and fiscal constraints.

Source: Prepared by the authors.

Since the early 1980s, industrial policy has largely ceased to be a priority in the development agenda of many countries, and Latin America is no exception. This occurred partly as a reaction to evidence of specific policy mistakes and abuses; but it reflected a more ideologically driven debate that blamed government failures much more than market failures for slow economic development and emphasized the need for market liberalization (UNCTAD, 2014).

Bielschowsky (2009) characterizes the 1990s in Latin America as a period of trade liberalization and international engagement, based on inefficient export specialization and vulnerability generated by capital movements. The author argues that the industrial policies developed in this period generally sought to nurture a production base that would combine continuous productivity growth and competitive engagement in the international economy. However, the structural conditions of economic growth and technical progress posed difficulties in implementing an effective productive and social transformation.

The regulatory reforms introduced since the 1990s were an important component of a reform agenda aimed a keeping Latin America at the forefront of FDI attraction (World Bank/CAF, 2013). According to Devlin and Moguillansky (2012), many concerned governments started to question the merits of deregulation and FDI attraction policies in developing countries, given the disappointing growth experiences in the 1980s and 1990s. The authors further argue that the emergence of major competitive challenges to trade arising from the process of economic liberalization and the questioning of the Washington Consensus allowed the State gradually to re-emerge as an active promoter of productive transformation and economic development.[2]

The second intervention period spans the 1990s, plus the period between 1998 and 2003 and then 2003–2008. The period is characterized by "outward-looking development" and reflects the industrial policies formulated and implemented by governments in the region prior to the subprime financial crisis of 2008. Table 2 summarizes the three phases that characterize this intervention period in terms of the configuration of international engagement and structural conditions.

[2] The Washington Consensus represents a set of policies, based mainly on fiscal austerity, privatization and market liberalization, that were deployed to solve Latin America's problems in the 1980s and 1990s (Vicente, 2009). It advocated the State's withdrawal from the economy, either as an entrepreneur or as a regulator of national and international transactions, to allow the region's economies to submit to market forces (Bandeira, 2002). According to the Washington Consensus, the root of the problems facing Latin American countries was the development strategy adopted in the post-war period. This was based on the import substitution industrialization model, in which State protection of domestic firms was considered to have reduced their external competitiveness and discouraged exports (Portella Filho, 1994).

Table 2
Second intervention and period of "outward-looking development"

Phase	International engagement	Domestic structural conditions
1990s	Ineffective export specialization and vulnerability caused by capital movements. Actions aimed at increasing trade openness, attracting multinational companies, and competitive participation in the international economy.	Reforms with the central objective of preserving macroeconomic stability. Actions to develop a production base with increased productivity and competitiveness in the international economy.
1998–2003	Weakened international engagement owing to slow growth following the wave of financial and exchange rate crises in the emerging economies.	Crises in emerging economies that slowed economic growth rates and fuelled market volatility.
2003–2008	Consecutive years of growth associated with the commodity price bonanza. A strong impetus for policies to promote and expand international trade in the region.	Period characterized by five consecutive years of economic growth, expansionary fiscal policies, burgeoning international trade and rising commodity prices. Interruption of the development cycle in the region owing to the subprime financial crisis.

Source: Prepared by the authors.

Interest in proactive industrial policies was renewed in the late 1990s, and especially at the turn of the millennium, for several reasons: (i) the accumulating evidence that the most successful developing countries (particularly the newly industrialized economies of East Asia) were those that had adopted a pragmatic approach to the promotion of industrial development, combining macroeconomic and structural policies, protectionism associated with progressive openness to trade and investment, and effective public-private partnership; (ii) a growing recognition that the policies associated with the Washington Consensus were doing little to support modernization and economic diversification in developing countries; and (iii) the acceptance, even by mainstream economists, of the idea that economic development has a "structural" dimension. Logically, within the classical framework, there was increasing recognition of the importance of linkages and learning to accelerate productivity growth and the key role of demand in the dynamic of the economy (UNCTAD, 2014).

In 2008–2014, and especially from the second half of 2009 onwards, there were significant signs of improvement in the region's economies, including the recovery of industrial production and exports. At the same time, the growth of global activity and international trade volumes fuelled the demand for commodities, the higher prices of which improved the terms of trade (Bárcena, 2010). During this period, government intervention in response to the crisis (of exogenous origin) consisted of countercyclical fiscal policies that mitigated the impact of the crisis on the growth of economic activity in the region. Table 3 summarizes the characteristics of this intervention period in terms of the configuration of international engagement and structural conditions.

Table 3
Third intervention and post-global financial crisis period

Phase	International engagement	Domestic structural conditions
Period after the global financial crisis	Significant signs of improvement in the region's economies, including the recovery of industrial production and exports. At the same time, growth in the volume of international trade fuelled the demand for commodities.	Structural conditions of economic growth, technical progress and employment characterized by rapid recovery in most Latin American economies. Increase in the level of global activity.

Source: Prepared by the authors.

The orientation of industrial policies has thus shifted in the most recent period. The industrial policy debate has come to focus on a broader and more pragmatic approach: discussions no longer centre on whether industrial policies are necessary, but on how best to implement them, and on the lessons that can be learned (and transferred) from successful industrialization experiences, obviously taking into account the fact that specific policy measures adopted in some countries may not be easily replicable in others (Rodrik, 2008).

These findings show that individual success stories —or the lack of them— are invariably linked to domestic structural conditions and those related to the international engagement of each country, which are unlikely to be replicated elsewhere. This justifies an in-depth study of these analytical dimensions for the case of Latin America.

1. Identification of the intervention periods

In this study, three intervention periods are defined by classifying seven distinct phases. The first three phases encompass: (i) the 1960s, the reform agenda and the economic and sociological theories of stagnation, dependency and structural heterogeneity; (ii) the 1970s and the reorientation of the industrialization process to promote industrial exports; and (iii) the 1980s and debt renegotiation, inflation control and expansionary adjustment. These three phases constitute the first period of intervention, characterized by what Bielschowsky (1998) calls inward-looking development. This period was dominated by the defence of Latin America's industrialization process, the reduction of external vulnerability and domestic structural reforms, all with active participation from the State. In terms of FDI, the inward-looking development period is characterized by policies such as: (i) prohibition of entry and restriction of the operations of multinational firms in the host economy, including prohibition of foreign ownership in a wide range of activities linked to national sovereignty interests; (ii) restrictions on the movement of funds, through bureaucratic controls or tax measures that made it difficult to remit profits, interest or royalties; and (iii) discretionary treatment, in which multinationals were subject to domestic legislation that discriminated between foreign- and domestically-owned firms.

The second intervention period mainly reflects the post-1990s, characterized by an intensification of the market opening and deregulation movement, and the dissemination of measures to promote and attract FDI. The next three phases thus correspond to the second intervention period, characterized by "outward-looking development", when liberalization reforms predominated in Latin America, and the State played a more role in complementing the process. The fourth phase spans the entire 1990s and the trade liberalization period, with State intervention policies promoting international capital mobility, deregulation and privatization, backdropped by greater regional integration. The fifth phase, based on Aldrighi and Cardoso (2009), Bárcena (2010) and Bielschowsky (1998), which starts in 1998 and ends in 2003, was a period of declining economic activity after a wave of currency crises in emerging economies. State intervention was based on policies associated with the Washington Consensus. The sixth phase, based on Bárcena (2010) and Bielschowsky (1998), starts in 2003 and lasts until 2008. This was a period of economic growth, driven by stronger commodity prices and expansionary fiscal policies. The industrial policy debate focuses on a broader and more pragmatic approach than previously. These three phases jointly constitute the second intervention period, which runs from the 1990s to 2008 (before the subprime financial crisis).

The third intervention period, which begins in 2008 and lasts until 2014, corresponds to the seventh phase identified in this study and represents the post-financial crisis stage. Following Bárcena (2010), it is characterized by a rapid recovery in most of the region's economies. In this period, State intervention —in response to the crisis— takes the form of countercyclical fiscal and monetary policies, which seek to mitigate the impact of the crisis on economic activity across the region. According to Bremmer (2014), the post–2008 period characterizes a new phase, which he calls "guarded globalization" —a more cautious globalization in which developing country governments have become more wary of opening their industries to multinational corporations and seek to protect local interests. They choose the countries and regions with which they want to do business and the sectors in which they will allow capital investment; and they often select the State-owned enterprises they wish to promote, in a process that is very different from globalization: slow-moving, selective and with traces of nationalism and regionalism.

III. Methodological process

1. The data

The variables chosen for the analyses performed in this section represent the two analytical dimensions: the countries' international engagement and the domestic structural conditions. The latter are represented by the following variables: (i) economic growth; (ii) gross fixed capital formation; and (iii) FDI inflows. The variables representing the countries' international engagement are: (i) international trade; (ii) high-tech exports; and (iii) FDI outflows.

The variables selected for the analysis in this section were taken from the World Bank (2016b) database and are described in detail in annex A1. The analyses were performed using the Gnu Regression, Econometrics and Time-series Library (Gretl) statistical software package.

2. Choice of sample countries

This research focuses on the following Latin American economies: (i) Argentina; (ii) Brazil; (iii) Chile; (iv) Colombia; (v) Costa Rica; (vi) Ecuador; (vii) Mexico; (viii) Peru; and (ix) the Bolivarian Republic of Venezuela. The choice of these countries is particularly relevant in the current economic scenario and in the context of the international diffusion of technology, because, although their economies are heterogeneous, their different characteristics and dynamics make it possible to define a relevant framework of comparison. Although the region's countries are very different in many respects, they share a common element: in recent decades, governments have made active use of a variety of industrial policy instruments, with different effects on their domestic structural conditions and their international engagement. Moreover, according to data from the Economic Commission for Latin America and the Caribbean (ECLAC), these nine countries accounted for over 90% of Latin America's gross domestic product (GDP) in 2013, with Mexico and Brazil alone accounting for more than 60% (ECLAC, 2013).

The Latin American countries included in the sample are those participating in research in the FDI Regulations project, published by the World Bank (2010–2013), which are also ranked as upper-middle (UM) or high (H) income countries, according to the World Bank's analytical classification based on the countries' per capita GDP.[3] The countries selected for analysis based on this classification are presented in table 4.

Table 4
Latin America (9 countries): ranking of countries by per capita GDP, 2010–2015
(Dollars)

	2010	2011	2012	2013	2014	2015
Low income (L)	≤ 1 005	≤ 1 025	≤ 1 035	≤ 1 045	≤ 1 045	≤ 1 025
Lower-middle income (LM)	1 006–3 975	1 026–4 035	1 036–4 085	1 046–4 125	1 046–4 125	1 026–4 035
Upper-middle income (UM)	3 976–12 275	4 036–12 475	4 086–12 615	4 126–12 745	4 126–12 735	4 036–12 475
High income (H)	> 12 275	> 12 475	> 12 615	> 12 745	> 12 735	> 12 475
Argentina	UM	UM	UM	UM	H	UM
Brazil	UM	UM	UM	UM	UM	UM
Chile	UM	UM	H	H	H	H
Colombia	UM	UM	UM	UM	UM	UM

[3] The income-based ranking is updated in July each year for World Bank member economies and all other economies with a population of over 30,000. It serves as the official analytical classification during the World Bank's fiscal year (ending June 30). Therefore, until July of the following year, economies remain in the categories in which they are classified, regardless of any revision of their per capita income data (World Bank, 2016c).

Table 4 (concluded)

	2010	2011	2012	2013	2014	2015
Costa Rica	UM	UM	UM	UM	UM	UM
Ecuador	UM	UM	UM	UM	UM	UM
Mexico	UM	UM	UM	UM	UM	UM
Peru	UM	UM	UM	UM	UM	UM
Venezuela (Bolivarian Republic of)	UM	UM	UM	UM	H	UM

Source: World Bank, "New country classifications by income level: 2016–2017", 2016 [online] http://blogs.worldbank.org/opendata/new-country-classifications–2016 [accessed on 26 May 2016].

Note: Updates of national accounts data include Argentina, which was temporarily declassified in July 2016 pending the release of revised statistics. It was subsequently classified as an upper middle-income country in 2015.

3. Autoregressive integrated moving average (ARIMA) models

The models used to describe the time series are stochastic processes, in other words processes controlled by probabilistic laws (Morettin and Toloi, 2006). Thus, according to the constructions presented in Morettin and Toloi (2006), a time series could be, in general, a vector $Z(t)$ of order $r \times 1$, where t is a vector of order $p \times 1$. Having obtained the time series, $Z(t)$, ..., $Z(t_1)$, ..., $Z(t_n)$, in this study represented by the series that identify domestic structural conditions and international engagement, the next step is to identify the effects of the relevant periodicities, represented by the three intervention periods defined in section II.1.

In addition, the hypothesis of uncorrelated errors imposes a series of constraints on the validity of time series models that aim to describe the behaviour of series of this type. In such cases, the recommended practice is to fit the series to ARIMA models, which Morettin and Toloi (2006) describe in three different forms.

The first form refers to stationary linear processes represented by:

$$Z_t - \mu = \alpha_t + \psi_1 \alpha_{t-1} + \psi_2 \alpha_{t-2} + \cdots = \sum_{k=0}^{\infty} \psi_k \alpha_{t-k}, \psi_0 = 1 \quad (1)$$

In (1), α_t is white noise, $\mu = E(z_t)$ and + ψ_1, ψ_2, ... is a sequence of parameters such that:

$$\sum_{k=0}^{\infty} \psi_k^2 < \infty \quad (2)$$

In this first form, there are three special cases of model (1), namely: (i) an autoregressive process of order p: AR(p); (ii) a moving average process of order q: MA(q); and (iii) an autoregressive and moving average process of origin p and q: ARMA (p, q).

The second form refers to homogeneous nonstationary linear processes —a generalization of stationary linear processes which assumes that the series-generating mechanism produces autocorrelated errors, and that the series are nonstationary in level or slope, or both. In these cases, the series can be made stationary by differencing a finite number of times.

ARIMA models can also be described as long memory processes —that is, stationary processes that have an autocorrelation function that decays very slowly and will require fractional differencing for its analysis.

A widely used methodology for fitting ARIMA models is the Box, Jenkins and Reinsel (1976) approach. According to Morettin and Toloi (2006), this consists of fitting ARIMA (p, d, q) models to a data set. Consequently, the Box, Jenkins and Reinsel (1976) approach includes both autoregressive (AR) and moving average (MA) terms.

In an autoregressive AR(p) model, the data series Z_t is described by its regressed past values and random noise a_t.

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \ldots + \phi_p Z_{t-p} + a_t \quad (3)$$

Where $Z_t = Z_t - \mu$. The autoregressive model of order 1, or AR(1), is the simplest version of this class of models and is expressed as:

$$Z_t = \phi_1 Z_{t-1} + a_t \quad (4)$$

In AR models, it is accepted that $\overline{Z_t} = Z_t - \mu$ are the deviations from μ. So, $\overline{Z_t} = \phi_1 \overline{Z_{t-1}} + \phi_2 \overline{Z_{t-2}} + \cdots + \phi_p \overline{Z_{t-p}} + \alpha_t$ is an autoregressive process of order p, denoted by AR(p). That is, the series is represented by a weighted sum of p previous observations of the series plus a random term. Then, by defining the autoregressive operator as $\phi(B) = I - \phi_1 B - \cdots - \phi_p B^p$, where $B^p Z_t = Z_{t-p}$ is the lag operator, it can be described as $\phi(B)\overline{Z_t} = \alpha_t$ where α_t is the residual, in other words the noise.

The moving average process MA(q) is represented by:

$$Z_t = \mu + \alpha_t - \theta_1 \alpha_{t-1} - \ldots - \theta_q \alpha_{t-q} \quad (5)$$

where $\tilde{Z}_t = Z_t - \mu$.

Moving average (MA) models admit a process $\overline{Z_t} = \alpha_t = \theta_1 \alpha_{t-1} - \theta_2 \alpha_{t-2} - \ldots - \theta_q \alpha_{t-q}$, which views the series as a weighted sum of q previous observations of the noise, and α_t is called a moving average process of order q, denoted by MA(q). The moving average operator can then be defined by $\theta(B) = I - \theta_1 B^1 - \theta_2 B^2 - \ldots - \theta_q B^q$ which can be written as $\overline{Z_t} = \theta(B)\alpha_t$.

Consequently, the mixed autoregressive and moving average model (ARMA) includes both autoregressive and moving average terms and is represented by ARMA(p,q):

$$\overline{Z_t} = \phi_1 \overline{Z_{t-1}} + \cdots + \phi_p \overline{Z_{t-p}} + \alpha_t - \theta_1 \alpha_{t-1} - \theta_q \alpha_{t-q} \quad ou \quad \phi(B)\overline{Z_t} = \theta(B)\alpha_t \quad (6)$$

It is generally assumed that the series is purely random, or independent white noise, with zero mean and constant variance (Wooldridge, 2011). In practice, however, many series exhibit some form of non-stationarity; and, according to Wooldridge (2011), economic series, in particular, have a tendency to grow over time, so ignoring this fact can lead to erroneous conclusions. Since the series are assumed to be stationary, the original data need to be transformed. The most common procedure consists of taking successive differences in the series until a stationary series is obtained (Morettin and Toloi, 2006).

Morettin and Toloi (2006) argue that in some cases it will be sufficient to take one or two differences for the series to become stationary. The number of differences needed to make a series stationary is called the order of integration (d). According to the aforementioned authors, inclusion of the order of integration term makes it possible to use the ARIMA (p,d,q) models given by equation $W_t = \Delta^d Z_t$. They argue that, for ARIMA models, if $W_t = \Delta^d Z_t$ is stationary, W_t can be represented by an ARMA (p,q) model, as follows: $\phi(B)\overline{Z_t} = \theta(B)\alpha_t$. If W_t is a difference of Z_t, then Z_t follows a autoregressive integrated moving average (ARIMA) model of order (p,d,q), namely $\phi(B)\Delta^d \overline{Z_t} = \theta(B)\alpha_t$.

4. Intervention models

Intervention models analyse the occurrence, at a certain point in time t (known *a priori*) of an event of some kind that may manifest itself later and which affects the series being analysed, either temporarily or permanently (Morettin and Toloi, 2006).

Intervention analysis consists specifically in evaluating the impact of such an event on the behaviour of the series. Morettin and Toloi (2006) argue that economic series, in particular, are often affected by exogenous events that manifest themselves through changes in the level or slope of the series at a given moment. Thus, an intervention can affect a time series in several ways. Its manifestation may be abrupt or residual, and its duration may be permanent or temporary.

The greatest effects caused by interventions usually entail a change in the level, direction or slope of the series. The model can be expressed by:

$$Y_t = \sum_{i=I}^{k} \upsilon_i(B) X_{it} + n_t \qquad (7)$$

where Y_t is the model's response variable; k is the number of interventions in the series; $\upsilon_i(B)$ the value of the transfer function; X_{it} the binary variable: and n_t the model noise, represented by an ARIMA model.

In this study, intervention models are constructed by augmenting the ARIMA models with the effects of exogenous variables; in other words the effects of temporary historical and macroeconomic events associated with the government intervention, on the behaviour of the series representing domestic structural conditions (economic growth, gross fixed capital formation and FDI inflows) and international engagement (international trade, high-technology content exports and FDI outflows).

The intervention variables incorporated into the model were selected on the basis of historical events that represent different intensities and configurations of State interventions in Latin American countries. The classification of the periods is based primarily on the work of Bielschowsky (1998), complemented by contributions from Aldrighi and Cardoso (2009), Bárcena (2010), Biglaiser and DeRouen (2006), Bremmer (2014), Devlin and Moguillansky (2012), Machinea and Vera (2006) and Rodrik (2008).

In this study, the intervention analysis is based on the three distinct periods defined in section II.1.

IV. Results and analysis

This section presents the results obtained for the ARIMA and intervention models fitted to the Latin American countries included in sample, in the following order: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru and the Bolivarian Republic of Venezuela.

1. Argentina

Estimations of the fit of the ARIMA model for Argentina are reported in table 5, comprising: (i) a model with autoregressive and integrated structure for the variable "FDI inflows"; (ii) a model with autoregressive and moving average structure for the variable "high-tech exports", and (iii) a model with autoregressive, integrated and moving average structure for the variable "FDI outflows".

Table 5
Argentina: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth				
Outward-looking development	3.98042	1.31403	3.029	0.0025 ***
FDI inflows ARIMA(1,1,0)				
Phi_1	-0.331300	0.140005	-2.366	0.018 **
High-tech exports ARMA(1,1)				
Phi_1	0.623372	0.182174	3.422	0.0006 ***
Theta_1	-1.00000	0.157732	-6.340	2.30e-010 ***
FDI outflows ARIMA(1,1,1)				
Constant	-0.00803544	0.004124	-1.949	0.0513 *
Phi_1	0.374805	0.142553	2.629	0.0086 ***
Theta_1	-1.00000	0.063339	-15.79	3.76E-56 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The results obtained indicate that the interventions characterizing the "inward-looking development" period in the region —that is, the 1960s, 1970s and 1980s— were unable to modify the behaviour of any of the series analysed (see table 5). Table 5 does not report the results that were not significant after fitting the model. It is therefore concluded that the results were only significant when the "outward-looking development" period is considered and the variable for which behaviour was modified was economic growth.

Between the end of World War II and the mid-1970s, industrial policies in Argentina pursued import substitution; the main instruments being tariff and non-tariff barriers to imports, taxes on agricultural exports, various exchange rate regimes, subsidies and tax credits for investments in manufacturing industry (Sánchez, Butler and Rozemberg, 2011). In general, these three decades were dominated by protection for Latin America's industrialization process, the reduction of external vulnerability and domestic structural reforms, all with the active participation of the State (Bielschowsky, 1998).

With respect to the next three phases, which correspond to the period of "outward-looking development" —characterized by liberalizing reforms in Latin America, with more passive State action complementary to this process— the results indicate that the intervention was significantly and positively related only to Argentina's economic growth. In this period, which coincides with the formation of the Southern Common Market (MERCOSUR) in 1991, industrial policies were not abandoned but less emphasis was placed on them; so they became oriented towards strengthening competitiveness in a more open economic environment (Sánchez, Butler and Rozemberg, 2011).

In the period following the global financial crisis (2008–2014), this did not change the behaviour of any of the series analysed (see table 5). In fact, this period is characterized by rapid recovery in most of the region's economies. However, the intervention periods tested, in which policies are implemented to enhance competitiveness in order to participate in global markets (Melo and Rodríguez-Clare, 2006) and mitigate the impact of the global financial crisis on economic activity (Bielschowsky, 1998), did not contribute to changes in any of the time series analysed.

2. Brazil

The results for Brazil show that the interventions corresponding to the region's inward-looking development period boosted the economic growth and gross fixed capital formation series (see table 6). This period, between the post-war years and the end of the 1970s, is one of rapid industrialization accompanied

by nationalist developmentalism and State interventionism, which combined the political forces and economic interests of the industrialization project (Suzigan and Furtado, 2006). These three decades were dominated by protection of the industrialization process and domestic structural reforms, with active State participation.

Table 6
Brazil: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth AR(1)				
Phi_1	0.462032	0.124966	3.697	0.0002 ***
Inward-looking development	6.16003	1.21386	5.075	3.88e-07 ***
Outward-looking development	2.73969	1.32122	2.074	0.0381 **
Gross fixed capital formation AR(1)				
Constant	18.2378	1.08609	16.79	2.78e-063 ***
Phi_1	0.733381	0.144691	5.069	4.01e-07 ***
Inward-looking development	3.87548	1.61253	2.403	0.0162 **
High-tech exports ARIMA(1,1,0)				
Phi_1	0.439195	0.174138	2.522	0.0117 **
FDI outflows ARIMA(1,1,0)				
Phi_1	-0.717119	0.100574	-7.130	1.00E-12 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

In the outward-looking development period, which is identified by a series of liberalizing reforms in the region and a more passive State, the results show that intervention only modified (positively) the behaviour of Brazil's economic growth series. The 1990s witnessed the exhaustion of the import substitution model and the elimination of protection mechanisms for the industrial sector. This led to the opening up of the Brazilian economy, and, at the same time, the roll-out of privatization and deregulation programmes (Coronel, Azevedo and Campos, 2014; Suzigan and Furtado, 2006). The period also coincides with the formation of MERCOSUR in 1991. Although industrial policies were not abandoned, they ceased to be a priority in Brazil's economic policy agenda.

The intervention in 2008–2014 did not change the behaviour of any of the series analysed. However, in the inward-looking development period, the behaviour of the economic growth and gross fixed capital formation variables changes; and, in the outward-looking development period the behaviour of economic growth variable is altered. Table 6 does not report the results that were not significant after fitting the model. This intervention characterizes the period following the financial crisis, which was one of rapid recovery in most Latin American countries, including Brazil. State intervention was based on implementing countercyclical fiscal and monetary policies to mitigate the impact of the crisis on economic activity in the region.

3. Chile

The results for Chile show that the intervention that characterizes the period of inward-looking development (comprising the 1960s, 1970s and 1980s) only modified (positively) the behaviour of the FDI outflows series (see table 7). This intervention characterizes a period in which domestic structural reforms and the implementation of a unilateral trade liberalization policy predominated in the country.

Table 7
Chile: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth ARMA(1,1)				
Constant	4.41086	0.754909	5.843	5.13e-09 ***
Phi_1	-0.543451	0.127358	-4.267	1.98e-05 ***
Theta_1	1	0.065637	15.24	2.06e-052 ***
Gross fixed capital formation ARIMA(1,1,1)				
Phi_1	0.704025	0.136737	5.149	2.62e-07 ***
Theta_1	-1.00000	0.074683	-13.39	6.93e-041 ***
Outward-looking development	2.86977	1.58419	1.812	0.0701 *
Global financial crisis	4.47275	1.69919	2.632	0.0085 ***
FDI inflows ARIMA(1,1,1)				
Constant	0.231501	0.027782	8.333	7.89e-017 ***
Phi_1	0.266776	0.157375	1.695	0.0900 *
Theta_1	-1.00000	0.069796	-14.33	1.47e-046 ***
FDI outflows ARIMA(1,1,1)				
Constant	-2.61969	1.12258	-2.334	0.0196 **
Phi_1	0.389821	0.155731	2.503	0.0123 **
Theta_1	-1.00000	0.071585	-13.97	2.39e-044 ***
Inward-looking development	2.67167	1.13426	2.355	0.0185 **
Outward-looking development	2.72713	1.10487	2.468	0.0136 **
Global financial crisis	2.6519	0.973648	2.724	0.0065 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The intervention that characterizes the outward-looking development period (from the 1990s to 2007) positively and significantly modified the behaviour of the gross fixed capital formation and FDI outflows series. Table 7 does not report the results that were not significant after fitting the model.

Since the 1990s, Chile's industrial policy repertoire can broadly be characterized as well-coordinated, horizontal and export-oriented, with the Production Development Corporation (CORFO) serving as the country's main development agency (Agosin, Larraín and Grau, 2010). The government complemented the unilateral trade liberalization of the 1980s with an extensive programme of bilateral free trade agreements (Aninat and others, 2010).

Interventions in the period following the global crisis positively influenced the behaviour of the gross fixed capital formation and FDI outflows series. This intervention reflects a period in which, according to Agosin, Larraín and Grau (2010), Chilean industrial policy embarked on a process of transition from a model based on horizontal policies to a new model based on vertical industrial policies targeted on specific groups of industries. This process, based on the correction of market failures, prevailed from the 1980s until around 2000.

4. Colombia

The results for Colombia show that the intervention periods prior to the 1990s —those corresponding to "inward-looking development"— were unable to modify the behaviour of any of the series analysed (see table 8). According to Meléndez and Perry (2010), although, like other Latin American countries, Colombia pursued an import substitution industrialization strategy from 1950 until the early 1990s, from 1967 onward the strategy was hybridized by adding export promotion to import substitution. The aforementioned authors argue that the main policy instruments used to implement the import substitution model included trade protectionism, tax exemptions and subsidized credit.

Table 8
Colombia: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth ARIMA(1,1)				
Phi_1	0.986632	0.023572	41.86	0.00E+00 ***
Theta_1	-0.635198	0.21847	-2.907	0.0036 ***
FDI inflows ARIMA(1,1,1)				
Constant	0.099417	0.014351	6.927	4.29e-012 ***
Phi_1	0.289042	0.147583	1.959	0.0502 *
Theta_1	-1.00000	0.062073	-16.11	2.17e-058 ***
High-tech exports(1,1)				
Phi_1	0.716328	0.108296	6.615	3.73e-011 ***
Theta_1	-1.00000	0.078472	-12.74	3.39e-037 ***
Outward-looking development	0.432655	0.11506	3.76	0.0002 ***
FDI outflows ARIMA(1,1,1)				
Phi_1	-0.308372	0.141821	-2.174	0.0297 **
Theta_1	-0.999999	0.075209	-13.30	2.43e-040 ***
Outward-looking development	0.066992	0.007546	8.878	6.82e-019 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

Interventions become significant from the 1990s onwards and characterize the period of "outward-looking development", dominated by the protection of Latin America's industrialization process, the reduction of external vulnerability and domestic structural reforms, all with the active State participation (Bielschowsky, 1998). This intervention period positively modified the behaviour of the high-tech exports and FDI outflows series (although to a lesser extent in the latter).

In Colombia, this period is characterized by the implementation of policies to eliminate a large part of the trade protection institutions and instruments, capital account liberalization and several other measures that changed the nature of industrial policies. The paradigm shifted from a model based on protectionism to a more open economy from the start of the 1990s (Meléndez and Perry, 2010).

In contrast, intervention in the post-global crisis period (2008–2014) did not change the behaviour of any of the series analysed. In the most recent period, Colombian industrial policies have been largely selective and highly sectoral (Meléndez and Perry, 2010). This intervention characterizes the period following the financial crisis, which saw rapid recovery in most Latin American countries, including Colombia. Table 8 does not report results that were not significant after fitting the model.

5. Costa Rica

The results show that the interventions characterizing the inward-looking development, outward-looking development and post global financial crisis periods had positive effects only on the behaviour of the economic growth series (see table 9). Table 9 does not report results that were not significant after fitting the model.

The results obtained for the intervention in the inward-looking development period reflect not only the 1960s and 1970s, when industrial policy instruments based on State protectionism and the "entrepreneurial state" model were adopted in Costa Rica, but also the period following the economic crisis of the early 1980s. Although interventionist industrial policies were not abandoned in the latter period, their nature and objectives were changed to align with a new vision that sought to promote non-traditional exports to markets outside Central America. This meant changing industrial policy instruments, target sectors and beneficiaries (Monge-González, Rivera and Rosales-Tijerino, 2010). Accordingly, this period is characterized by an inward-looking economic strategy that was deployed during the 1960s, 1970s and part of the 1980s (Bielschowsky, 1998).

Table 9
Costa Rica: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth MA(1)				
Theta_1	0.557633	0.122807	4.541	5.61e-06 ***
Inward-looking development	4.81883	0.854516	5.639	1.71e-08 ***
Outward-looking development	4.86091	0.954928	5.09	3.57e-07 ***
Global financial crisis	2.59415	1.42713	1.818	0.0691 *
Gross fixed capital formation ARIMA(1,1,0)				
Constant	4.74098	0.70175	6.756	1.42E-11 ***
Phi_1	0.426795	0.128572	3.32	0.0009 ***
FDI outflows ARIMA(1,1,1)				
Phi_1	-0.305765	0.137118	-2.230	0.0258 **
Theta_1	-0.512060	0.166541	-3.075	0.0021 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The policies implemented in the 1990s —which in this study are represented by the second intervention period (corresponding to outward-looking development) and show changes only in the behaviour of the economic growth variable— reflect a period of State intervention associated with the Washington Consensus.

The intervention that characterizes the post-financial crisis period (2008–2014) and influences the behaviour of the economic growth series corresponds to a period in which economic policies pursued increasing integration into the international economy. Thus, especially since the last decade, the implementation of a policy based on free trade agreements, in conjunction with the export promotion strategy of the last two decades, made attracting FDI a pillar of Costa Rica's growth (Monge-González, Rivera and Rosales-Tijerino, 2010). However, the behaviour of these variables was not modified during this period of analysis.

6. Ecuador

The results obtained for Ecuador indicate that the intervention characterizing the inward-looking development period did not alter the behaviour of any of the series analysed (see table 10). Table 10 does not report the results that were not significant after model fit.

Table 10
Ecuador: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth ARIMA(1,1,1)				
Phi_1	0.415984	0.137282	3.03	0.0024 ***
Theta_1	-1.00000	0.117616	-8.502	1.86e-017 ***
Gross fixed capital formation ARIMA(1,1,0)				
Phi_1	-0.318841	0.13705	-2.326	0.0200 **
Global financial crisis	0.996318	0.577856	1.724	0.0847 *

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The structural adjustment programmes implemented in Ecuador began in the 1980s and sought greater trade liberalization. The priority objectives were economic recovery, adjustment and economic stabilization, which led to a significant reduction in the role of the State as planner and regulator of

economic activity. There was no formally structured industrial policy in this country until the 1990s (Ministry for the Coordination of Production, Employment and Competitiveness/Ministry of Industry and Productivity, 2016).

The intervention that characterized the period of outward-looking development and prior to the global financial crisis did not change the behaviour of any of the series analysed.

The intervention that characterized the period following the global financial crisis only modified the behaviour of the gross fixed capital formation series (see table 10). The policies adopted in Ecuador in this period, include those of the Ministry of Industries and Productivity, the Industrial Policy of Ecuador 2008–2012 and the Institutional Strategic Plan 2011–2013. These aimed to nurture the development of national industry, through public policies and programmes, with a view to raising levels of quality, productivity and competitiveness (Coordinating Ministry of Production, Employment and Competitiveness/ Ministry of Industries and Productivity, 2016).

7. Mexico

The results for Mexico indicate that the intervention characterizing the inward-looking development period (the 1960s, 1970s and 1980s) did not change the behaviour of any of the series analysed (see table 11). Table 11 does not report the results that were not significant after model fit.

Table 11
Mexico: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth AR(1)				
Constant	3.74967	0.67551	5.551	2.84E-08 ***
Phi_1	0.298475	0.135397	2.204	0.0275 **
Gross fixed capital formation ARIMA(1,1,2)				
Phi_1	0.686771	0.134888	5.091	3.55e-07 ***
Theta_1	-0.725219	0.179953	-4.030	5.58e-05 ***
Theta_2	-0.274781	0.155734	-1.764	0.0777 *
FDI inflows ARIMA(1,1,0)				
Phi_1	-0.466714	0.1445	-3.230	1.20E-03 ***
International trade ARIMA(2,1,1)				
Constant	0.881001	0.122849	7.171	7.42e-013 ***
phi_1	0.82687	0.131533	6.286	3.25e-010 ***
phi_2	-0.390884	0.130074	-3.005	0.0027 ***
theta_1	-1.00000	0.058491	-17.10	1.57e-065 ***
Outward-looking development	0.539929	0.233057	2.317	0.0205 **
FDI outflows ARIMA(1,1,0)				
Phi_1	-0.410740	0.153539	-2.675	7.50E-03 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

From the 1940s until the second half of the 1970s, Mexico's economic development was based on robust State intervention to promote industrialization through import substitution and the adoption of protectionist policies. These included: (i) an import licensing requirement; (ii) officially set prices for imported goods; (iii) a ban on imports of a range of products obtained from abroad; and (iv) stringent regulation of FDI (Moreno-Brid, Rivas and Santamaría, 2005).

Between the early 1950s and the early 1970s, Mexico implemented an economic model known as "stabilizing development". Although the pillars of the import substitution model were maintained, in those two decades a set of economic measures were implemented that prioritized monetary stabilization, the reduction of balance of payments deficits, and measures such as exchange rate devaluation and the creation of mechanisms to attract FDI (Iglecias, Cardoso and Neves Streich, 2014).

In the case of Mexico, the intervention represented by the period of outward-looking development and prior to the global financial crisis only modified (positively) the behaviour of the international trade series. Since the mid-1980s, the Mexican economy started to operate under a liberal economic model, in which the economic policies had been established in the 1990s, based on the principles of the Washington Consensus (Calderón and Sánchez, 2012). Since the early 1990s, especially since the implementation of the North American Free Trade Agreement (NAFTA), State intervention was reduced, and neoliberal reforms were deepened through the process of privatization of State-owned enterprises, trade deregulation, Mexico's admission into NAFTA and the deregulation of FDI (Iglecias, Cardoso and Neves Streich, 2014).

The results of this study show that the intervention that characterized the post-financial crisis period did not modify the behaviour of any of the series analysed for Mexico.

8. Peru

The results reported in table 12 show that the period of inward-looking development (the 1960s, 1970s and 1980s) only modified (positively) the behaviour of the economic growth series (see table 12).

Table 12
Peru: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth AR(1)				
Phi_1	0.394873	0.137625	2.869	0.0041 ***
Inward-looking development	2.4205	1.42934	1.693	0.0904 *
Outward-looking development	4.55783	1.62294	2.808	0.0050 ***
Global financial crisis	4.21665	2.50132	1.686	0.0918 *
Gross fixed capital formation ARIMA(0,1,1)				
Theta_1	0.214174	0.114255	1.875	0.0609*
International trade				
Outward-looking development	2.03125	1.13326	1.792	7.31E-02 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The intervention that characterized the 1990s affected (positively) the behaviour of the economic growth and international trade series, as shown in table 12, which does not report the results that were not significant after fitting the model.

In the late 1980s, the Peruvian government started to adopt liberal policies and implement economic reforms (Prado, 2014).

The liberalization, privatization and deregulation policies adopted in the early 1990s contributed to macroeconomic adjustment and control of inflation and public debt; they also consolidated the structural reforms implemented to deregulate and privatize the economy (IMF, 2015).

In this study, the intervention representing the period after the global financial crisis (2008–2014) only modified (positively) the behaviour of the economic growth series.

9. Bolivarian Republic of Venezuela

The results obtained for the Bolivarian Republic of Venezuela show that the intervention period corresponding to inward-looking development did not alter the behaviour of any of the series analysed (see table 13). Table 13 does not report results that were not significant after fitting the model.

Table 13
Bolivarian Republic of Venezuela: Estimations of the ARIMA and intervention parameters

	Coefficient	Standard error	z	p-value
Economic growth				
Outward-looking development	3.55847	1.25173	2.843	0.0045 ***
Gross fixed capital formation AR(1)				
Constant	22.178	1.62985	13.61	3.62e-042 ***
Phi_1	0.704271	0.097842	7.198	6.11e-013 ***
FDI inflows ARIMA(1,1,0)				
Phi_1	-0.433137	0.138245	-3.133	0.0017 ***
FDI outflows				
Constant	0.189834	0.093235	2.036	0.0417 **
Outward-looking development	0.497542	0.122874	4.049	5.14e-05 ***

Source: Prepared by the authors.
Note: *significant p< 0.05; **highly significant p< 0.01; ***highly significant p< 0.001.

The discovery of oil, and its industrial extraction leveraged by foreign oil companies, contributed to changes in the Venezuelan production structure starting in the 1940s and 1960s. Based on the import substitution model, the Venezuelan State deployed policies to foster the formation of a more diversified production base (Levy-Carciente, 2013). However, none of the interventions of this period were significant.

On the other hand, the intervention that characterized the period of outward-looking development and prior to the global financial crisis did affect (positively) the behaviour of the economic growth series and FDI outflows. An important development in the 1990s in the Bolivarian Republic of Venezuela was the adoption of measures to eliminate non-tariff barriers, promote exports and deepen integration into the international economy (Levy-Carciente, 2013). In the Bolivarian Republic of Venezuela, this period reflects a set of policies adopted to increase the role of the State in the economy, not only as a regulator of economic activity, but also as the owner of the means of production (Guerra, 2013). The period is also characterized by an expansionary budgetary policy, formally established with the Economic and Social Development Plan of the Nation 2001–2007. This aimed to develop a diversified production system, open to international markets, and with the State participating in strategic sectors, but with openness to private investment to develop the later stages of the industrial fabric (Guerra, 2013).

The intervention in the period following the global financial crisis did not alter the behaviour of any of the series analysed for the Bolivarian Republic of Venezuela.

10. Summary of results

The results obtained show that interventions analysed did not significantly alter the behaviour of the series considered, except economic growth in the following cases: (i) for Argentina and the Bolivarian Republic of Venezuela in the outward-looking development period; (ii) for Brazil in the inward and outward-looking development periods; and (iii) for Costa Rica and Peru in all three intervention periods analysed.

Apart from these cases, the interventions proved to be quite self-contained; and no behavioural pattern could be detected for the sample of countries in terms of temporal shifts in the behaviour of the time series associated with the three intervention periods analysed.

In terms of gross fixed capital formation, the results indicate that: (i) in Brazil, the behaviour of this series was only modified (positively) during the inward-looking development period; (ii) in the case of Chile, it was altered (positively) in the outward-looking development periods and in the period following the global financial crisis; and (iii) in Ecuador there were also positive shifts in the behaviour of this series in the period following the global financial crisis. For most of the other countries, the effects revealed concern the trend component and gradual changes in the behaviour of the series (fluctuations around a straight line, with a positive or negative slope). The exceptions were Ecuador and the Bolivarian Republic of Venezuela, for which the trend component was not observed in this series. In fact, gross capital formation has proven to be one of the main challenges for resuming the path of vigorous and systematic growth in the region.

In the case of FDI inflows, no intervention was significant for the countries analysed. The results show that the FDI inflows series behaved like most economic series, in the period under review, since it presented only the trend component (with a positive or negative slope). The same applies to the variables of international trade, high-tech exports and FDI outflows. The exceptions are changes in the following series: (i) international trade for the intervention corresponding to the outward-looking development period in Mexico; (ii) high-tech exports during the outward-looking development period in Colombia, and (iii) FDI outflows in the three intervention periods for Chile and during the outward-looking development period in both Colombia and the Bolivarian Republic of Venezuela.

The results for the FDI outflows series in Chile, Colombia and Peru reveal behavioural shifts from the 1990s onwards. In the case of Chile, the effect begins in the inward-looking development period and extends into the period following the global financial crisis. This result reflects the recent intensification of the process of internationalization of the Latin American economies, in which FDI flows originating in the region itself started to increase through cross-border investment by Latin American multinational companies, known as “multilatinas”. For the other countries, the effects identified refer to the trend component (except for the Bolivarian Republic of Venezuela, for which no trend component was observed in this variable).

No significant results were found for the intervention characterizing the inward-looking development period for the FDI outflows variable, except in the case of Chile. This partly reflects the import substitution period in which Latin American firms were protected from foreign competition and faced limited competition domestically.

V. Final remarks

This article answers the question initially posed and achieves its objective of analysing the impact of different industrial policy configurations on the growth and international engagement of a selected group of nine Latin American countries. The study finds that the interventions analysed did not significantly modify the behaviour of the series examined, except in the case of economic growth. For the other variables, the interventions were quite self-contained, and no behavioural shift based on the intervention periods analysed was observed.

In fact, the results reported in this study reflect not only the uncertainty and negative shocks pervading the global economy, but also the sharp decline in consumption and domestic investment. Undoubtedly, economic activity slowed more rapidly in Latin America than in other emerging regions, and this accentuated slowdown partly reflects the role of commodity prices. The impossibility of identifying uncertainty and negative shocks in the global economy, the sharp fall in consumption and domestic investment, and the role of commodity prices in the analysis is a shortcoming of this study. However, these issues also suggest a direction for future research.

Lastly, the region has undergone profound economic and social transformations in recent decades. However, the challenges that remain include the need to place greater emphasis on building new skills and reducing barriers to economic activity, such as precarious infrastructure and inflexible, bureaucratic regulation; and the need to boost investment in gross fixed capital formation. Historically, rates of gross fixed capital formation in Latin America have been lower than those of other developing regions —particularly in terms of investment in machinery and equipment, which is usually associated with productivity. As a result, productivity cannot be maintained at sustainable levels.

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Annex A1

Table A1.1
Description of the selected variables and their respective periods of analysis

Dimension	Variable	Description	Period
Domestic growth conditions	Economic growth	Annual growth of gross domestic product (GDP) at constant local currency market prices.	1966–2014 for all countries.
	Gross fixed capital formation	Includes land improvements; plant, machinery and equipment purchases; construction of roads, railroads, schools, offices, hospitals, private residential housing and buildings.	1966–2014 for all countries, except Brazil 1970–2014.
	Inflows of foreign direct investment (FDI)	Net investment inflows to acquire a long-term organizational interest (10% or more of the voting shares) in an enterprise operating in an economy other than that of the investor. Includes the sum of equity capital, reinvested earnings and other short-term and long-term capital.	Argentina, Colombia, Mexico and Peru 1970–2014; Brazil and Chile 1975–2014; Costa Rica 1977–2014; Ecuador 1976–2014; the Bolivarian Republic of Venezuela 1970–2013.
International engagement	International trade	Sum of exports and imports of goods and services measured as a percentage of GDP.	1966–2014 for all countries.
	High-tech exports	High-tech exports of R&D-intensive products, such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery.	Argentina 1992–2014; Brazil 1989–2014; Chile 1990–2014; Colombia 1991–2014; Costa Rica 1994–2013; Ecuador 1990–2014; Mexico 1989–2014; Peru 1992–2014; the Bolivarian Republic of Venezuela 1990–2014.
	FDI outflows	Cross-border investment associated with a resident that has control, or a significant degree of influence, over the management of an enterprise in another economy. Includes the sum of equity capital, reinvested earnings and other types of capital. Ownership of 10% or more of the ordinary shares of voting capital is the criterion for determining the existence of a direct investment relationship.	Argentina, Brazil and Colombia 1970–2014; Chile and Costa Rica 1976–2014; Ecuador 1980–2014; Mexico 1979–2014; Peru 1981–2014; the Bolivarian Republic of Venezuela 1980–2013.

Source: Prepared by the authors, on the basis of World Bank, World Development Indicators [online database] http://databank.worldbank.org/data/home.aspx [accessed on 26 May 2016].

The relationship between universities and business: identification of thematic communities[1]

Cristian Brixner, Octavio Lerena, Mariana Minervini and Gabriel Yoguel

Abstract

This article analyses the link between universities and business from a neo-Schumpeterian evolutionary theory perspective. It aims to identify the thematic communities present in the literature that deals with the university-business relationship, highlighting the focuses of interest of this literature and currently emerging themes. Social network analysis and text mining tools are used for this purpose. The present contribution differs from other reviews by using large datasets, which made it possible to discern aggregate trends in scientific output. Six thematic communities were detected in the literature: technology parks, entrepreneurial university, triple helix, transfer channels, geographic perspective and open innovation. Once these communities were defined, the characteristics of each one were identified, along with their linkages, differences and limitations, with a view to gaining an understanding of the knowledge transfer processes.

Keywords

Knowledge management, universities and colleges, industrial sector, intellectual cooperation, scientific literature, data analysis, statistical methodology

JEL classification

C80, C88, L20, L24, 032, 050

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[1] A precursor of this article is the work of O. Lerena, M. Minervini and G. Yoguel "Comunidades temáticas en el estudio de la relación universidad-empresa: redes bibliométricas y minería de textos", *Working Paper*, No. 13, Buenos Aires, Centro Interdisciplinario de Estudios en Ciencia, Tecnología e Innovación (CIECTI).

I. Introduction

There are many studies of the university-business relationship that address the specific forms in which knowledge transfer occurs (Bozeman, 2000; Siegel and others, 2003), analysing its aggregate impact and role in promoting development (Drucker and Goldstein, 2007; Hessels and Van Lente, 2008).

This article seeks to identify different thematic communities present in this literature, based on a bibliometric analysis. The term "thematic community" is used here to refer to a group of contributions to the field of study that: (i) resemble each other in terms of the set of bibliographic references to which they refer; (ii) are nourished by a shared lexical repertoire; (iii) address the same issue or subject; and (iv) tend to be discursively related to each other by alluding to a distinctive set of dominant ideas or motifs. The study addresses the following research questions: What thematic communities can be identified through a bibliometric analysis of the literature on relations between universities and enterprise? What are the specific (identity) characteristics of each community? What type of communicating channels and dialogues can be identified between them through time?

The article's main contribution relative to previous research in this field is the use of large volumes of data that make it possible to examine aggregate trends in scientific output. Unlike most previous studies, which conduct either reviews (Bozeman, 2000; Perkmann and others, 2013; Drucker and Goldstein, 2007; Geuna and Muscio, 2009; Salter and Martin, 2001; Uyarra, 2010; Smith, 2007; Hessels and Van Lente, 2008), traditional bibliometric analyses (Abramo and others; Calvert and Patel, 2003), or small network analysis (Meyer and others, 2014; Randhawa, Wilden and Hohbergeret, 2016; Teixeira and Mota, 2012), this article draws on a large corpus of literature to identify different thematic communities that emerge from the network of contributions.

Section II of this article describes the theoretical framework in which the study is approached. Section III presents the methods used to detect the emergence of thematic communities in the study of the university-business relationship, namely social network analysis and text mining. Section IV presents the descriptive statistics of the corpus, and section V deploys content analysis to identify the predominant conceptual dimensions in each community. Section VI discusses linkages and differences between the communities in terms of the set of analytical dimensions they give rise to. Lastly, section VII presents the conclusions.

II. Theoretical framework

The aim of this paper is to understand the multiple and varied mechanisms through which knowledge is transferred in the university-business relationship. Given the complex and evolutionary nature of the knowledge generation derived from this linkage, the article is framed by three complementary theoretical approaches: the Schumpeterian and evolutionary approaches and complexity theory.

Specifically, the corpus of the university-enterprise relation can be characterized as a network with multiple nodes (authors and contributions), in which connections are based on the co-occurrence of bibliographic references. There are also hierarchies (the position of contributions in the thematic network) and relationships between epistemic communities.

To understand this dynamic, the concepts of "creative destruction" and "emergence of innovation" will be adopted in the framework of a competitive process derived from the Schumpeterian approach. Analogously, it is posited that the evolution of the different thematic communities in the study of the university-business relationship can be viewed as the result of competition between academic contributions. This dynamic gives rise to a new body of knowledge and diminishes the relevance of other contributions. Within this competitive process, different communities emerge that provide new interpretations and explanations of the university-enterprise relationship, while others lose explanatory power.

This theoretical approach is complemented by the evolutionary legacy perspective (Nelson and Winter, 1982; Langlois, 2003; Metcalfe, 2010; Nelson, 2003), which makes it possible to account for the competitive dynamics that exist between the different interpretations of the relationship between universities and firms. These dynamics, centred on variation, selection and retention processes, foster the emergence of explanations (contributions) that have more followers and greater presence and dynamism in the network.

The two legacies —Schumpeterian and evolutionary— are combined with the complexity perspective, which analyses systems formed by heterogeneous components (in this case, contributions to the literature on the relationship between university and business). The interaction of the different nodes (contributions), located in a network of connections with nonlinear relationships, reveals emergent properties, understood as diverse ways of interpreting the relationship (Kirman, 1997; Dopfer, Foster, and Pottset, 2004; Hodgson, 1998; Potts, 2001; Dosi, 1982; Metcalfe, Foster, and Ramloganet, 2006; Antonelli, 1999; Edquist and Hommen, 1999; Robert, Yoguel, and Lerena, 2017).

In this framework, to understand the emergence of, and changes in, the weights of the different thematic communities studying the university-business nexus, it is necessary to consider the following dimensions specifically: (i) the evolutionary path of institutions and organizations involved in knowledge transfer (Rosenberg and Nelson, 1994); (ii) the deepening of the division of labour in production, the appropriation of knowledge (Langlois, 2003) and the organization of technological knowledge production (Antonelli, 1999); (iii) the strategies deployed by firms to increase internal and external knowledge absorption capacities (Cohen and Levinthal, 1990); (iv) the ability to link with other agents that produce technological knowledge (Robert and Yoguel, 2010); (v) the degree of development of social technologies (Nelson and Sampat, 2001); (vi) the academic capacities of universities (Liefner and Schiller, 2008; Mansfield and Lee, 1996) for establishing linkages with the production sector in innovation projects; (vii) the supply of skilled labour from universities to firms (Salter and Martin, 2001; Lundvall, 2010; Metcalfe, 2010); and (viii) the design of science and technology policy (Rosenberg and Nelson, 1994; Lundvall, 2010; Metcalfe, 2010).

In this context, the characteristics of the linkages between universities and firms, and the way in which each contribution captures, describes and analyses the phenomenon, are fundamental for understanding the emergence of thematic communities. Far from being evident from the outset of the research, these communities emerge from the set of interrelationships that exist between the contributions (nodes) that make up the corpus. This gives rise to the generation of structures that model an idiosyncratic network architecture, which evolves over time and may result in the emergence of new communities. Linkages can also be conceptualized on the basis of relationships between authors and between communities through time. These dynamics relate directly to the "evolution" concept, insofar as they imply the selection and emergence of contributions in the network.

III. Method

The method used to identify thematic communities is based on social network analysis and text mining. Social network analysis is compatible with a complex-systems perspective, since it makes it possible to identify communities in the network of contributions, based on the structure of their linkages. These linkages are derived both from the relational data present in the bibliographic references and from the terminology appearing in the textual content of the contributions. Whenever contributions in the network have incomplete linkages, a structure emerges with a non-trivial configuration. This particular structure makes it possible to detect distinct communities through social network analysis.

Text mining, in contrast, is based on automated analysis of textual data and seeks to extract key concepts or significant relationships from large corpuses. Using these techniques, a bibliometric mapping was performed of the different communities or thematic areas that predominate in research into the university-business relationship.

The data source used was the Scopus repository, which encompasses more than 22,600 journals with external referees, books and publications in other media. A search was made for all contributions that included the university-industry syntagm in any part of the text, or at least one of the following three terms: linkage, transfer and interaction.

The results were restricted to the disciplines of management, economics and social sciences. The disciplinary boundary was determined so as to fit the theory that frames the research question. This was a methodological decision based on three factors. First, the relationship between the university and enterprise is an interdisciplinary research problem; so restricting the search to academic output in economics would be at odds with the nature of what is being studied. Secondly, such a decision would mean denying the strong roots that neo-Schumpeterian evolutionism has in the discipline of management, thus contradicting the theoretical framework that has been adopted. Strictly speaking, neo-Schumpeterian evolutionary economics has been in dialogue with researchers in both economics and management since its origins (Nelson and Winter, 1982; Nelson, 1991). Lastly, inclusion of the social sciences among the selected disciplines not only reflects the authors' quest to build an interdisciplinary corpus of studies on the relationship between the university and business, but is also in conformity with the methodology adopted in this study. This implies the creation of a network that is sufficiently open and complex for unforeseen results to emerge. This is only possible if a more general discipline is incorporated, which includes contributions produced outside the familiar field of economics.

The search yielded a set of 6,794 contributions. For each one, the abstracts, bibliographic references and a set of additional metadata were downloaded, including the title, author, source, publication date, and the number of citations received in Scopus. For this purpose, two Elsevier application programming interfaces (APIs) were used, which provide access to curated data.[2]

Of the 6,794 original contributions, records that did not include bibliographic reference data were discarded. Then, contributions that did not cite, or were not cited by, others were also eliminated, leaving 5,917 contributions published between 1981 and 2017.

Next, the similarity between two contributions i and j was measured using the Salton index (Salton and McGill, 1983):

$$P_{ij} = \frac{C_{ij}}{\sqrt{s_i \cdot s_j}} \quad (1)$$

where C_{ij} is the number of common elements in the references of contributions i and j; s_i is the number of references cited by i; and s_j is the number of references cited by j.

A reference co-occurrence analysis (Kessler, 1963) was performed using the UCINET 6 software for the analysis of social network data (Borgatti, Everett and L. Freeman, 2002). The references-documents matrix consisted of 5,917 contributions and 239,681 unique references, so its processing involved the calculation of nearly 1.5 billion possible combinations and almost 1 million edges.

Communities were detected using the Gephi network analysis software (Bastian, Heymann and Jacomy, 2009), in which the modularity tool is based on the Louvain algorithm. This algorithm seeks to determine the optimal number of partitions, such that the modularity index is maximized (Blondel

[2] The data were downloaded between 18 and 22 September 2017. Further details on the method implemented in this study are provided in Lerena (2019).

and others, 2008). The modularity index of a partition is a scalar between -1 and +1 that measures the density of linkages within communities, versus the density of linkages between them. For a weighted network, the modularity index is:

$$Q = \frac{1}{2m}\sum_{ij}\left[A_{ij} - \frac{k_i k_j}{2m}\right]\delta\left(c_i, c_j\right) \quad (2)$$

where:

A_{ij} represents the weights of the edges between nodes i and j; k_i is the sum of the weights of the edges associated with node i; c_i is the community to which node i is assigned; the function δ takes the value 1 if $c_i = c_j$ and 0 otherwise; and $2m$ is the sum of the weights of all edges. Using this algorithm, six thematic communities were detected in the corpus.[3]

Using the titles and abstracts of the contributions, a word co-occurrence analysis was performed in each of the detected communities. The VOSViewer software and the similarity measure known as association strength (Van Eck and Waltman, 2010) were used for this. The similarity s_{ij} between two items i and j was calculated as:

$$s_{ij} = \frac{c_{ij}}{w_i w_j} \quad (3)$$

where cij denotes the number of co-occurrences of items i and j; and wi and wj denote the total number of occurrences of items i and j, respectively.

IV. Descriptive statistics

Of the 6,794 contributions obtained, 5,231 (77%) are journal articles, 1,155 (17%) are books or book chapters, and 408 (6%) are contributions in other media.[4] The results include articles published in 977 scientific journals. Of the journals identified, 53% are associated with a single contribution. This suggests that more than half of the articles on the relationship between universities and business were not published in journals specialized in this thematic area. The 10 journals with the most contributions account for over 29% of the total number of articles in the database.

Based on social networks and an analysis of the co-occurrence of terms through text mining, six thematic communities were identified: (i) technology parks; (ii) entrepreneurial university; (iii) triple helix; (iv) transfer channels; (v) geographic perspective; and (vi) open innovation.

Just over 13% are contributions that are cited once only. The top five contributions in terms of the number of local citations, weighted by age, are shown in table 1. The term "local citation" means the number of times a contribution has been cited by others in the total network of 5,917, whereas "global citation" is the total number of citations reported by Scopus for each work.[5] As can be seen in table 1, the five contributions with the most local citations have a local-to-global citations ratio above 50%, which indicates that they are referenced more within the network than outside it. This pattern suggests that it is a cohesive network; in other words, the links that the contributions have inside the network are stronger than those that they have outside it.

[3] In this article, the term "corpus" refers to the 5,917 contributions that make up the literature on the relationship between universities and business.

[4] The descriptive statistics refer to the complete set of contributions obtained from the Scopus search.

[5] Local citations were weighted by age to make it possible to compare contributions without penalizing those published more recently.

Table 1
Five contributions with the most local citations, weighted by age
(Number of citations per year)

Classification	Contribution	Journal or book	Citations per year	Local/global citations *(percentage)*
1	"Academic engagement and commercialization: a review of the literature on university–industry relations" (Perkmann and others, 2013)	*Research Policy*	41.2	76
2	"University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?" (D'Este and Patel, 2007)	*Research Policy*	31.5	87
3	"University entrepreneurship: a taxonomy of the literature" (Rothaermel, Agung and Jiang, 2007)	*Industrial and Corporate Change*	27.8	62
4	"University-industry relationships and open innovation: towards a research agenda" (Perkmann and Walsh, 2007)	*International Journal of Management Reviews*	26.6	74
5	"Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study" (Siegel, Waldman and Link 2003)	*Research Policy*	24.7	68

Source: Prepared by the authors, on the basis of data from the corpus obtained at Scopus.

For each thematic community, table 2 shows, the percentage of contributions with respect to the total corpus, the period of publication, the most frequent researchers, the journal with the highest occurrence of publication, the most cited article and contributions from developing countries.[6]

Table 2
Main features of the thematic communities identified

	Technology parks	Entrepreneurial university	Triple helix	Transfer channels	Geographic perspective	Open innovation
Number of contributions (% of corpus)	210 (4)	757 (13)	1 378 (23)	1 040 (18)	1 291 (22)	1 241 (21)
Period of publication (average length of time in years)	1981–2017 (11)	1995–2017 (6)	1987–2017 (7)	1987–2017 (8)	1981–2017 (8)	1990–2017 (7)
Most frequent researchers (occurrences as first author)	Mian, S. (5) Schwartz, M. (5) Minguillo, D. (4)	Siegel, D. (10) Wright, M. (9) Guerrero, M. (8)	Etzkowitz, H. (30) Leydesdorff, L. (24) Bozeman, B. (8)	Mowery, D. (17) Azagra Caro, J. (10) Thursby, J. (10)	Huggins, R. (13) Cooke, P. (13) Leydesdorff, L. (11)	Carayannis, E. (12) Santoro, M. (11) Wang, Y. (9)
Most frequent journal (occurrences)	*Technovation* (32)	*The Journal of Technology Transfer* (70)	*Scientometrics* (96)	*Research Policy* (129)	*Research Policy* (81)	*Research Policy* (64)
Main contribution by degree of entry (indegree)	"Science parks and university-industry interaction: geographical proximity between the agents as a driving force" (Vedovello, 1997)	*Academic entrepreneurship: University Spinoffs and Wealth Creation* (Shane, 2004)	"The norms of entrepreneurial science: cognitive effects of the new university-industry linkages" (Etzkowitz, 1998)	"Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study " (Siegel, Waldman and Link, 2003)	"Science-based technologies: university–industry interactions in four fields" (Meyer-Krahmer and Schmoch, 1998)	"Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community" (Owen-Smith and Powell, 2004)
Authors from developing countries	Zhou, Xu and Manyike (2013)		Cassiolato and Lastres (1997), Brisolla (1998), Arocena and Sutz (2001), Eun, Lee and Wu (2006)	Giuliani and Arza (2009), Arza (2010), Dutrénit, De Fuentes and Torres (2010)	Sutz (2000), Corona, Doutriaux and Mian (2006), Lenger (2008)	López-Martínez and others (1994), Prabhu (1999), Numprasertchai and Igel (2005), Caetano and Amaral (2011), Guan and Zhao (2013)

Source: Prepared by the authors, on the basis of data from the corpus obtained at Scopus.

[6] The human development index (HDI) (UNDP, 2018) was used to identify developing countries. Developed countries were those with an HDI of at least 0.847. Thus, the list comprises 42 developed countries (the last of which is Portugal) and 147 developing ones.

V. Content analysis: thematic communities of the university-business relationship corpus

This section analyses the content and conceptual dimensions that predominate in each thematic community, based on the results of the bibliometric study.

1. Technology parks

This community, although the oldest on average, is also the smallest in terms of volume of contributions (see table 2). Technovation articles predominate. The oldest contribution (Brown and O'Brien, 1981) was published when some universities in the United States and Europe began to venture into the incubation of technology-based enterprises to participate in territorial economic development (Mian, 1997).

Technology parks are conceived as a defined space for interaction between universities and firms, where the latter —consolidated businesses, spin-offs or start-ups— are key agents for the commercialization of basic and applied research generated by universities. In this sense, the parks are considered important spaces (Vedovello, 1997) for firms to access research results through informal links that enable them to valorize the knowledge generated by researchers.

After the 1990s, this thematic community lost relevance in studies on the university-business relationship. This can partly be explained by the criticism of technology parks as relevant sources of technology transfer, and the questioning of their effectiveness in promoting innovation or joint research between scientists and entrepreneurs.

2. Entrepreneurial university

The entrepreneurial university community draws on contributions from strategic management, economics and network theory (Rothaermel, Agung and Jiang, 2007). Despite being the community with the youngest average age in the corpus (see table 2), it enjoyed rapid dissemination in the late 1990s.

The entrepreneurial university phenomenon was boosted in the United States by the enactment of the Patent and Trademark Amendments Act 1980 (the Bayh-Dole Act), which had significant effects in terms of the commercialization of intellectual property and other forms of university technology transfer (Siegel and Wright, 2015).[7] The emergence and expansion of this thematic community was largely due to a defensive strategy in the absence of formal research funding.

Although university technology transfer offices focused initially on issuing licenses and patents, this model influenced the emergence of start-up firms (Shane, 2004) and had positive effects on basic research in universities (Siegel and Wright, 2015). Interaction with biotechnology, nanotechnology and information and communication technology (ICT) start-ups located at the technological frontier kept the academic agenda up to date.

More recently, the entrepreneurial university model has evolved from a role based on technology transfer offices, in which the main objective was to commercialize the intellectual property generated at the university, to the formation of a new institutional framework known as the "entrepreneurial ecosystem". This shift involves a greater weight of incubators or business accelerators and science and technology parks to support technology transfer and the emergence of entrepreneurship centres (Siegel and Wright, 2015). Thus, there has been a shift from visualizing the university-enterprise relationship in terms of affiliates and intellectual property revenues, to considering it in terms of start-up businesses.

[7] The Bayh-Dole Act gave universities and research and development institutions in the United States the right to retain ownership of inventions.

3. Triple helix

In the framework of a new form of interaction between universities, firms and government, external funding for university research has increased since the 1980s, as part of a paradigm known as the "triple helix" (Etzkowitz and others, 2000). This is the community with the most contributions and the oldest average age (see table 2). The triple helix refers to a government strategy aimed at stimulating cooperation between universities and firms in creating and commercializing intellectual property, based on joint research and development (R&D) processes.[8]

It is postulated that the circulation of scientists, professionals and technicians belonging to each of the helixes is a key factor for the creation, circulation and appropriation of knowledge; and that it represents a new division of labour that requires specialists to act as interfaces.

From this standpoint, university research teams involved in interaction processes can be viewed as quasi-firms. These endeavour to capitalize knowledge by converting research results into a "club" type of good that allows its members to access rents. The helixes generate alliances and consortia, as well as a continuous division of labour among them, which manifests itself in out-of-equilibrium dynamics (Etzkowitz and others, 2000).

This new type of cooperation goes beyond the traditional function of the university, centred on research and human resource training. Changes in the financing of basic and applied research —in conjunction with budget constraints and increased private funding— are accompanied by a retargeting of research projects towards solving problems of industry and society. This change in the social contract is reflected in a loss of autonomy for researchers, and has given rise to differing views of the validity of the triple helix: both critical (Rosenberg and Nelson, 1994) and optimistic (Feller, 1990; Kleinman and Vallas, 2001).

4. Transfer channels

This community addresses the issue of knowledge transfer, also called the universities' "third mission" (Cohen and others, 2002; D'Este and Patel, 2007), and it studies the channels of public-private interaction. The most frequent channels are informal contacts, professional mobility, attendance at conferences, consultancies, technical assistance and joint research projects.[9] This transfer dynamic requires organizational changes and technological integration processes in both universities and firms.

In the seminal works of this line of research, the idea of academic engagement represents inter-organizational collaboration between universities and firms, involving direct interactions between actors (Rosenberg and Nelson, 1994; Srinivas and Viljamaa, 2008; Perkmann and others, 2013). This type of collaboration, which can be traced back to the American universities of the mid-nineteenth century, was confined to transfer, human resource training, consulting, training courses, research contracts, and problem solving.

In addressing the determinants of transfer, several contributions highlight the importance of non-institutionalized relationships; and they suggest that direct linkage with individual researchers may be more effective than transfer through research teams. The academic characteristics —both environmental and institutional— and the organizational practices of the universities to which they belong are key factors in explaining their performance (Siegel and others, 2003; Siegel, Waldman and Link, 2003; D'Este and Patel, 2007).

[8] The distinctive term "research collaboration" expresses these interactions.

[9] The publication of scientific texts should be added to this list of transfer channels, since "publication" is a distinctive term in the scientific community.

Much of this literature (Mansfield and Lee, 1996; Schartinger, Schibany and Gassler, 2001; Mowery and Sampat, 2004) argues that the set of channels used is biased in terms of the number of participating researchers: while most researchers are not linked, a small proportion collects most of the transfers.

Some contributions from this community (Rosenberg and Nelson, 1994; Dasgupta and David, 1994) approach the transfer from the perspective of different modes of organizing scientific research. The former provide a critical discussion of the literature that had proposed aligning knowledge from academia with the needs of industry, on the basis of institutional reforms that in practice restricted the researchers' independence from the firms.

Dasgupta and David (1994), meanwhile, analyse the institutional and normative features that characterize open science, and show that, although the reward system based on college reputation worked reasonably well, it entails various inefficiencies in the allocation of basic and applied scientific resources.

5. Geographic perspective

This literature uses a systemic approach to address the various modalities of technology transfer from universities to firms, which take place in geographically defined environments: local districts, regions or nations. The specifics of local environments shape the knowledge transfer process and influence its potential to promote systemic development.

Although this thematic community proclaims the proximity between university and business, the proximity to which it refers extends beyond the geographical dimension to also encompass cognitive aspects (Boschma and Frenken, 2010). Thus, a critical mass of firms in science-based sectors interacting with universities can lead to the formation of a regional system based on specific analytical knowledge (Asheim and Coenen, 2005).

At the same time, some contributions warn of problems that could potentially arise from excessive proximity between universities and business. For example, when analysing the capital goods industry in Germany, Meyer-Krahmer and Schmoch (1998) detect lock-in effects, which result in reduced openness to new technologies and are attributed to the stability of the sector and the long-standing links between firms and universities.

There is also evidence that regional knowledge spillovers occur depending on the number of firms, proximity to universities and local research capabilities (Audretsch and Lehmann, 2005). Despite the widely accepted idea that the economic benefits of public funding for research generate spillovers and localization effects, these can only be appropriated under specific technological, sectoral and knowledge-type conditions (Salter and Martin, 2001). Although advocates of the university focused on basic research see a trade-off between entrepreneurial activities and the volume of scientific texts published, Van Looy and others (2004) report experiences in which these activities complement each other.

6. Open innovation

This thematic community is the second most recent in the corpus of literature analysed. The thematic affinity between the older contributions of the group and the more recent literature on open innovation is evidenced by a distinctive set of terms.[10]

The increasing mobility of knowledge workers, the rise of the Internet, venture capital and the greater availability of potential external suppliers are some of the factors invoked to explain the emergence of open innovation (Giannopoulou and others, 2010; Lee, Ohta and Kakehi, 2010).

[10] Conceptually, this literature is closely intertwined. Some contributions highlight its "outward" linkages with other more traditional currents, such as those of regional innovation systems (Cooke and Leydesdorff, 2006) and national ones (Cooke and Leydesdorff, 2006).

This literature highlights the permeable nature of enterprise boundaries, which enables a constant knowledge flow. Within this framework, it analyses linkages with external sources of knowledge, based on cooperation with partners. This can take various forms, such as bilateral collaboration, innovation ecosystems and networks. The valorization of knowledge and its subsequent commercialization depend on endogenous business capabilities, the incorporation of external knowledge and collaboration networks.

The practice of open innovation brings with it a specific division of labour: it requires firms to valorize their formal innovation projects and make them available to other actors, such as competitors, suppliers, customers, venture capitalists and public research organizations. Although the focus is often on larger firms and knowledge-intensive sectors such as biotechnology (Owen-Smith and Powell, 2004), relationships can also involve small and medium-sized enterprises (SMEs) (Lee, Ohta and Kakehi, 2010) and traditional sectors (Spithoven, Clarysse and Knockaert, 2010).[11]

These dynamics require actors to have a minimum threshold of absorption capacities (Lane, Koka and Pathak, 2006) to be able to make linkages. Thus, the presence of intermediary institutions can be decisive (Spithoven, Clarysse and Knockaert, 2010) for small firms and traditional sectors, which often need support to establish linkages. The creation of new linkages can expand absorption capacities in these firms and trigger a virtuous feedback loop.

Intellectual property is a central pillar in this community; so open innovation enables firms to benefit from the assets of their partners, including their reputation and their relationships with investors. Thus, as participation in inter-firm alliances becomes increasingly important, distributed co-creation practices and collaboration with customers increase trust between actors and become a core value (Santoro and Saparito, 2003; Giannopoulou and others, 2010). However, contracts are often insufficient to ensure that the firm can appropriate the value of its innovation. In particular, firms no longer leave their inventions on the shelf simply because they cannot commercialize them themselves (Giannopoulou and others, 2010). On the contrary, they must engage in careful management of intellectual property in order to strategically exploit their own knowledge and the innovations of other firms (Giannopoulou and others, 2010).

VI. Discussion

This article has identified six thematic communities in the literature on the university-business relationship: technology parks, entrepreneurial university, triple helix, transfer channels, geographic perspective and open innovation.

Table 3 schematically displays the main differences and similarities between these thematic communities in terms of the research question, the prevailing theoretical framework, the focus of analysis, the lead actor in the relationship, the conceptual linkages between communities, and the role played by the new division of labour in the type of cooperation that is established.

In each of the thematic communities, dominant theoretical approaches coexist with a minority of critical contributions. In the case of the technology park community, the prevailing theoretical framework reflects neoclassical assumptions because the development of these parks can be understood as a response to the generation of spillovers in the context of market failures. For its part, the entrepreneurial university community has a pragmatic approach and bases its proposals on an eclectic theoretical perspective. The triple helix community involves a third actor —the government— the analysis of which requires a systemic theoretical framework, such as the innovation systems approach.

[11] The term "coopetition" is often used to refer to cooperation strategies that include participation by a competitor as a partner (Carayannis, Alexander and Ioannidis, 2000).

Table 3
Thematic communities: similarities and differences in several key dimensions

	Technology parks	Entrepreneurial university	Triple helix	Transfer channels	Geographic perspective	Open innovation
Research question	Limitations of spillovers generated by universities	Role of the university in economic development	Role of the actors involved in the new division of labour	What are the relevant transfer channels?	Regional and sectoral specifics explaining the transfer process	Role of stakeholder capabilities in an open innovation process
Theoretical framework	Neoclassical	Pragmatic, eclectic	Innovation systems	Evolutionary	Evolutionary economic geography	Evolutionary
Focus of analysis	Market failures	University involvement in the development	Interaction between university, business and government	Capabilities and connectivity in the university-industry relationship	Technology transfer based on geographic, cognitive, social, institutional and organizational proximity	Openness of research and development (R&D) projects of companies with partners
Actor assuming leadership	Technology parks and universities	Universities	Universities, business and government	Universities and companies	Regions and sectors	Firms
Conceptual linkages between communities	Entrepreneurial university	Technology parks, triple helix	Entrepreneurial university	Open innovation, entrepreneurial university	Open innovation	Transfer channels, geographic perspective, triple helix
Role of division of labour	Not relevant	Intellectual division of labour	Changes in the functions of each helix	Not relevant	Geographically bounded	Centralized in the firm and partners

Source: Prepared by the authors, on the basis of data from the corpus obtained from Scopus.

The other communities (transfer channels, geographic perspective and open innovation) are closer to the evolutionary theoretical framework discussed. In the transfer channels community, the contributions inquire about the presence or absence of capabilities and linkages between universities and firms. This community suggests that the predominant channels are not based on the generation of start-ups, licences or patents. The geographic perspective community, in contrast, is interested in technology transfer based not only on geographic proximity but also on cognitive, social, institutional and organizational proximity. Lastly, the open innovation community studies the co-evolution and synergy between the capacities of organizations, the connections between them and the mechanisms of open innovation. In all three communities (transfer channels, geographic perspective and open innovation), the spillovers generated by economic engagement —materialized in transfer mechanisms or in the generation of research activities themselves— are not considered a market failure. On the contrary, spillovers are a positive aspect of the generation and circulation of knowledge and rent capture by firms in the competition process.

Much of the evolutionary literature stresses the need to view the link between the university and the firm as a deepening of the division of labour, in a context in which the generation and appropriation of knowledge are becoming increasingly important for developing competitive advantages and appropriating quasi-rents (Nelson and Sampat, 2001; Langlois, 2003). However, these issues are not discussed in all communities. For example, since technology parks are designed to take advantage of knowledge spillovers, the analysis of the division of labour is not a frequent approach. In the entrepreneurial university community, another perspective on the division of intellectual labour is raised, focused on bringing universities and firms closer together, by virtue of the former's new entrepreneurial role. The triple helix community, for its part, highlights the importance of synergies in the division of labour and the interaction between university, business and government, as well as the geographical and entrepreneurial aspects that condition them. This issue is not considered in the community transfer channels because it focuses on the predominant types of channel. Lastly, the division of labour is bounded regionally in the geographic perspective community and acquires a new central role in the open innovation community, owing to the significant weight of the firms that open their research and development (R&D) projects to the partners.

With respect to developing countries, from the perspective of the technology park community, there is a weak link between national innovation systems and production structures. In the case of the entrepreneurial university community, the main constraints are underestimation of the importance of forming skilled human resources to improve enterprise capacities (Nelson and Sampat, 2001; Salter and Martin, 2001; Lundvall, 2010) and the failure to consider the importance of teaching and research as pillars of university modus operandi.

For its part, the triple helix community has been addressed by the literature of developing countries, especially in Latin America, since the mid-1990s (Arocena and Sutz, 2001; Brisolla, 1998; Casas Guerrero, 1997; Cassiolato and Lastres, 1997; Sutz, 2000; Vessuri, 1995). Criticisms of this approach can be summarized as follows: (i) there is a weak demand from firms for knowledge-intensive activities, partly owing to the nature of the predominant pattern of production specialization; (ii) under these conditions, the university-helix may have more linkages with helixes located in developed countries than with national ones; and (iii) the reduction in the public budget for science and technology, the increase in private financing and the pressures for universities to earn income from intellectual property have impaired the interaction between universities, government and enterprise in Latin America.

In contrast, the transfer channels community describes transfer processes in developing countries that go beyond patents, start-ups and licensing. The contributions originating in this community include Giuliani and Arza (2009), Arza (2010) and Dutrénit, De Fuentes and Torres (2010), who analyse transfer channels as a contribution to the design of institutional policies. The focus of interest is on issues such as the determinants of the formation of "valuable" links, the risk-benefit calculus associated with the different channels of public-private interaction, the relationship between the channels of interaction involved and the differential benefits perceived by the agents (researchers and firms) in the transfer processes.[12]

The geographic perspective community emphasizes that the relationship between universities and enterprise is mediated by the characteristics of the production specialization profile and by the small share of knowledge-intensive activities. Lastly, the open innovation community notes the reduced absorption capacities of firms in developing countries, the limited connectivity and the scant development of open innovation activities, which is compounded by the weakness of the networks to which the firms belong.

VII. Closing remarks

This article has explored the main trends in the literature on the relationship between universities and business in the last 20 years. Using a methodology based on social network analysis and text mining, it considers recent developments through a large corpus of literature. Six thematic communities are identified and analysed on the basis of a neo-Schumpeterian evolutionary conceptual framework extended with complexity. As stated in the theoretical framework, major differences and heterogeneities were found among the six communities identified. The study focused on a set of key characteristics in each community, to expose the linkages, counterpoints and constraints that these communities reveal, in order to understand the processes of knowledge transfer, both globally and in developing countries.

The set of communities, and especially the open innovation, triple helix and geographic perspective communities, make it possible to consider the relationship between universities and business from the neo-Schumpeterian evolutionary theory framework. These analyse the relationship as mechanisms of exchange, transfer and diffusion of knowledge through non-linear linkages that generate positive exchanges between the parties, beyond the production of spillovers, or as a strategy for universities to allocate funds to their research projects.

[12] In contrast to the dominant literature, which considers university-business linkages as beneficial per se, "valuable" linkages are those with the greatest potential to disseminate knowledge to other firms in the regional economy (Giuliani and Arza, 2009).

Another common characteristic of these communities is that they allude to processes of deepening the division of labour that give rise to the appropriation of knowledge and the obtaining of quasi-rents from innovation. Moreover, these transfer mechanisms require the development of social technologies to enable the flow of knowledge between the university and the firm.

The identification of thematic communities makes it possible to understand knowledge transfer between universities and firms, and, at the same time, to highlight the different science and technology policy guidelines that could emerge in each community. While the technology parks community prioritizes the need to foster the appropriation of knowledge spillovers generated in the link between universities and firms and in start-up incubation, the entrepreneurial university community recommends the creation of universities that emphasize entrepreneurial functions related to basic research. Especially since the passage of the Bayh-Dole Act in the early 1980s, these trends have been accentuated; and participation by scientists in the commercialization of patents and licenses, and in the emergence of start-ups, has become central.

The triple helix community highlights the need for a systemic approach, in terms of the capabilities of the helixes and their connections and in relation to the overlap between the functions of each one. In contrast, the transfer channels community shows the need to connect research groups, stimulate informal channels and focus on channels that are not centred on patents, start-ups and licenses. Lastly, the technology parks community focuses its recommendations on the need to increase capacities and linkages at the regional and sectoral levels; while the open innovation community proposes to operate on the determinants of capacities, encouraging open innovation processes and network formation.

Much of the literature on the university-business relationship has emerged and disseminated since the mid-twentieth century in developed countries. The results of this research indicate that in the last two decades an uncritical adoption of these contributions has prevailed in developing countries, although some exceptions can be identified.[13] In general, the literature has not considered the specifics of emerging countries, which tend to have patterns of production specialization characterized by weak interaction between firms, universities and public agencies, as well as low thresholds of technological knowledge. There is also large cognitive distance between the university and the private sector, weaknesses in science and technology infrastructure, and firms with low R&D-oriented absorption and linkage capacities.

The identification and evolution of the different thematic communities that represent the link between the university and enterprise express the evolutionary path of the institutions and organizations involved in the dynamics of technological change. Thus, each community contains its own questions regarding the way in which universities and firms address the demands of competition and institutional change. One of the distinctive aspects of each community is the role assigned to technological and organizational capacities, and the type of linkages that exist among of the agents involved in generating and appropriating knowledge. The degree of complexity of the relationship depends, in turn, on the predominant specialization profile, the regime of incentives facing the universities and firms, and the resources and dynamic capacities that both actors develop over time.

[13] See, for example, Suzigan and Motta and Albuquerque (2008).

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The economic impacts of tourism-related private investment in Jamaica

Martín Cicowiez and Romina Ordoñez

Abstract

This study assesses the economy-wide impacts of private investment in the hotel industry in Jamaica. Specifically, the paper develops a tourism-extended social accounting matrix (SAM) and a dynamic computable general equilibrium (CGE) model tailored to the Jamaican economy. To analyse impacts in terms of poverty and inequality, the CGE model results are linked with a microsimulation model. The results demonstrate that private tourism investments leading to an expansion of foreign demand for tourism can have positive impacts on national economies in terms of gross domestic product (GDP), employment, household incomes and poverty reduction. However, the distribution of benefits is dependent on socioeconomic factors such as the distribution of factor endowments among households. At the sectoral level, sectors catering more directly to tourism experience the highest rates of growth, while more export-oriented sectors do not fare as well given the upward pressure on prices and the real exchange rate resulting from higher tourism spending.

Keywords

Tourism, investments, private sector, hotel industry, economic growth, poverty mitigation, equality, evaluation, mathematical models, Jamaica

JEL classification

L83, C68, I3, O1

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I. Introduction

Jamaica possesses diverse natural resources and a rich cultural heritage, which provide a range of attractions for tourists. In fact, tourism has been an important sector of Jamaica's economy since the 1950s (Taylor, 2003). International arrivals in Jamaica (excluding cruise passengers) grew from around 1.7 million visitors in 2006 to 2.2 million in 2016, an average annual growth rate of 2.7%.[1]

Tourism is a major source of foreign exchange for the economy and a potentially powerful means of reducing poverty. In fact, together with remittances, tourism is the largest source of foreign exchange: in 2016, earnings from tourism and remittances each represented about 15% of gross domestic product (GDP). The Statistical Institute of Jamaica (STATIN, 2017) estimates that the industry's share of total GDP in 2015 was 7.8%. The Bahamas, the Dominican Republic and Mexico recorded receipts from international tourism equivalent to 22%, 9% and 2% of GDP, respectively, showing how much the importance of the sector varies across economies in the Latin America and Caribbean region. In 2015, international tourism receipts accounted for 58% of exports in Jamaica, which ranked twelfth out of 195 countries on this measure. For comparison, the figures were 78%, 37% and 5% in the Bahamas, the Dominican Republic and Mexico, respectively (UNWTO, 2017).

Tourism also has the potential to advance the economic and social inclusion of women. For example, women account for approximately 59% of hotel and restaurant employees in Latin America and 55% in the Caribbean (UNWTO/UN-Women, 2011).

The tourism supply chain involves a wide range of social and economic sectors. The industry's contribution to growth, poverty reduction and long-term development depends upon complex and dynamic economic, social, environmental and institutional linkages, spillovers and externalities. The present study develops and applies a computational tool to assess the impact of tourism-related (private) investments. Specifically, it develops a tourism-extended social accounting matrix (SAM) and dynamic computable general equilibrium (CGE) and microsimulation models for Jamaica. It builds on previous work as published in Banerjee, Cicowiez and Gachot (2015) and Banerjee, Cicowiez and Cotta (2016) by focusing on private investments in the hotel industry and the sectoral composition of per capita tourist spending. In recent years, the CGE method has been used as a tool for coherent, forward-looking economy-wide analysis of tourism-related shocks from a medium- to long-run perspective (Dwyer, 2015; Blake, 2015). The present paper contributes to this literature by analysing the impact of a US$ 600 million private investment in the accommodation industry combined with an increase in the inflow and spending of foreign tourists in a relatively small island economy such as Jamaica.[2]

The results show that increased private investment in the hotel industry, combined with higher tourism spending, has a positive impact on GDP, employment, household incomes and poverty in Jamaica. With regard to inequality, the study does not find statistically significant changes in any of the scenarios considered. As for impacts on GDP growth at the sectoral level, the findings show service industries that cater directly to tourists, including hotels, restaurants and recreation activities, being strongly stimulated by the expansion in tourism investment. However, upward pressure on prices and the real exchange rate due to higher tourism spending leads to reduced competitiveness and a decrease in employment and value added in manufacturing and mining, two of Jamaica's most export-oriented sectors.

This paper is organized as follows. Section II provides an overview of the literature on tourism and growth. Section III provides a non-technical description of our CGE model for Jamaica and its current database. Section IV presents the model simulation scenarios and results. Lastly, section V offers concluding remarks. Annex A1 presents the results of a systematic sensitivity analysis with respect to selected elasticities, and annex A2 provides additional simulation results.

[1] In the same period, the number of cruise passengers arriving in Jamaica increased from around 1.3 million to 1.6 million.

[2] In 2017, this was equivalent to about 4% of GDP.

II. Literature review[3]

This section provides a concise review of recent literature that has assessed the impact of the tourism industry on growth and poverty using diverse methods. In recent years, tourism has been one of the fastest-growing economic sectors, generating 10% of global GDP and 30% of global exports in the service sectors (UNWTO, 2017). Tourism employs 1 in every 10 workers across the globe, equivalent to 330 million jobs in 2019 (WTTC, 2019). Pablo-Romero and Molina (2013) found a positive correlation between tourism and economic growth in 55 of 87 econometric studies reviewed that used time series, panel data and cross-sectional data. The relationship also holds good in the case of Latin America and the Caribbean, where Eugenio-Martín, Martín Morales and Scarpa (2004) confirmed this finding for 21 countries in the region between 1985 and 1998, with a particular focus on low- and middle-income countries. Furthermore, a study by Fayissa, Nsiah and Tadesse (2011) that used panel data for the period 1990–2005 found that a 10% increase in tourism expenditure in the Latin America and Caribbean region could increase per capita GDP by 0.4%. The overall relationship between tourism and economic growth in the region generally appears positive, though how benefits are distributed is more variable (Moreda and others, 2017).

The distribution of benefits depends on a variety of factors which may be destination- or activity-specific and conditioned by the country context, among other factors. For instance, Mitchell and Ashley (2010) review a range of empirical literature (CGE, input-output, regression analysis, qualitative analysis of microenterprises and livelihoods, and pro-poor value chain analysis) for destinations in Africa, Asia and Latin America and find evidence that 10% to 30% of tourism expenditure tends to accrue to the poor. In a recent study using a dynamic CGE model similar to ours, Njoya and Seetaram (2018) map the primary channels through which tourism can impact the poor, both positively and negatively. These include poor people's labour participation in the tourism value chain, the collection of taxes which can then be transferred to the poor, price channels (with currency appreciation as an example) and complex dynamic channels which can affect the socioeconomic environment of the destination and thus the setting in which the poor undertake their livelihood activities. In their application to Kenya, they find that where the economy of a destination is characterized by lower-skilled and labour-intensive sectors, there is a great probability that tourism development will increase the income of the poor. Interestingly, Jamaica's labour market is also dominated by (mostly unskilled) labour-intensive activities.

In the Latin American and Caribbean context, a number of country case studies have been undertaken to ascertain the dynamics between tourism development and poverty reduction (Moreda and others, 2017). In Costa Rica and Nicaragua, for example, evidence from time series econometrics suggests that a 1% increase in foreign tourism expenditure reduces poverty by 0.58% and 0.64%, respectively (Vanegas, Gartner and Senauer, 2015). For Panama, using a SAM multiplier model, Klytchnikova and Dorosh (2013) found that 20% of national income deriving from tourism expenditure reached the poor; this impact increased to 43% in destinations in the country that were particularly poor but tourism-oriented. In Haiti, using a regional CGE model, Banerjee, Cicowiez and Gachot (2015) found that a US$ 36 million public investment in tourism could reduce the number of people living in poverty by 1.6%. In Ecuador, analysis undertaken by Croes and Rivera (2017) using a SAM multiplier model found strong potential for tourism to reduce poverty and inequality (albeit this was a hypothetical simulation exercise). Lastly, where island States are concerned, Jiang and others (2011) found that for the 16 island States considered in their study, human development indicators and per capita GDP were positively correlated with tourism intensity, defined as the ratio of tourists to residents.

Interestingly, most applications of CGE modelling to the tourism sector assess the impact of changes in (i) tourism arrivals, (ii) per capita tourism expenditure and (iii) public investments in tourism-related infrastructure. Thus, our study is unique in using a CGE model to assess the economy-wide impact of an (exogenous) increase in private investment in the tourism sector.

[3] This section draws on Banerjee and others (2018).

III. Method and data

The tourism industry is not a single clearly defined sector. On the contrary, it is composed of many sectors such as hotels, restaurants, food and beverages, and transport. Similarly, investments in tourism also target diverse sectors, ranging from infrastructure development, the provision of basic public services such as water and sanitation and capacity-building in the services sector to measures to strengthen institutions in the interests of tourism sector governance. Thus, to assess the impact of any combination of policy interventions, private investments and external shocks affecting the tourism sector, a framework that includes all economic sectors and their interlinkages is essential (see, for example, Dwyer, 2015). In this study, a tourism-extended recursive dynamic CGE model for Jamaica was developed and implemented. CGE modelling offers a systematic method for predicting both the direction and approximate sizes of the impacts of policies, changes in private investment and external shocks on different agents.

1. The model

In a nutshell, our model integrates a fairly standard recursive dynamic CGE model (see, for example, Lofgren, Lee Harris and Robinson, 2002, and Robinson, 1989) with additional equations and variables that identify: (i) foreign tourism demand as the product of the number of foreign tourists and their spending per capita and (ii) the impact of private investments in the tourism sector. More precisely, our starting point for model development was our previous work as published in Banerjee, Cicowiez and Gachot (2015) and Banerjee, Cicowiez and Cotta (2016). In this particular application, however, we focus on private investments in tourism-related businesses such as hotels instead of public investments in tourism-related infrastructure. Thus, in contrast to other CGE models, the CGE that was developed for this particular application offers features relevant to the study of tourism investment, tourist arrivals and expenditure scenarios in a country's economy.

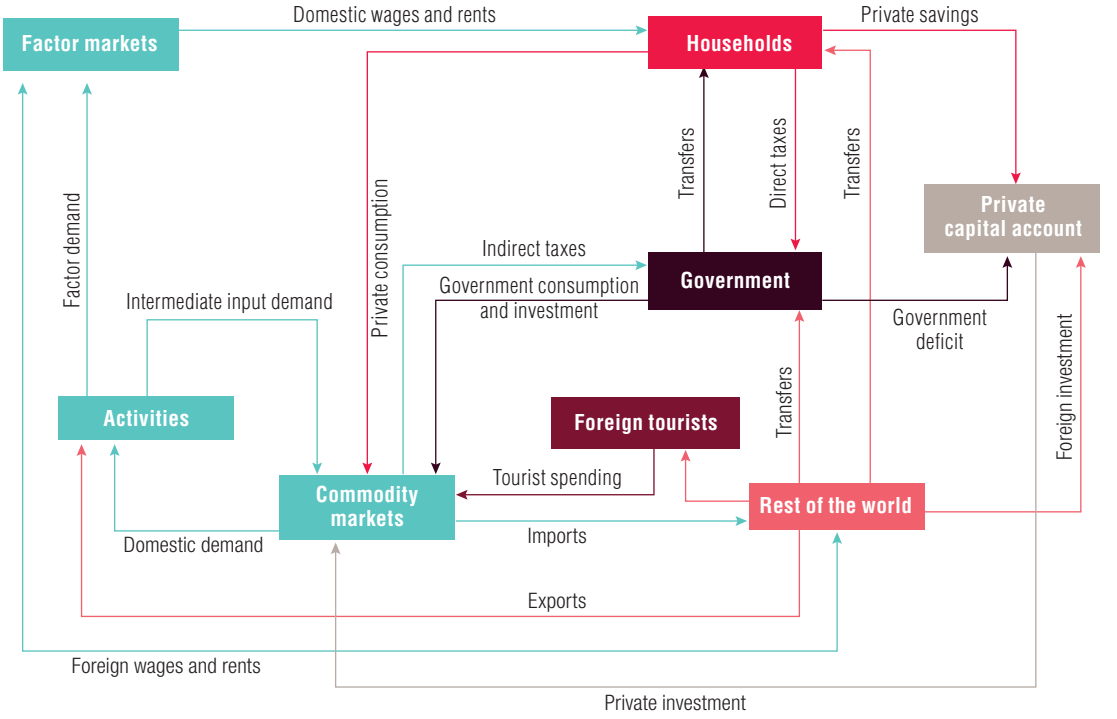
Figure 1 depicts, for each simulation period, the circular flow of income within the economy and between the economy and the rest of the world. The major building blocks of our CGE model may be divided into: (i) businesses (the entities that carry out production); (ii) commodities (business outputs or, exceptionally, imports in the absence of domestic production, linked to markets); (iii) factors (also linked to markets); and (iv) institutions (households, the government, the rest of the world and foreign tourists). In the Jamaica application (and database) of our CGE model, most of the blocks in figure 1 are disaggregated on the basis of the available data.

In any given year, our CGE model for Jamaica has the structure summarized in the above chart. Businesses produce and sell their output at home (to both residents and foreign tourists) or abroad (to Jamaica's trading partners), using their revenues to cover the costs of intermediate inputs, factors of production and taxes. Their decisions regarding factor employment, which determines output level, are driven by profit maximization. The shares of their output that are exported and sold domestically depend on relative selling prices in the domestic and export markets.

Figure 2 provides additional detail on the production technology of production activities. The level (or quantity) of any activity and the quantity of output (via yield coefficients) are a constant elasticity of substitution (CES) function of the quantities of factors employed (in this example, labour and capital). Intermediate input use is a Leontief function of activity levels.[4]

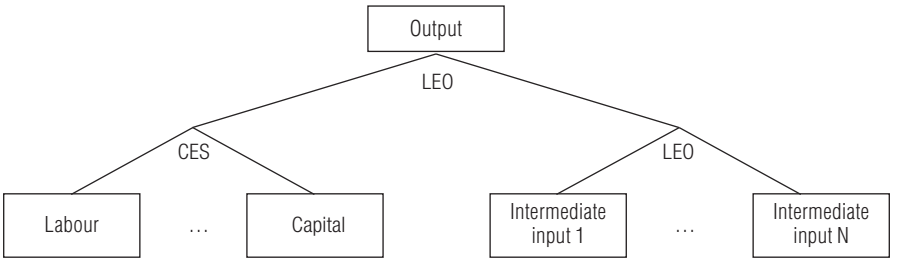
[4] CES, Leontief (or fixed coefficients) and constant elasticity of transformation (CET) functional forms are widely used in CGE modelling.

Figure 1
Circular income flow in the computable general equilibrium: within-period module



Source: Prepared by the authors.

Figure 2
Production function: factor and intermediate input demand



Source: Prepared by the authors.
Note: CES and LEO refer to constant elasticity of substitution and Leontief production functions, respectively. N commodities are used as intermediate inputs.

Returning to figure 1, our CGE model for Jamaica includes four types of institutions: households, the government, foreign tourists and the rest of the world. As shown, households receive income from factors, transfers from the government and transfers from the rest of the world. This income is used for direct taxes, savings and consumption. After deducting net financing of the government (which in the real world equals household lending to the government minus household interest revenue) and resources needed for changes in foreign reserves, household savings are used to finance private investment. Household consumption decisions change in response to income and price changes. By construction (and as required by household budget constraints), household consumption equals income net of direct taxes and savings.

The government obtains its receipts from taxes, transfers from abroad and net financing (borrowing net of interest payments) from households and the rest of the world. It uses these receipts for transfers

to households, consumption and investment (to provide the capital stocks required for government services).[5] To remain within its budget constraint, it either adjusts some part or parts of its spending to match available receipts or mobilizes additional receipts of one or more types in order to finance its spending plans.

Foreign wages and rents are the only non-trade payment to the rest of the world; they are typically an exogenous projection. The non-trade payments received from the rest of the world consist of tourism expenditures, net transfers to households, foreign borrowing and foreign investment, net of changes in foreign reserves. Total financing from the rest of the world (going to the government and to the non-government capital account) is positive (negative) if the model country has a deficit (surplus) in its non-borrowing payments. The balance of payments clears (inflows and outflows are equalized) via adjustments in the real exchange rate (the ratio between the international and domestic price levels), influencing export and import quantities and values.

In this application, international tourism receipts are modelled as the product of per capita tourism expenditures and the number of tourists arriving in Jamaica (see equation (1). The simulations in the next section model an increase in the number of foreign tourist arrivals combined with an increase in their per capita spending. Alternatively, foreign tourism demand can be modelled using a constant elasticity demand function (see equation (2)). In the latter case, the demand curve for the modelled country's tourism exports will be downward-sloping. In both cases, total tourism demand is disaggregated across domestically produced commodities in fixed proportions.[6] In equation (2), foreign tourists' demand is a function of local (tourism-related) prices relative to the exchange rate EXR_t.

$$QTRSMROW_{c,t} = qtrsmrowpc_{c,t} \cdot qtrsmrowpop_t \tag{1}$$

$$QTRSMROW_{c,t} = \overline{qtrsmrow_{c,t}} \left(\frac{PQ_{c,t}/EXR_t}{PQ_c^0/EXR^0} \right)^{\eta^{trsmrow}} \tag{2}$$

Where t is time, c is tourism-related commodities such as hotel and restaurant services, $QTRSMROW_{c,t}$ is the quantity of commodity c demanded by tourists from the rest of the world, $PQ_{c,t}$ is the price of commodity c in Jamaica, EXR_t is the exchange rate, $qtrsmrowpop_{c,t}$ is the quantity of commodity c demanded per foreign tourist, $qtrsmrowpop_t$ is the number of foreign tourists arriving in Jamaica and $\eta^{trsmrow}$ is the (constant) price elasticity of foreign tourism demand (< 0).

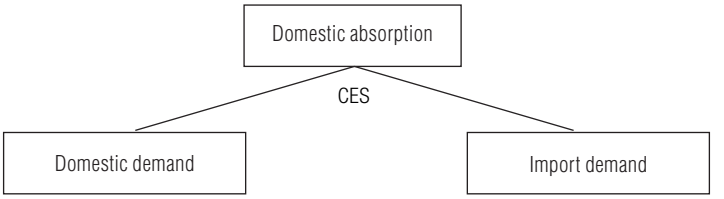
On the supply side, the modelling of alternative modes of tourism (e.g. all-inclusive beach resorts, boutique hotels and eco-lodges) is straightforward provided the required data are available. If they are, the model can incorporate different cost structures for the various modes of tourism on the supply side.

In commodity markets, flexible pricing ensures a balance between the demand for domestic output from domestic purchasers and the supply to the domestic market from domestic suppliers. The portion of domestic demand that is for imports pays exogenous world prices; following the common small-country assumption, prices in foreign currency are fixed. On the basis of relative prices, domestic purchasers decide on the split between domestic purchases and imports (see figure 3). Similarly, domestic suppliers (businesses) also consider relative prices when deciding on the allocation of their output between domestic sales and exports (see figure 4). For exports, we also assume that Jamaica has to deal with exogenous world prices.

[5] The government primary deficit is defined as spending on consumption, investment and domestic transfers minus taxes and transfers from abroad. This deficit is covered by domestic and foreign net financing.

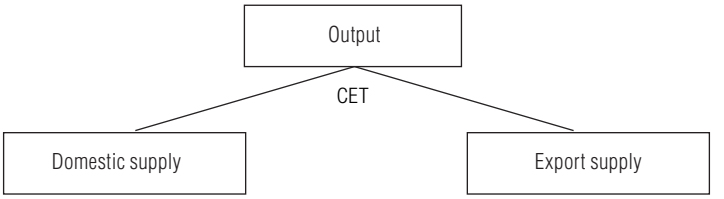
[6] In addition, the model allows one or more modes of tourism demand to be identified.

Figure 3
Allocation of domestic demand across alternative sources



Source: Prepared by the authors.
Note: CES refers to constant elasticity of substitution. The demand structure in the figure applies to each of the commodities identified in the social accounting matrix and the model.

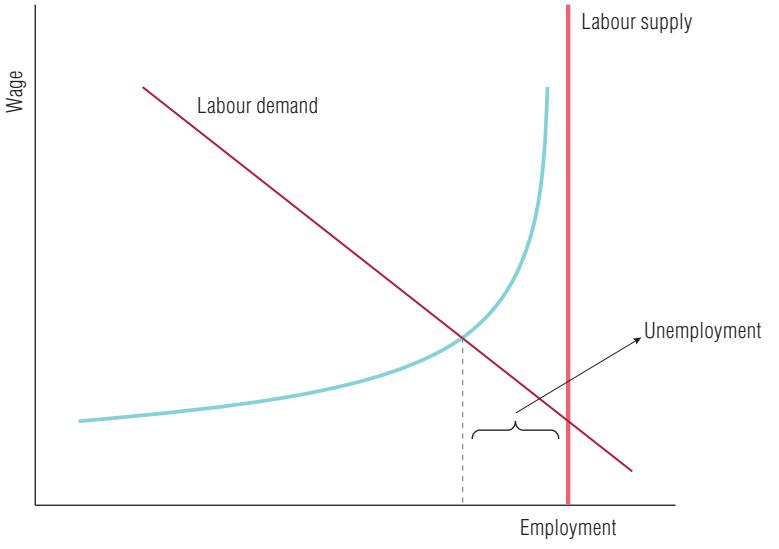
Figure 4
Allocation of output across alternative destinations



Source: Prepared by the authors.
Note: CET refers to the constant elasticity of transformation function. The supply structure in the figure applies to each of the commodities identified in the social accounting matrix and the model.

For non-labour factors, markets clear demand and supply via rent adjustments. Across all factors, the demand curves are downward-sloping, reflecting the responses of production activities to changes in wages. In labour markets, unemployment may be endogenous. If so, the model includes a wage curve that establishes a negative relationship between the real wage and the unemployment rate or, alternatively, a positive relationship between the real wage and the employment rate (see figure 5). For non-labour factors, full employment is assumed.

Figure 5
Labour market specification



Source: Prepared by the authors.

The above discussion refers to the functioning of the model economy in a single year. In our Jamaica CGE, growth over time is endogenous. The economy grows because of capital accumulation (determined by investment and depreciation), exogenous growth in the stocks of labour and other non-capital factors (e.g. agricultural land) and growth in total factor productivity (TFP). Apart from an exogenous component, the TFP of any production activity potentially depends on the level of capital stocks (typically stocks of government infrastructure).

2. Data

(a) The social accounting matrix

The basic accounting structure and much of the underlying data required to implement our Jamaica CGE model will be derived from a social accounting matrix (SAM).[7] A SAM is a comprehensive, economy-wide statistical representation of the modelled economy at a specific point in time. It is a square matrix with identical row and column accounts where each cell in the matrix shows a payment from its column account to its row account. It can be used for descriptive purposes and is the key data input for a CGE. Major accounts in a standard SAM are: (i) businesses that carry out production; (ii) commodities (goods and services) which are produced, imported or both and sold domestically, exported or both; (iii) factors used in production which include labour, capital, land and other natural resources; and (iv) institutions such as households, government, tourists and the rest of the country and world. Most features of the Jamaica SAM are familiar from social accounting matrices used in other models.[8] However, the Jamaica SAM has non-conventional features related to the explicit treatment of foreign tourism-related spending together with the corresponding inflow of foreign exchange.

In most cases, a SAM is built using supply and use tables (SUTs) as the starting point. However, in the case of Jamaica, given that the latest available SUTs are more than 10 years old (i.e. they refer to the year 2007), as many data as possible from the Statistical Institute of Jamaica (STATIN) and other government agencies were used as well, namely the 2015 national accounts for GDP by activity and GDP by expenditure, the 2015 tourism satellite account, the balance of payments, government receipts and spending and household surveys such as the four waves of the 2014 Labour Force Survey and the 2012 Survey of Living Conditions.[9]

The disaggregation of our Jamaica SAM matches that of the rest of the model database. As shown in table 1, it is disaggregated into 17 sectors (activities and commodities), including agriculture, mining, 3 manufacturing sectors and 12 service sectors, with each activity producing a single commodity for which it is the only domestic producer. The factors are split into labour, private capital and two types of natural resources, namely agricultural land and a natural resource used in extractive industries. Institutions are split into households, government, the rest of the world and domestic and foreign tourists. A set of auxiliary accounts covers the different tax instruments as well as trade and transport margins on domestic sales, imports and exports.

[7] Technically, the SAM is used to calibrate the CGE model. In other words, the SAM is used to compute reference (or initial) values for all behavioural parameters and exogenous variables in the CGE model.

[8] See Pyatt and Round (1985) and King (1981) for a more detailed introduction to SAM construction and interpretation.

[9] In a related study, we use the 2011 Population and Housing Census to regionalize the national SAM.

Table 1
Accounts in Jamaica's 2015 social accounting matrix

Category *(number)*	Item	Category *(number)*	Item
Sectors (17)	Agriculture, forestry and fishing	Factors (4)	Labour
	Mining		Capital
	Food, beverages and tobacco		Land
	Textiles and wearing apparel		Extractive resources
	Other manufacturing	Taxes (5)	Business taxes
	Electricity and water		Tariffs
	Construction		Commodity taxes
	Commerce		Income tax
	Hotels		Bauxite tax
	Restaurants	Institutions (4)	Households
	Transport		Government
	Communications		Rest of the world
	Financial services		Domestic tourism
	Real estate and business services		Foreign tourism
	Government services, education and health	Institutional capital accounts (3)	Households capital account
	Recreation		Government capital account
	Other services		Rest of the world capital account
Distribution margins (3)	Domestic margin	Investment (3)	Non-governmental investment
	Import margin		Governmental investment
	Export margin		Changes in inventories

Source: Prepared by the authors.

On the basis of the SAM data, table 2 summarizes the sectoral structure of the Jamaican economy, giving sectoral shares of value added, production, employment, exports and imports, as well as the split of domestic sectoral supply between exports and domestic sales and of domestic sectoral demand between imports and domestic output. For instance, while the hotel industry represents a substantial share of exports (around 26.9%), its shares of value added and production are much smaller (3.1% and 4.3%, respectively), while the share of its output that is consumed by foreign tourists (i.e. exported) is around 94.8%. The Jamaica SAM also identifies expenditure on accommodation and restaurants by residents of Jamaica who travel abroad, listed as "Hotels (imports)" and "Restaurants (imports)" in table 2. In 2015, for instance, "imports" of hotel and restaurant services represented 3.8% and 1.1% of total imports, respectively.[10]

Interestingly, while (primary) agriculture represents a significant share of employment (around 17.8%), its shares of value added, production and exports are much smaller (in the range of 2% to 7.6%). On the import side, the "other manufacturing" category (which includes, for example, machinery and equipment) represents a large share of total imports: about 59.5%. Furthermore, the share of domestic demand for "other manufacturing" products met by imports is 61.3%.

Table 3 shows the factor shares of total sectoral value added. For example, it shows that agriculture is relatively intensive in the use of labour and land, while mining is intensive in the use of capital and extractive natural resources. Interestingly, table 3 also shows, on the basis of information from the 2007 SUTs, that hotels and restaurants have similar factor intensities. It is often important to be aware of these aspects of sectoral structure when analysing simulation results. In the tourism industry, hotels and restaurants prove to be relatively labour-intensive.

[10] In 2015, total international tourism expenditures were equivalent to 6.2% of total imports.

Table 2
Sectoral structure of the Jamaican economy, 2015
(Percentages)

Sector	Value added	Output	Employment	Exports	Exports as a share of output	Imports	Share of demand met by imports
Agriculture, forestry and fishing	7.6	6.5	17.8	2.0	4.1	1.1	4.6
Mining	2.2	2.9	0.5	14.6	84.3	0.0	0.4
Food, beverages and tobacco	5.0	8.8	3.6	5.3	8.0	7.3	18.3
Textiles and wearing apparel	0.1	0.1	0.1	0.1	5.0	1.7	71.2
Other manufacturing	4.4	8.3	2.7	12.2	18.6	59.5	61.3
Electricity and water	3.4	4.5	0.8	0.4	1.4	0.1	0.4
Construction	7.7	7.7	7.3	0.0	0.0	0.1	0.3
Commerce	18.7	15.4	20.0	0.0	0.0	0.9	1.5
Hotels	3.1	4.3	3.2	26.9	94.8	0.0	0.0
Hotels (imports)	0.0	0.0	0.0	0.0	0.0	3.8	100.0
Restaurants	1.2	2.4	4.6	4.1	27.9	0.0	0.0
Restaurants (imports)	0.0	0.0	0.0	0.0	0.0	1.1	100.0
Transport	4.2	5.7	4.3	13.3	39.6	5.6	23.9
Communications	3.7	2.8	2.3	3.2	19.1	1.7	14.4
Financial services	8.6	7.2	2.3	2.1	5.0	3.4	10.6
Real estate and business services	10.9	8.2	6.5	2.5	5.3	11.9	27.5
Government services, education and health	15.0	10.5	14.0	0.0	0.0	0.1	0.2
Recreation	2.2	3.1	1.6	9.8	51.0	1.3	9.4
Other services	2.1	1.5	8.4	3.5	38.2	0.5	7.0
Total	100.0	100.0	100.0	100.0	16.1	100.0	23.4

Source: Prepared by the authors, on the basis of Jamaica's 2015 social accounting matrix (SAM) and employment data.

Table 3
Sectoral factor intensity
(Percentages)

Sector	Labour	Capital	Natural resources	Total
Agriculture, forestry and fishing	45.1	20.8	34.1	100.0
Mining	34.9	40.7	24.3	100.0
Food, beverages and tobacco	53.6	46.4	0.0	100.0
Textiles and wearing apparel	44.9	55.1	0.0	100.0
Other manufacturing	43.4	56.6	0.0	100.0
Electricity and water	32.4	67.6	0.0	100.0
Construction	72.2	27.8	0.0	100.0
Commerce	63.2	36.8	0.0	100.0
Hotels	66.2	33.8	0.0	100.0
Restaurants	66.8	33.2	0.0	100.0
Transport	71.8	28.2	0.0	100.0
Communications	28.5	71.5	0.0	100.0
Financial services	52.9	47.1	0.0	100.0
Real estate and business services	31.4	68.6	0.0	100.0
Government services, education and health	99.3	0.7	0.0	100.0
Recreation	65.4	34.6	0.0	100.0
Other services	66.0	34.0	0.0	100.0
Total	59.9	37.0	3.1	100.0

Source: Prepared by the authors, on the basis of Jamaica's 2015 social accounting matrix (SAM).

Table 4 shows the composition of demand for each commodity. For instance, most demand for construction services is driven by gross fixed capital formation, e.g. building or expanding a hotel. In turn, about 26% of the demand for restaurant services comes from foreign tourists visiting Jamaica.

Table 4
Demand structure
(Percentages)

Sector	Intermediate use	Distribution margins	Private consumption	Fixed investment	Change in inventories	Government consumption	Exports	International tourism	Total
Agriculture, forestry and fishing	42.4	0.0	53.4	0.3	0.0	0.0	3.9	0.0	100.0
Mining	16.3	0.0	0.0	0.0	-0.2	0.0	83.9	0.0	100.0
Food, beverages and tobacco	30.8	0.0	63.2	0.0	0.0	0.0	6.0	0.0	100.0
Textiles and wearing apparel	10.9	0.0	88.0	0.1	0.2	0.0	0.8	0.0	100.0
Other manufacturing	51.7	0.0	28.2	14.2	0.2	0.0	5.7	0.0	100.0
Electricity and water	59.0	0.0	39.7	0.0	0.0	0.0	1.4	0.0	100.0
Construction	25.5	0.0	0.0	74.5	0.0	0.0	0.0	0.0	100.0
Commerce	8.2	82.4	5.7	3.7	0.0	0.0	0.0	0.0	100.0
Hotels	5.6	0.0	0.2	0.0	0.0	0.0	0.0	94.3	100.0
Hotels (imports)	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Restaurants	5.8	0.0	68.3	0.0	0.0	0.0	0.0	25.9	100.0
Restaurants (imports)	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Transport	59.3	0.0	10.0	0.0	0.0	0.0	18.9	11.8	100.0
Communications	50.0	0.0	34.9	0.0	0.0	0.0	15.1	0.0	100.0
Financial services	52.5	0.0	43.3	0.0	0.0	0.0	4.2	0.0	100.0
Real estate and business services	59.7	0.0	35.9	0.6	0.0	0.0	3.8	0.0	100.0
Government services, education and health	4.7	0.0	21.4	0.0	0.0	73.9	0.0	0.0	100.0
Recreation	8.3	0.0	45.8	1.4	0.0	0.0	3.4	41.1	100.0
Other services	4.4	0.0	60.3	0.0	0.0	0.0	0.0	35.3	100.0
Total	35.4	8.8	31.0	8.0	0.1	5.3	5.9	5.6	100.0

Source: Prepared by the authors, on the basis of Jamaica's 2015 social accounting matrix (SAM).

(b) Non-SAM data

In addition to the SAM, our tourism-extended dynamic CGE model requires a set of elasticities (for production, consumption and trade, whether econometrically estimated or obtained from the literature) and estimates for sectoral employment levels and unemployment in the base year (2015). Furthermore, given that this is a dynamic model, we need to project the modelled economy on the assumption of a "business as usual" (BAU) scenario. This BAU scenario will then serve as a benchmark for comparing the non-base simulation scenarios, i.e. scenarios in which one or more shocks are introduced. For the BAU scenario, we require base year capital stocks, a baseline projection for population and labour force growth and a baseline projection for GDP growth.

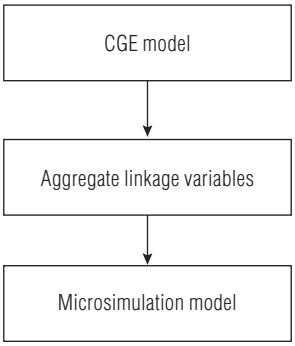
In this application, the chosen values for elasticities are as follows: (i) the elasticities of substitution between factors (labour, capital and natural resources) are in the 0.2 to 0.9 range, being lowest for natural resource activities such as agriculture (0.25) and mining (0.2) (Narayanan, Aguiar and McDougall, 2012); (ii) wage curve unemployment elasticity is 0.5 (Blanchflower and Oswald, 2005); and (iii) following Sadoulet and De Janvry (1995) and Annabi, Cockburn and Decaluwé (2006), trade-related elasticities are in the 2 to 2.15 range for substitution between imports and domestic purchases and transformation between exports and domestic sales, respectively. In addition, and given the uncertainty surrounding our elasticity values, in annex A2 we conduct a systematic sensitivity analysis of the values of our simulation results, finding that those presented here are robust.

(c) The microsimulation model and data

As discussed, CGE models are effective in capturing macro and meso[11] responses to shocks such as an increase in tourist arrivals. However, the standard configuration of a CGE model is not well suited to analysis of questions related to poverty and income inequality. This is due to the fact that most CGE models use a representative household formulation whereby all households in an economy are aggregated into one or a few households to represent household and consumer behaviour. The main limitation of the representative household formulation is that intra-household income distribution does not respond to shocks introduced into the model.

Consequently, in order to provide greater resolution with regard to household-level impacts, we generate results for poverty and inequality at the micro level by linking the CGE model with a microsimulation model. The two models interact in a sequential "top-down" fashion (i.e. without feedback): the CGE communicates with the microsimulation model by generating a vector of (real) wages,[12] aggregate employment variables such as labour demand by sector and the unemployment rate, and non-labour income such as government transfers and remittances. In figure 6, these are depicted as the aggregate linkage variables between the CGE model and the microsimulation model. The functioning of the labour market thus plays an important role in the microsimulation model. In turn, the CGE model determines the changes in employment by factor type and sector and changes in factor and product prices that are then used for the microsimulations.

Figure 6
The macro-micro approach



Source: Prepared by the authors.

To build the microsimulation model, the Jamaica Survey of Living Conditions (JSLC) for 2012, conducted by the Statistical Institute of Jamaica (STATIN), was used. These data cover 20,532 individuals in 6,579 households throughout Jamaica. The JSLC is the only available household survey in Jamaica that covers both income and spending. No attempt was made to reconcile the household survey data with the national accounts. Instead, the results from the CGE model were transmitted to the microsimulation model as percentage deviations from base values. To estimate poverty, we used the poverty line and the food poverty line for 2012; the national poverty rates were calculated as 19.8% and 7.5%, respectively.

[11] Meso is a word of Greek origin meaning middle, this being the level between macro and micro at which most SAMs and CGEs operate; i.e. there are no data at the level of individual micro units (households or firms), but the level of disaggregation is greater than is typical in macro analysis, with some 40 businesses and commodities typically being covered.

[12] The real wage is defined in terms of the CPI.

The microsimulation model follows the non-parametric method described in Vos and Sánchez (2010), but extended to incorporate changes in non-labour income.[13] First, the labour market structure is defined in terms of unemployment rates U among different segments of the working age population (divided by skill levels), the structure of employment as defined by sectors of activity S (the share of each industry in total employment) and (relative) remuneration $W1$, as well as overall remuneration $W2$. The labour market structure can thus be written as

$$\lambda = (U, S, W1, W2)$$

The effect of altering each of the four poverty and inequality parameters can then be analysed by simulating counterfactual individual earnings and family incomes. Briefly, the model selects at random (with multiple repetitions) from the corresponding groups the individuals who will change employment status (between employment and unemployment and between sectors) in response to the shock(s) being simulated and assigns wages to new workers according to parameters for the average groups. The new wage and employment values for each individual yield new household per capita incomes that are then used to determine the new poverty and income distribution results. Analytically, we can write

$$yl_i = f(\lambda, X_i)$$

where yl_i is individual labour income and X_i is individual characteristics, e.g. skill level. In each scenario, labour market conditions might change and in turn affect individual labour income, i.e.:

$$yl_i^* = f(\lambda^*, X_i)$$

where λe^* refers to the simulated labour market structure parameters.

The labour market variables and procedures that link the CGE model with the microsimulations are as follows. The "unemployment effect" is simulated by changing the employment status of the active population in the JSCL 2012 sample, in accordance with the results of the CGE model. For instance, if the CGE simulations show unemployment decreasing at the same time as employment increases for skilled workers in a given sector, the microsimulation model "hires" randomly from the unemployed skilled workers in the JSCL 2012 sample. However, the order in which workers are moved between labour market statuses is the same in all scenarios. For instance, if two scenarios require that 10 individuals be moved from unemployment to employment, the same 10 individuals are selected in both scenarios. As explained above, individual incomes for the newly employed are assigned on the basis of their characteristics (e.g. educational level) by looking at similar individuals who were employed to begin with. If the CGE simulations indicate a decrease in employment for a specific labour category and sector, the microsimulation program "fires" the equivalent percentage from that category and sector, and the counterfactual income for those newly unemployed is zero.

The "sectoral structure effect" is simulated by changing the sectoral composition of employment. For those individuals who move from one sector to another, we simulate a counterfactual labour income based on their characteristics and on their new sector of employment, again by looking at individuals who were employed in the destination sector to begin with.

To model changes in relative wages, the wage level for a given labour category (e.g. skilled workers in a given sector) is adjusted according to the changes yielded by the CGE simulations, but keeping the aggregate average wage for the economy constant. The impact of a change in the aggregate average wage for the economy is simulated by changing all labour incomes in all sectors by the same proportion on the basis of the changes yielded by the CGE simulations. Next, all the above steps are repeated several times and averaged.

[13] In turn, this approach is an extension of the earnings inequality method developed by Dos Reis and De Barros (1991).

Non-labour incomes, such as government transfers and remittances from abroad, are scaled up or down proportionally using changes yielded by the CGE model. The final step in the microsimulation model is to adjust the microdata so that the percentage change in household per capita income matches the change in the level of household per capita income for each representative household in the CGE simulations. This residual effect implicitly accounts for changes in all items not considered up to this point, such as natural resource and capital rents.

Lastly, it should be noted that our CGE model can only solve for relative prices and real variables in the economy. In other words, inflation cannot occur in our CGE model. Accordingly, a normalization rule has been applied to anchor the absolute price level. The consumer price index (CPI) has been chosen as the numéraire, so all changes in nominal prices and incomes in simulations are relative to the weighted unit price of households' initial consumption bundle (i.e. a fixed CPI).

IV. Simulations and results

1. Scenario design

This section presents the simulations and analyses the results. To illustrate the use of the Jamaica model and dataset we have developed, the following five scenarios were simulated and analysed:

(i) base: the baseline or reference scenario is the BAU scenario.

(ii) trsm10+: a US$ 200 million yearly increase in private investment in hotels during 2018–2020. An increase of US$ 200 million is equivalent to 1.4% of 2015 GDP and can pay for an additional 800 hotel rooms a year on top of the base growth in the number of rooms (assuming an average cost of US$ 250,000 per room in a four- or five-star hotel).[14] Given that the total number of rooms available in the country is approximately 25,000, the increase in the room supply is around 6.2% (assuming baseline growth of approximately 3% and 3.2% growth on top of the baseline created by the investment shock). This is slightly above the average 3% increase in room supply in the Caribbean during the last 15 years, but below the 8% increase in the supply of rooms in Jamaica in 2016 (Jamaica Tourist Board, n/d). Subsequently (2021–2030), private investment in hotels is around US$ 2.5 million higher than in the baseline because of additional maintenance costs (see figure 4.1a). In all years, the increase in private investment is financed with foreign resources. In practice, most large hotel investments in Jamaica are financed through foreign debt, foreign direct investment (FDI) or a mixture of the two. Overall, we assess an impact of US$ 600 million in tourism-related FDI over a three-year period. In addition, this scenario assumes that foreign tourism spending is 10% higher than in the base scenario every year during the period 2021–2030 (see figure 4.1b) (more specifically, the simulated increase is 5% in 2019, 7.5% in 2020 and 10% thereafter). This might result from a combination of (i) an increase in tourist arrivals and (ii) an increase in spending per tourist. For instance, in 2021 the number of foreign tourist arrivals could increase from 2.47 million in the baseline to 2.56 million (+3.5%), while per capita spending could increase from US$ 975 in the baseline to US$ 1,036 (+6.3%) at constant 2015 prices.[15]

[14] In the period 2013-2016, FDI in the tourism industry averaged US$ 213.6 million per year. Our non-base scenarios therefore assume that FDI in the tourism industry increases by about 94% relative to its recent trend (i.e. US$ 200 million above the baseline).

[15] In addition, we ran a simulation with the same increase in private investment in hotels but without the increase in foreign tourist arrivals, i.e. the number of foreign tourist arrivals and their per capita spending are assumed to be constant at their baseline values (the results are not shown, but are available from the authors on request). Interestingly, the long-run effects of this simulation are negative, since Jamaica overinvests in the accommodation sector. In other words, there is an increase in the number of hotel rooms not accompanied by an increase in the number of (foreign) tourists.

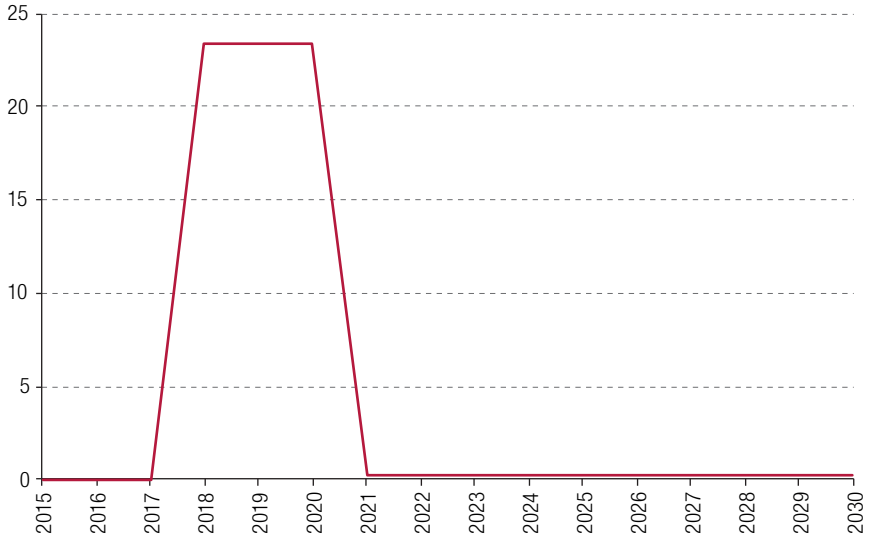
(iii) trsm20+: the same investment as in trsm10+, but the increase in foreign tourism spending is 20% higher every year during the period 2021–2030 than in the base scenario. In practice, such an increase in foreign tourism spending would require an increase in per capita spending, as it would be implausible for it to be attained only with an increase in foreign tourist arrivals.

(iv) trsm10-: the same investment as in trsm10+, but foreign tourism spending is 10% lower than in the base scenario during the period 2021–2030 (see figure 4.1b) (more specifically, the simulated decrease is 5% in 2019, 7.5% in 2020 and 10% thereafter). For instance, on the assumption that spending per tourist remained constant, in 2030 the number of tourists would be 2.85 million, as compared to 3.17 million in the base scenario. This scenario could reflect the impact of a natural disaster.

(v) trsm20-: the same investment as in trsm10+, but foreign tourism spending is 20% lower than in the base scenario. Again, this scenario could reflect the impact of a natural disaster.

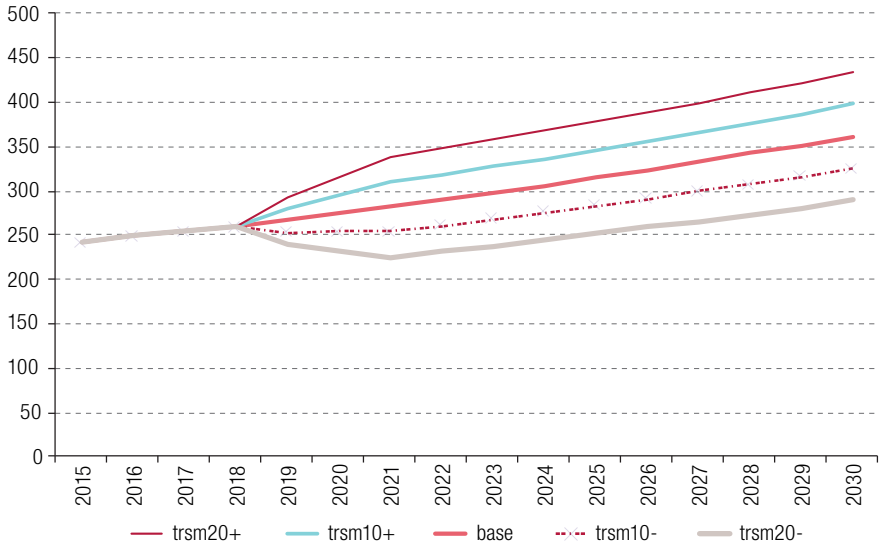
In reality, any tourism-related scenario would be likely to contain some of the elements present in this set of scenarios. In what follows, all simulations cover the period 2015–2030. The starting year, 2015, was selected in light of data availability (see above). The base simulation was designed to replicate trends since 2015 at the macro and sectoral levels. From 2018 onward, it is assumed that past trends will continue. In what follows, all shocks are introduced during the period 2018–2030; i.e. the base and non-base scenarios are the same up to and including 2017 (see figures 7 and 8).

Figure 7
Non-base scenarios: change in private investment in hotels relative to the base scenario, 2015–2030
(Billions of Jamaican dollars at 2015 prices)



Source: Prepared by the authors.

Figure 8
Non-base scenarios; foreign tourism spending
(Billions of Jamaican dollars at 2015 prices)



Source: Prepared by the authors.
Note: base: business as usual scenario; trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

2. Results and analysis

(a) Base scenario

For the period from the base year (2015) up to 2017, we draw on available information and estimates to generate a plausible picture of Jamaica's economic development that is the same for all simulations, including observed growth rates for real GDP at factor cost for the year 2016. Drawing on projections from the International Monetary Fund's *World Economic Outlook, April 2017: Gaining Momentum?* (IMF, 2017), we impose an average growth rate of 2.6% for the period 2017–2030. In addition, we assume that government services, transfers from government to households and net domestic and foreign government financing are all kept fixed as shares of GDP at their base year values. Taxes are fixed at their base year rates, which means that revenues will grow at the same pace as the overall economy.

For foreign tourism receipts, the baseline scenario, drawing on recent data, assumes (a) constant real per capita spending and (b) an exogenous growth rate for tourist arrivals equal to the GDP growth rate (for the period 1995–2016, the simple correlation between real GDP and foreign tourist arrivals is 0.75, i.e. is positive and statistically significant).

At the macro level, our CGE model for Jamaica, like any other CGE model, requires the specification of equilibrating mechanisms ("closures") for three macroeconomic balances: government, savings-investment and the balance of payments. For the base scenario, the following closures are used: (i) government: its accounts are balanced via adjustments in the direct tax rate; (ii) savings-investment: household savings adjust to generate exogenous GDP shares for domestically financed private investment while government investment is financed within the government budget; and (iii) balance of payments:

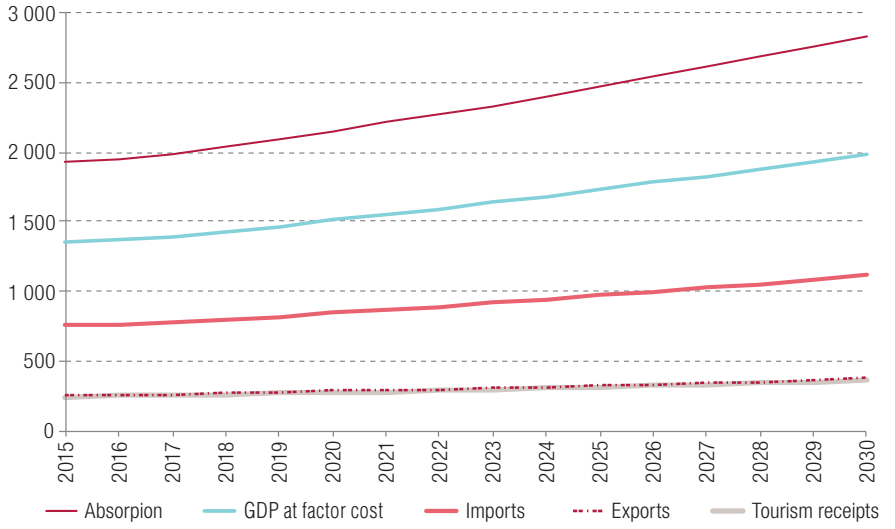
the real exchange rate equilibrates this balance by influencing export and import quantities and values, while the non-trade-related payments of the balance of payments (transfers and non-government net foreign financing) are non-clearing and remain fixed as shares of GDP.

In the non-base scenarios, the treatment of the balance of payments is the same as for the base scenario: the real exchange rate adjusts to equalize inflows and outflows of foreign exchange. For the balance between savings and (private) investment, instead of a fixed GDP share being imposed for private investment, this becomes the clearing variable, adjusting to make use of available financing in the context of exogenous household saving rates. For the government balance, the treatment is the same as for the base scenario (with a flexible direct tax rate).[16]

For each simulation, our CGE model provides the evolution over time of a wide range of indicators, including (i) macro outcomes: GDP (split into private and government consumption and investment, exports and imports); the composition of the government budget, the balance of payments and the savings-investment balance; total factor productivity; and domestic and foreign debt stocks; (ii) the sectoral structure of production, incomes, exports and imports; and trade flows disaggregated by trading partner; and (iii) the labour market: wages, unemployment and employment by sector.

Figures 9 to 11 show key macroeconomic results for the base scenario.[17] In this, the economy evolves in accordance with recent trends, with most macro aggregates growing at 2.7% to 2.8% per year during 2018–2030. The exchange rate appreciates slightly over time. GDP growth is sufficient to bring about a relatively rapid expansion of employment, and the unemployment rate falls from 13.5% in 2015 to 8.8% in 2030, while real wage growth averages 1.7% per year.

Figure 9
Base scenario: selected macroeconomic indicators
(Billions of Jamaican dollars at 2015 prices)

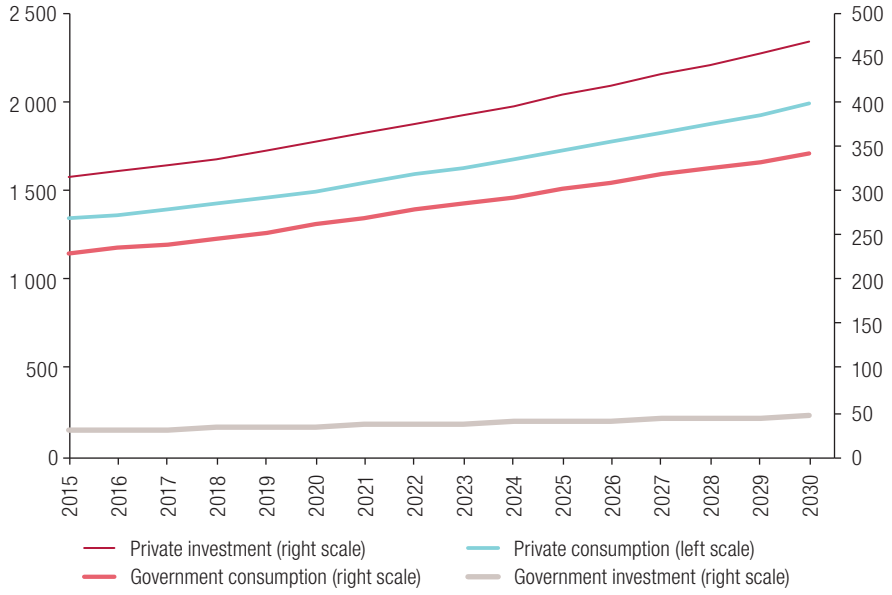


Source: Prepared by the authors, on the basis of simulation results.

[16] It is important to note that, for the non-base simulations, parameters related to the savings-investment and government balances are adjusted so that the introduction of changes in the treatment of these balances without any other changes have no impact on the results, and thus the base results are replicated exactly. However, when other changes are introduced (such as a change in tourist arrivals), then the exact treatment of, for example, the savings-investment balance has an impact on the results. More concretely, the base scenario generates a path for household saving rates that is consistent with the shares of private investment to GDP that are imposed. For all non-base scenarios, the path of household saving rates from the base is imposed while the private investment share of GDP is now endogenous. If this were the only change introduced in a non-base scenario, then the results would be the same as for the base. However, if another shock is introduced, then the response will be different when private investment is savings-driven as opposed to being an exogenously determined share of GDP (the base assumption).

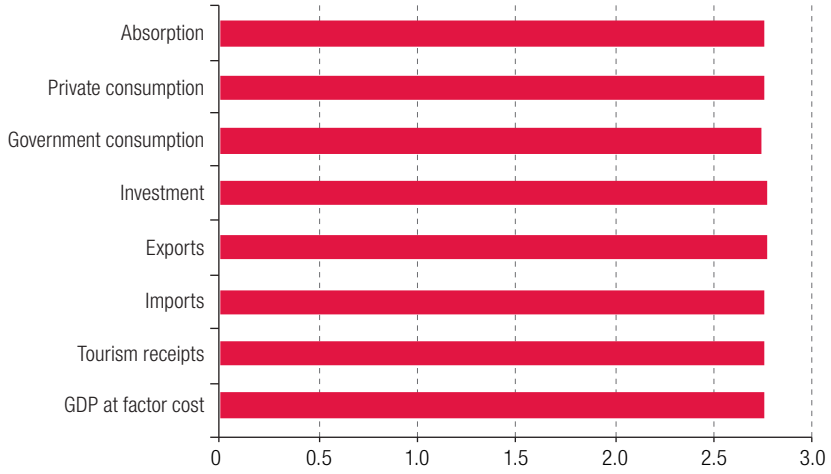
[17] Tables A2.1 to A2.5 in annex A2 show additional results for the base and non-base scenarios, covering macro and sectoral indicators as well as the government budget and the balance of payments.

Figure 10
Base scenario: domestic final demand
(Billions of Jamaican dollars at 2015 prices)



Source: Prepared by the authors, on the basis of simulation results.

Figure 11
Base scenario: real annual macroeconomic growth, 2018–2030
(Percentages)

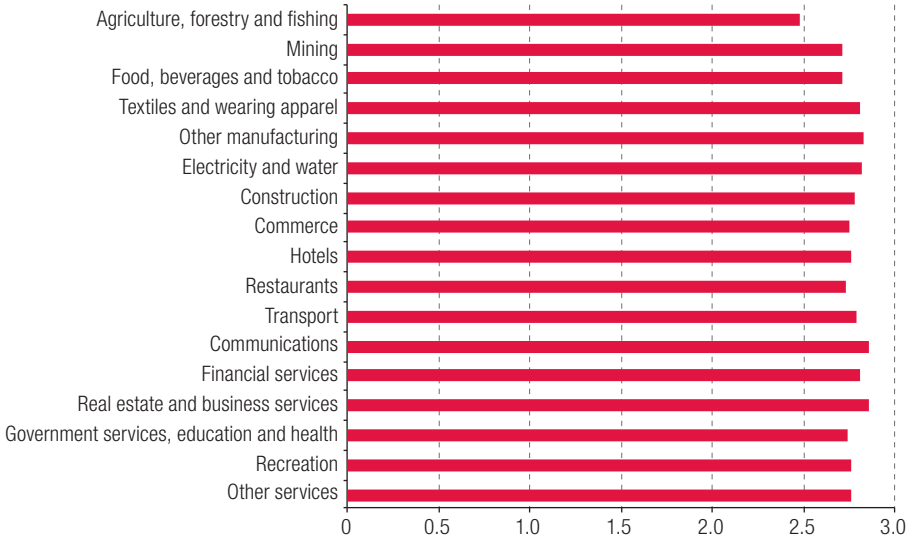


Source: Prepared by the authors, on the basis of simulation results.

In terms of sectoral structure (see figure 12), growth for agriculture is relatively low owing to slow growth in the supply of land (which is assumed to increase by 0.1% annually) and low income elasticities of demand. The sectoral structure of value added and exports shifts in favour of manufacturing and services, which enjoy more favourable supply and demand conditions. Among services, hotel

and restaurant growth is strongly influenced by foreign tourist arrivals. Consequently, the growth rate of tourism-related industries closely follows the GDP growth rate (see above). Per capita household consumption grows at a rate of 2.6% per year, leading to a significant decrease in the poverty rate, from 20.8% in 2015 to 9.1% in 2030 (see figure 13).

Figure 12
Base scenario: real annual sectoral growth, 2018–2030
(Percentages)



Source: Prepared by the authors, on the basis of simulation results.

Figure 13
Base scenario: real per capita household consumption and headcount poverty

A. Real per capita household consumption
(Jamaican dollars at 2015 prices)

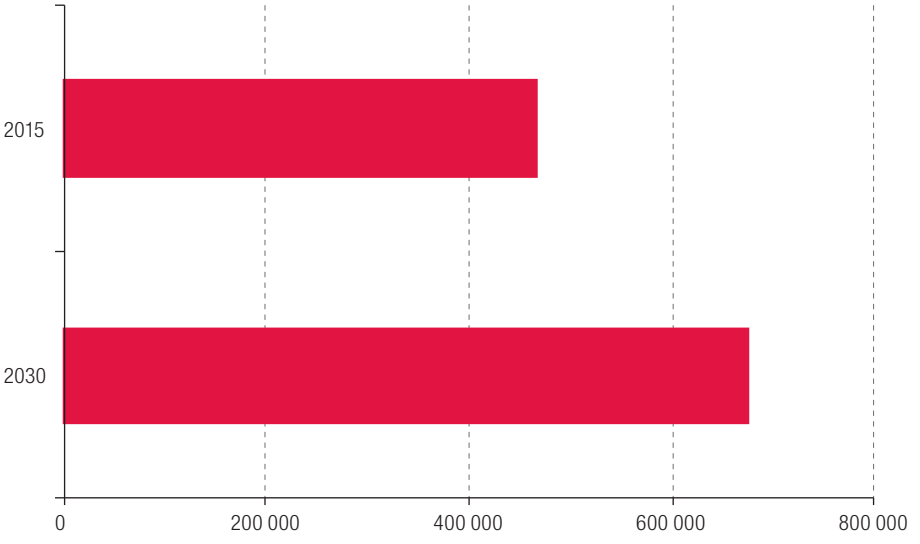
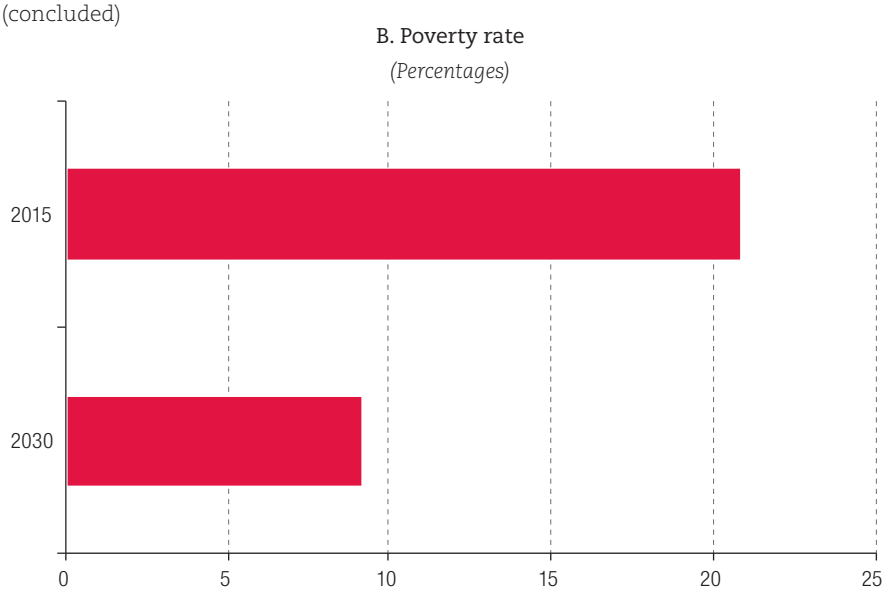


Figure 13 (concluded)

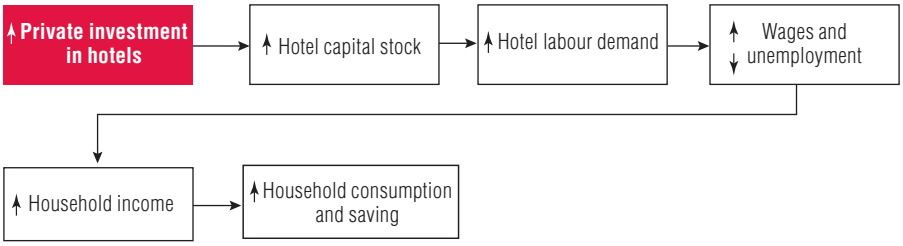


Source: Prepared by the authors, on the basis of simulation results.

(b) Non-base scenarios

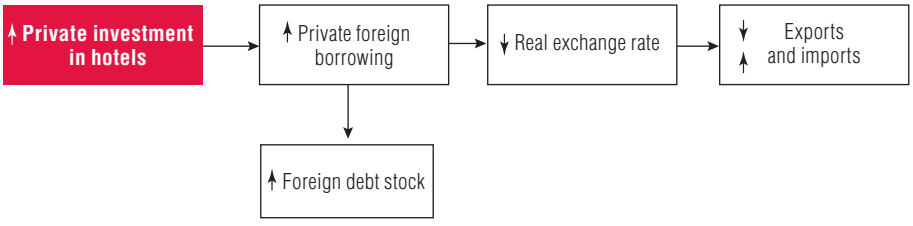
Figures 14 and 15 summarize the main transmission channels for the increase in private investment in hotels financed from abroad. Naturally, an increase in hotel investment will have a positive impact on the supply of accommodation services, i.e. the number or quality of hotel rooms, or both, will increase. In addition, when financing for additional investment comes from foreign borrowing, the inflow of foreign resources will lead to slower export growth and faster import growth, both induced by appreciation of the real exchange rate.

Figure 14
Main transmission channels for private investment in hotels



Source: Prepared by the authors.

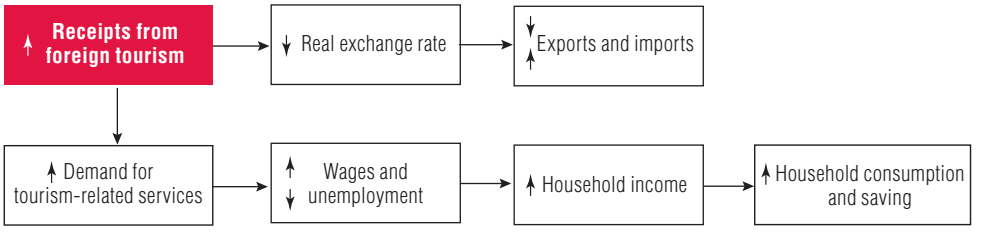
Figure 15
Main transmission channels for foreign financing of private investment in hotels



Source: Prepared by the authors.

Figure 16 summarizes the main transmission channels for the increase in receipts from foreign tourism. Overall, a rise in foreign tourism demand results in higher household income growth because these inflows of foreign exchange increase total resources in the economy. However, as shown in the figure, the increase in "tourism exports" also generates a real exchange-rate appreciation that hurts tradable sectors.

Figure 16
Main transmission channels for increased tourism receipts



Source: Prepared by the authors.

(c) Macro results

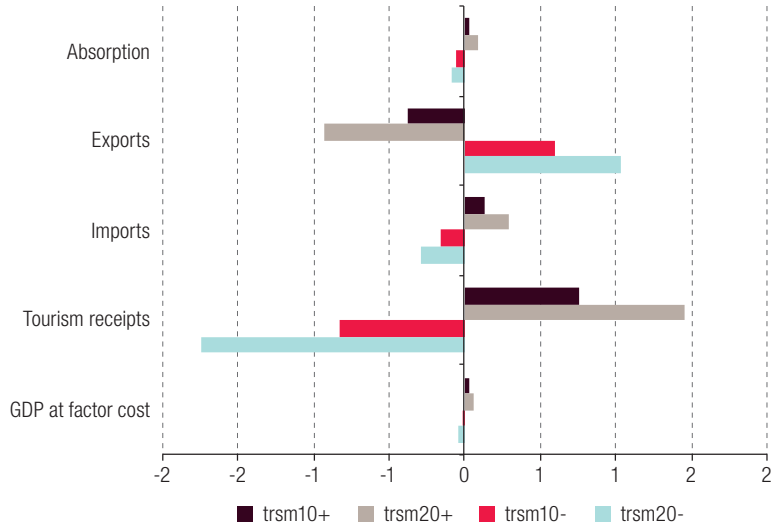
The main results for the non-base scenarios are presented in figures 17 to 21, and additional information can be found in tables A2.1 to A2.5 in annex A2. As shown in figures 17 and 18, increased private investment in hotels financed with foreign resources has a positive impact on the level of activity (see the results in table A2.1 for the trsm10+ and trsm20+ simulations in 2018). On the other hand, the inflow of foreign resources leads to slower export growth and faster import growth, both induced by real exchange-rate appreciation.[18] In turn, the expansion of tourism demand tends to increase domestic absorption more rapidly than GDP, likewise causing deterioration in the (non-tourism) trade balance (again, see scenarios trsm10+ and trsm20+). In other words, the increase in foreign tourism receipts also generates a real exchange-rate appreciation that hurts tradable sectors, while slower export growth here is also a function of increasing domestic demand and prices in Jamaica due to the investment. Thus, where there are constraints in the supply of factors (labour, capital, land and natural resources), an increase in domestic prices relative to world prices results in a reallocation of resources to domestic production in order to cater to more rapid growth in domestic demand, which includes demand from tourists visiting Jamaica.

Figure A2.1 in annex A2 provides information on the time path for deviations from the base for private consumption and investment in our set of scenarios. It shows that the short- and long-run effects of the four scenarios are similar. In the short run, however, the increase in private investment financed with foreign resources has a positive impact during the period 2018–2020. As explained, this is the period in which the accommodation sector expands. Overall, scenarios with decreased foreign tourist arrivals and spending show results of the opposite sign.

In the past, numerous authors have used input-output analysis to estimate income multipliers related to tourism expansion. Estimates generally range between 0.37 and 1.98 (Dwyer and Forsyth, 1998). However, income multipliers greater than 1 are suspect since the typical input-output approach assumes no constraints on capacity. In contrast to input-output analysis, which always produces a gain to the economy, CGE modelling acknowledges that price increases due to resource constraints may limit the increase in economic activity caused by growth in foreign tourism spending. In fact, as our results show, they may even lead to contractions in economic activity in some sectors. Consequently, our estimate of the income multiplier for 2030 and the trsm20+ scenario is 0.38, at the low end of the above spectrum. This is mainly because of capacity constraints.

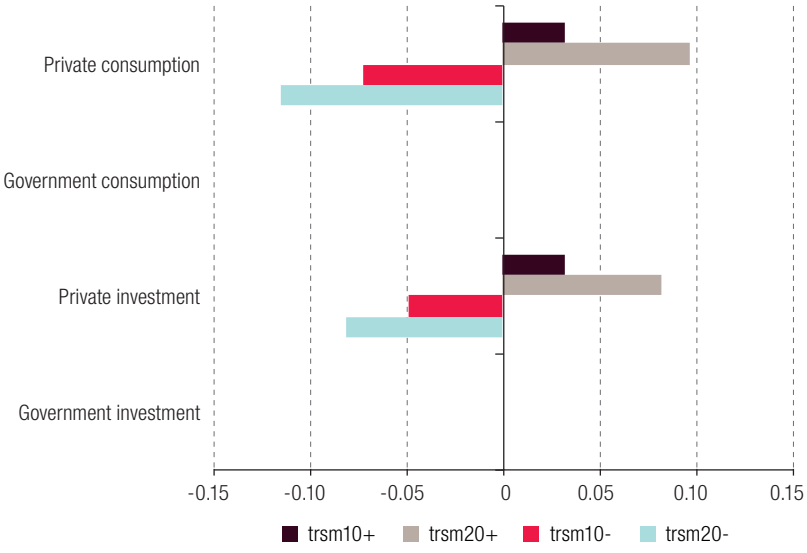
[18] Note that "exports" do not include tourism-related spending by foreigners. The latter certainly qualifies as tourism exports, but the two are treated differently in the model and figure 17.

Figure 17
Macro growth by simulation: deviation of average annual growth from the base scenario
(Percentage points)



Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

Figure 18
Consumption and investment growth by simulation:
deviation of average annual growth from the base scenario
(Percentage points)

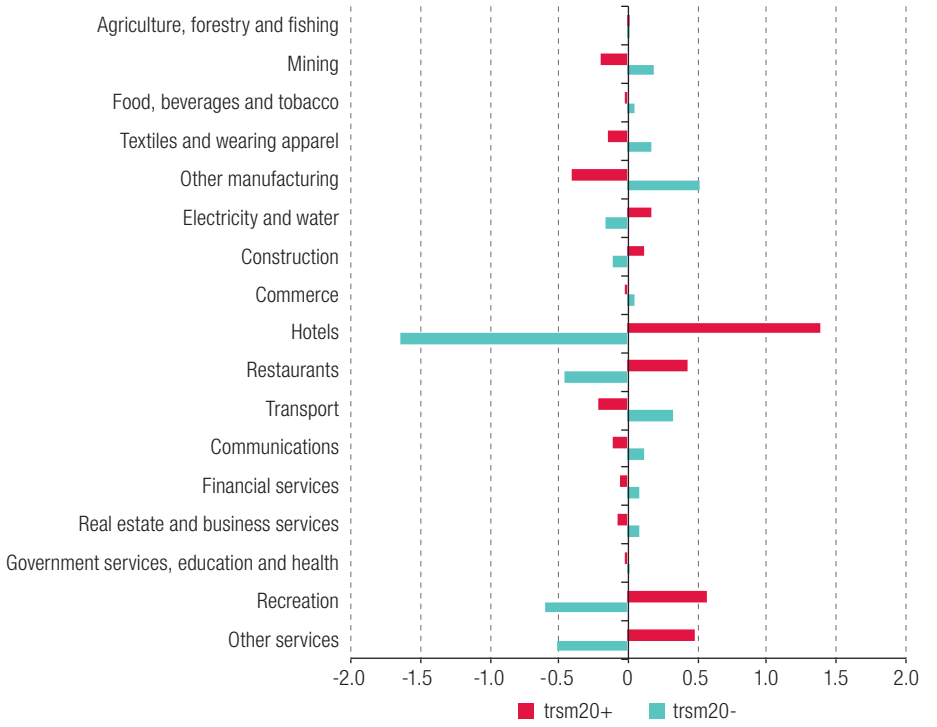


Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

(d) Sectoral results

Unsurprisingly, at the sectoral level, service industries catering directly to tourists, including hotels and restaurants, are strongly stimulated by growth in foreign tourist spending (simulations trsm10+ and trsm20+). In 2022, scenario trsm20+ shows employment in hotels and restaurants as being 6.6% and 6.3% higher than in the base scenario, respectively (see table A2.2). On the other hand, the upward pressure on prices and the real exchange rate leads to reduced competitiveness for the other (non-tourism) export sectors. Specifically, figure 19 and table A2.2 show a decrease in employment and value added in manufacturing and mining, two of the most export-oriented sectors (see table 2). In turn, scenarios trsm10- and trsm20- show that a 10% and 20% decrease in foreign tourist spending combined with an increase in FDI in the accommodation industry would lead to a large reduction in the number of workers employed in the hotel sector (again, see table A2.2). Our simulations show that the key mechanisms determining the size of the economic impacts from increased tourism demand include: factor supply constraints, exchange rate appreciation and current government economic policy (see Dwyer and others, 2000). In the period 2018–2020, the increase in private investment in hotels leads to a quite large expansion of the construction industry. Afterwards, higher incomes and saving mean that construction output is still above the baseline.

Figure 19
Sectoral GDP growth by simulation: deviation of average annual growth from the base scenario
(Percentage points)



Source: Prepared by the authors, on the basis of simulation results.
Note: For simplicity, only the results for the trsm20+ and trsm20- non-base scenarios are shown. trsm20+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm20+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

(e) Distributive results

With regard to poverty, our results show, for example, the poverty headcount ratio in Jamaica falling by about 0.3 percentage points and 0.11 percentage points relative to the base scenario by 2022 and 2030, respectively, in the trsm20+ scenario (see figure 20). The main drivers of this result are a decrease in unemployment, a higher average wage and an increase in non-labour income for households linked to the tourism industry. Interestingly, in the medium to long run the negative impact of real exchange-rate appreciation reduces the gains brought about by the increase in foreign tourism spending. Where inequality is concerned, we do not find statistically significant changes.

Figure 20
Headcount poverty by simulation in 2022 and 2030: deviation from the base scenario
(Percentage points)

Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

V. Concluding remarks

In this paper, a consistent quantitative framework has been developed for the assessment of private investments in the hotel industry and their impacts on a nation's economy and household welfare. The tourism sector's contribution to growth, poverty reduction and long-term development depends upon complex and dynamic economic, social, environmental and institutional linkages, spillovers and externalities. The results demonstrate that tourism and investment in this have positive impacts on national economies, though the distribution of benefits is dependent on socioeconomic factors such as the distribution of factor endowments among households. The sectoral distribution of benefits is also conditioned by these factors and by the initial conditions at the destination, such as the sectoral structure of the economy. There are invariably winners and losers when a new investment (or policy) is implemented.

In the present study, we applied this framework to simulate the impacts of US$ 600 million worth of private investment in tourism in Jamaica. To summarize, our results showed this investment combined with an expansion of foreign tourism demand to result in a positive impact on GDP, employment, household incomes and poverty. On the other hand, the expansion of foreign tourism demand leads to domestic absorption increasing more rapidly than GDP, which results in a deterioration of the merchandise trade balance. At the sectoral level, sectors catering more directly to tourism are found to experience the highest rates of growth, with sectors further removed from the tourism value chain growing more slowly. For instance, service industries such as hotels and restaurants are strongly stimulated by the expansion of tourism, with their value added increasing by 19% and 5.5%, respectively, when tourist demand increases by 20%. On the other hand, real exchange-rate appreciation leads to a loss of competitiveness in other (non-tourism) export sectors such as manufacturing and mining.

In addition, the results show that a 20% increase in tourism spending together with more private investment in the hotel industry could reduce poverty in the country by 0.3 percentage points by 2022 relative to the BAU scenario. This result is equivalent to a 2.3% average annual decrease in poverty relative to the BAU scenario between 2018–2030, and is mainly driven by a decrease in unemployment and a higher average wage. This could represent approximately 120,000 Jamaicans, or about 4% of today's population, being lifted out of poverty during the 13-year time frame. With regard to inequality, the study does not find statistically significant changes in any of the scenarios.

Overall, the findings show that investments in hotel infrastructure can bring major development impacts to local economies in developing countries. As global demand for tourism continues to grow and the supply of tourism services adjusts to changing preferences, it will be important to reach a greater understanding of the economy-wide impacts of different types of tourism investment, e.g. all-inclusive versus limited-service hotels. Multilateral development banks and impact investors working with the private sector have a key role to play in promoting tourism investments that drive broader development impacts.

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Annex A1

Sensitivity analysis

The results from our Jamaica CGE model are a function of (i) the model structure (including functional forms used to model production and consumption decisions and macroeconomic closures), (ii) the database used for model calibration (including the SAM) and (iii) the values assigned to the model elasticities or, more generally, to the model's free parameters. In other words, the elasticities used in this study implicitly carry an estimation error, as they do in any similar model. To better understand the implications of this, we performed a systematic sensitivity analysis of the results with respect to the value assigned to the model elasticities. If the conclusions of the analysis are robust to changes in the set of elasticities used for model calibration, we will have greater confidence in the results presented above.

In the systematic sensitivity analysis, it is assumed that each of the model elasticities is uniformly distributed around the central value used to obtain the results. The range of variation allowed for each elasticity is +/-75%, i.e. a fairly wide range of variation for each model elasticity is incorporated. Our method is a variant of the one originally proposed by Harrison and Vinod (1992). Briefly, the model is solved iteratively with different sets of elasticities. The resulting distribution of results is used to build confidence intervals for selected model results. The steps for the systematic sensitivity analysis are as follows:

(i) The distribution (i.e. the lower and upper bound) is computed for each model parameter to be modified: elasticities of substitution between the primary factors of production, trade-related elasticities, expenditure elasticities and unemployment elasticities for the wage curves.

(ii) The model is solved repeatedly, each time with a different set of elasticities, following a Monte Carlo type procedure. First, the value for all model elasticities is randomly selected. Second, the model is calibrated using the selected elasticities. Third, the same base and non-base scenarios as previously described are calculated.

These three steps are repeated 1,000 times, employing sampling with replacement for the value assigned to the elasticities.

Table A1.1 shows the percentage change in private consumption estimated (i) with the central elasticities and (ii) as the average of the 1,000 observations generated by the sensitivity analysis. For the second case, the upper and lower bounds under the normality assumption were also computed. All runs from the Monte Carlo experiment receive the same weight. As can be seen, the results reported in the main text are significant and the estimates presented in table A2.1 are within the confidence intervals reported in table A1.1. For example, it is almost completely certain that the investment and tourism shock simulated in scenario trsm20+ would have a positive effect on private consumption. In addition, mean-comparison tests show that the increase in private consumption is significantly higher the larger the increase in foreign tourist arrivals.

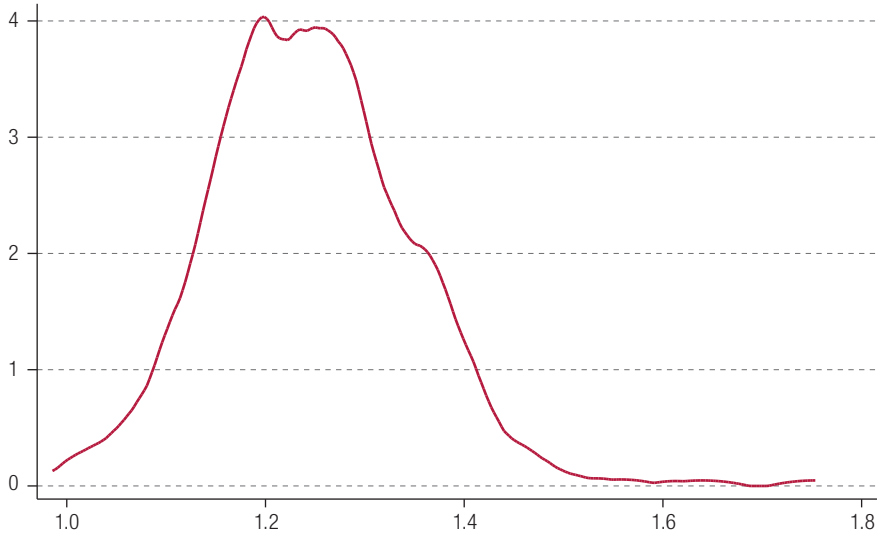
Figure A1.1 shows non-parametric estimates of the density function for the percentage change in private consumption in the trsm20+ scenario with respect to the base scenario. Again, the sign of the results (positive) does not change when model elasticities are allowed to differ by +/-75% from their "central" values.

Table A1.1
Systematic sensitivity analysis: 95% confidence interval for real private consumption under the normality assumption, deviation from the base scenario by 2030
(Percentages)

Item	trsm10+	trsm20+	trsm10-	trsm20-
Mean	0.387	1.246	-0.965	-1.494
Standard deviation	0.118	0.102	0.174	0.191
Lower bound	0.155	1.047	-1.306	-1.868
Upper bound	0.619	1.445	-0.623	-1.121
Central elasticities	0.401	1.231	-0.923	-1.447

Source: Authors' calculations.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

Figure A1.1
Sensitivity analysis, real private consumption under scenario trsm20+,[a] deviation from the base scenario by 2030
(Percentages)



Source: Authors' calculations.
[a] Scenario with a US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario.

Annex A2

Additional simulation results

Tables A2.1 to A2.5 show key macroeconomic and sectoral results for the non-base scenarios in 2022 (the first year after the simulated tourism-related investment is completed) and 2030.

Table A2.1
Real macro indicators and deviations from the baselines in the different scenarios

Item	Baseline (2015)	trsm10+		trsm20+		trsm10-		trsm20-	
		2022	2030	2022	2030	2022	2030	2022	2030
Absorption	1 923 274	0.2	0.3	0.8	1.0	-0.8	-0.7	-1.2	-1.2
Private consumption	1 346 283	0.2	0.4	0.9	1.2	-1.0	-0.9	-1.5	-1.4
Investment	345 265	0.3	0.4	0.9	0.9	-0.6	-0.6	-1.0	-0.9
Private investment	314 516	0.3	0.4	0.9	1.0	-0.7	-0.6	-1.1	-1.0
Exports	255 040	-3.5	-4.7	-9.6	-11.1	8.5	7.8	14.4	13.9
Imports	752 995	1.3	1.6	3.4	3.8	-2.2	-2.1	-3.7	-3.6
Foreign tourism	241 875	10.0	10.0	20.0	20.0	-10.0	-10.0	-20.0	-20.0
GDP at market prices	1 667 194	0.5	0.4	0.8	0.7	-0.1	-0.2	-0.5	-0.6
Net indirect taxes	319 582	1.0	1.0	2.1	2.1	-1.0	-1.0	-1.9	-1.9
GDP at factor cost	1 347 612	0.4	0.3	0.6	0.4	0.1	0.0	-0.1	-0.2
Real exchange rate (index)	1	-0.9	-1.3	-3.0	-3.5	3.0	2.5	4.7	4.3
Wages (index)	1	0.6	1.1	2.1	2.8	-1.9	-1.9	-3.0	-3.2
Return on capital (index)	1	0.3	0.0	0.4	-0.2	0.3	0.6	0.4	0.9
Unemployment rate (%)	13.5	-0.2	-0.2	-0.5	-0.5	0.5	0.3	0.8	0.6

Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario. Except where otherwise indicated, the 2015 column shows levels in millions of Jamaican dollars, while the simulation columns show percentage deviations from the base in the same year. For unemployment, the 2015 column shows the actual rate, while the simulation columns show percentage point deviations from that baseline the same year.

Table A2.2
Sectoral employment in the different scenarios

Sector	Baseline 2015	trsm10+		trsm20+		trsm10-		trsm20-	
		2022	2030	2022	2030	2022	2030	2022	2030
Agriculture, forestry and fishing	202 600	0.08	0.00	-0.09	-0.11	0.46	0.25	0.65	0.38
Mining	5 815	-1.16	-1.74	-2.95	-4.21	1.94	2.48	3.29	4.30
Food, beverages and tobacco	25 527	-0.01	-0.40	-0.77	-1.29	1.49	1.31	2.22	2.13
Textiles and wearing apparel	11 366	-0.70	-1.02	-2.12	-2.43	2.11	1.77	3.49	3.14
Other manufacturing	36 271	-2.10	-2.96	-6.23	-7.02	6.24	5.30	10.43	9.47
Electricity and water	8 723	1.78	0.99	3.43	1.58	-1.45	-0.33	-3.04	-1.05
Construction	82 789	0.60	0.60	1.38	1.29	-0.85	-0.68	-1.52	-1.27
Commerce	227 915	-0.19	-0.50	-0.70	-1.32	0.97	1.25	1.60	2.16
Hotels	36 480	-6.86	1.95	6.57	16.76	-31.38	-25.05	-42.45	-37.22
Restaurants	52 000	3.02	2.92	6.27	5.94	-3.34	-3.03	-6.46	-5.97
Transport	59 957	-0.29	-1.24	-2.74	-3.77	4.41	3.66	6.66	6.03
Communications	14 962	-1.20	-1.95	-3.74	-4.77	3.51	3.33	5.71	5.80
Financial services	26 469	-0.22	-0.68	-1.29	-1.93	1.77	1.65	2.70	2.73
Real estate and business services	74 393	-0.52	-1.14	-2.30	-3.14	2.66	2.44	4.08	4.05
Government services, education and health	159 964	0.01	-0.01	0.00	-0.04	0.03	0.05	0.04	0.07
Recreation	17 810	4.66	4.24	8.92	8.16	-4.01	-3.86	-8.41	-8.02
Other services	95 734	3.71	3.47	7.29	6.77	-3.52	-3.30	-7.16	-6.75
Total	1 138 775	0.18	0.20	0.59	0.52	-0.56	-0.38	-0.90	-0.65

Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario. The 2015 column shows the number of workers in each sector, while the simulation columns show percentage deviations from that baseline the same year.

Table A2.3
Sectoral real value added in the different scenarios

Sector	Baseline 2015	trsm10+		trsm20+		trsm10-		trsm20-	
		2022	2030	2022	2030	2022	2030	2022	2030
Agriculture, forestry and fishing	101 764	0.05	0.03	-0.04	0.02	0.25	0.09	0.35	0.13
Mining	29 359	-0.68	-1.07	-1.51	-2.56	0.72	1.37	1.31	2.38
Food, beverages and tobacco	67 014	0.00	-0.10	-0.33	-0.33	0.68	0.37	1.01	0.62
Textiles and wearing apparel	1 129	-0.54	-0.77	-1.58	-1.76	1.53	1.20	2.54	2.18
Other manufacturing	59 118	-1.43	-2.15	-4.22	-5.09	4.07	3.75	6.78	6.69
Electricity and water	45 242	0.81	0.96	1.61	2.04	-0.72	-1.07	-1.46	-2.02
Construction	103 898	0.62	0.64	1.35	1.38	-0.73	-0.70	-1.36	-1.32
Commerce	252 541	0.03	-0.09	-0.15	-0.24	0.50	0.36	0.76	0.64
Hotels	41 899	9.51	9.50	18.99	18.98	-9.45	-9.46	-18.93	-18.94
Restaurants	15 858	2.59	2.69	5.38	5.53	-2.88	-2.89	-5.57	-5.63
Transport	56 866	-0.25	-0.87	-1.92	-2.63	2.93	2.53	4.44	4.17
Communications	50 166	-0.37	-0.67	-0.98	-1.45	0.74	0.78	1.24	1.44
Financial services	116 150	-0.09	-0.28	-0.61	-0.75	0.86	0.62	1.30	1.04
Real estate and business services	147 320	-0.19	-0.37	-0.75	-0.95	0.80	0.63	1.22	1.06
Government services, education and health	202 138	0.01	-0.01	0.01	-0.04	0.03	0.04	0.03	0.06
Recreation	29 133	3.84	3.80	7.34	7.41	-3.35	-3.59	-7.02	-7.36
Other services	28 016	3.09	3.14	6.06	6.21	-2.96	-3.11	-6.02	-6.26
Total	1 347 612	0.43	0.30	0.59	0.45	0.11	-0.01	-0.06	-0.17

Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario. The 2015 column shows value added in millions of Jamaican dollars that year, while the simulation columns show percentage deviations from that baseline.

Table A2.4
Sectoral exports in the different scenarios

Sector	Baseline 2015	trsm10+		trsm20+		trsm10-		trsm20-	
		2022	2030	2022	2030	2022	2030	2022	2030
Agriculture, forestry and fishing	10 037	-6.18	-7.93	-16.38	-18.26	14.26	12.88	24.41	23.25
Mining	72 475	-0.71	-1.11	-1.52	-2.65	0.60	1.35	1.14	2.35
Food, beverages and tobacco	26 257	-5.25	-6.81	-14.55	-15.81	13.19	11.01	22.29	19.77
Textiles and wearing apparel	273	-6.49	-8.76	-18.28	-20.23	17.60	14.71	29.77	26.57
Other manufacturing	60 562	-4.96	-7.06	-14.12	-16.49	13.32	12.09	22.38	21.74
Electricity and water	1 831	-4.36	-4.05	-11.70	-9.36	10.02	5.90	17.05	10.56
Commerce	12	-4.11	-5.62	-12.21	-13.30	11.75	9.39	19.48	16.68
Transport	40 839	-4.16	-5.79	-11.95	-13.87	11.21	10.30	18.77	18.26
Communications	15 661	-2.81	-3.80	-7.14	-8.53	5.03	4.79	8.60	8.71
Financial services	10 607	-4.52	-5.95	-12.55	-13.85	11.28	9.53	19.02	17.06
Real estate and business services	12 642	-4.24	-5.24	-10.86	-11.90	8.57	7.48	14.76	13.55
Government services, education and health	89	-4.85	-6.88	-13.95	-16.36	13.42	12.25	22.53	21.80
Recreation	3 755	-1.54	-2.75	-7.48	-8.30	8.73	6.57	13.02	10.31
Total	255 040	-3.47	-4.75	-9.60	-11.14	8.53	7.77	14.40	13.88

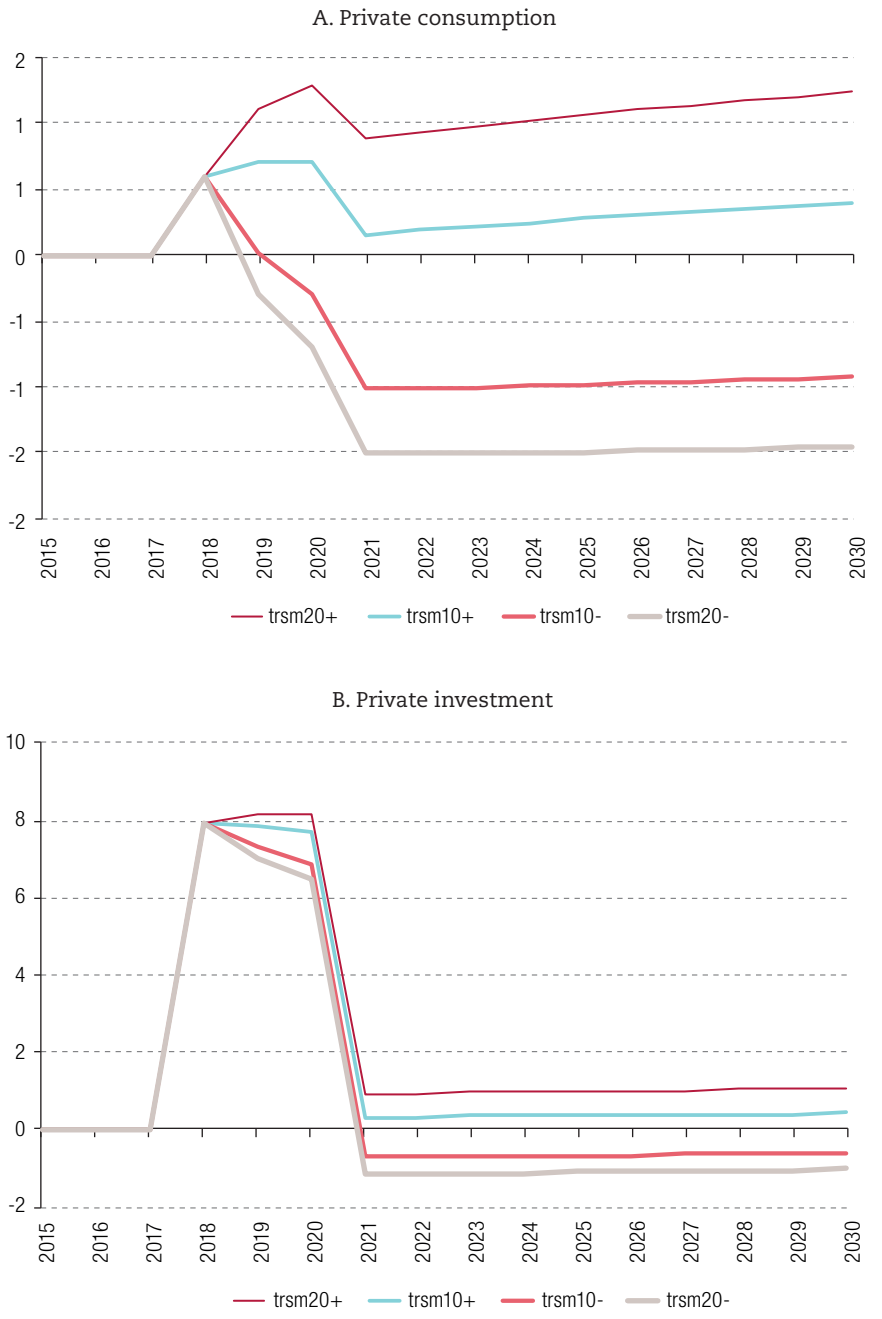
Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario. The 2015 column shows exports in millions of Jamaican dollars that year, while the simulation columns show percentage deviations from that baseline.

Table A2.5
Sectoral imports in the different scenarios

Sector	Baseline 2015	trsm10+		trsm20+		trsm10-		trsm20-	
		2022	2030	2022	2030	2022	2030	2022	2030
Agriculture, forestry and fishing	8 556	2.50	3.12	6.68	7.57	-4.49	-4.28	-7.45	-7.39
Mining	58	-0.40	-0.75	-1.45	-1.85	1.74	1.55	2.81	2.73
Food, beverages and tobacco	55 340	2.35	2.88	6.23	6.87	-4.33	-3.95	-7.23	-6.90
Textiles and wearing apparel	12 464	0.99	1.30	2.83	3.25	-2.21	-2.04	-3.61	-3.48
Other manufacturing	447 858	0.56	0.67	1.44	1.61	-0.90	-0.87	-1.50	-1.49
Electricity and water	522	3.61	3.67	9.28	8.53	-5.90	-4.52	-9.94	-8.03
Construction	639	2.52	3.38	7.33	8.46	-5.41	-4.92	-8.71	-8.34
Commerce	7 053	2.17	2.80	6.48	7.02	-4.70	-3.87	-7.46	-6.53
Hotels (imports)	28 574	1.07	1.53	3.45	4.00	-2.89	-2.55	-4.56	-4.24
Restaurants (imports)	8 556	1.07	1.53	3.45	4.00	-2.89	-2.55	-4.56	-4.24
Transport	41 872	3.78	4.19	8.82	9.42	-5.04	-4.89	-8.94	-8.89
Communications	12 669	1.68	2.06	4.30	4.85	-2.72	-2.56	-4.58	-4.49
Financial services	25 542	2.55	3.16	6.96	7.64	-4.78	-4.25	-7.87	-7.35
Real estate and business services	89 248	2.23	2.58	5.55	6.00	-3.47	-3.19	-5.95	-5.66
Government services, education and health	706	2.54	3.61	7.82	9.29	-6.07	-5.57	-9.63	-9.31
Recreation	9 923	7.00	7.67	16.66	17.32	-9.64	-8.92	-16.90	-16.15
Other services	3 415	6.48	7.23	15.88	16.64	-9.39	-8.61	-16.17	-15.37
Total	752 995	1.34	1.59	3.44	3.77	-2.21	-2.06	-3.73	-3.60

Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario. The 2015 column shows exports in millions of Jamaican dollars that year, while the simulation columns show percentage deviations from that baseline.

Figure A2.1
Real private consumption and investment in the different scenarios: deviations from the base scenario
(Percentages)



Source: Prepared by the authors, on the basis of simulation results.
Note: trsm10+: US$ 200 million yearly increase in private investment in hotels during 2018–2020 and foreign tourism spending 10% higher every year during the period 2021–2030 than in the base scenario; trsm20+: same investment as trsm10+, but foreign tourism spending 20% higher every year during the period 2021–2030 than in the base scenario; trsm10-: same investment as trsm10+, but foreign tourism spending 10% lower every year during the period 2021–2030 than in the base scenario; trsm20-: same investment as trsm10+, but foreign tourism spending 20% lower every year during the period 2021–2030 than in the base scenario.

Fiscal and monetary policy rules in Brazil: empirical evidence of monetary and fiscal dominance

Tito Belchior S. Moreira, Mario Jorge Mendonça and Adolfo Sachsida

Abstract

Based on the hypothesis that the rules of monetary and fiscal policy in Brazil may have been subject to different regimes, the present study applies the Leeper model (1991 and 2005) to identify the chronology of policy regimes in terms of their active and passive character. The policy rules are estimated using the Markov-switching model, with a monthly database from November 2002 to December 2015, in which the regimes are endogenously determined. The results obtained indicate that fiscal dominance occurred in 2010 and between 2013 and 2014, while monetary dominance marked much of 2003 and the period 2005–2007. The model also seeks to explain why the inflation rate continued to rise during 2015 even though Central Bank of Brazil took an active monetary policy stance that year.

Keywords

Monetary policy, fiscal policy, inflation, gross domestic product, public debt, macroeconomics, econometric models, Brazil

JEL classification

E31, E52, E62, H60

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I. Introduction

The government budget constraint means that the government's current debt must be compatible with the present value of its future income. The optimal monetary rule assumes that fiscal policy is not relevant to monetary policy and public debt is therefore assumed to be sustainable. In other words, the fiscal authority will always adjust taxes to ensure the payment of the debt. However, if the government uses seigniorage to balance the budget, the budget deficit will impact on the current or future rise in the money supply. It therefore needs to be determined whether the rise in debt may lead to an increase in the rate of inflation.

As remarked by Walsh (2003), if fiscal policy acts independently, the monetary authority is forced to create seigniorage revenue to balance the government accounts.[1] Leeper (1991) describes this situation —where fiscal policy is active and monetary policy is passive— as fiscal dominance. Sargent and Wallace (1981) show that one adverse effect of fiscal dominance is that if the primary balance falls, seigniorage revenue will have to be increased in order to accommodate the government budget constraint. In this context, attempts to control current inflation will lead to higher inflation in the future. The idea underlying this point is this: reducing seigniorage revenue will increase the deficit and, thus, total debt. Over time, the monetary authority will be forced to increase the money supply.

Leeper (1991) states that equilibrium policies can be classified in two ways, on the basis of a fiscal policy rule or a monetary policy rule. The first set are those in which the basic rate of interest responds to the rate of inflation (monetary rule) and taxes respond to fluctuations in public debt (fiscal rule). Here, monetary policy is active and fiscal policy is passive, fiscal shocks do not influence equilibrium prices, interest rates or real wages. This first case is a situation of monetary dominance. In the second set of rules, fiscal policy is active and monetary policy is passive. Fluctuations in public debt lead to money creation. In this case, the public deficit increase inflation, prices depend on government liabilities and the nominal interest rate depends on the relation between the amount of money and the government debt. A monetary contraction will push up inflation. This second situation is one of fiscal dominance, where monetary policy is a consequence of fiscal policy.[2]

Leeper (1991) studied the interaction between monetary and fiscal policy by analysing the equilibria produced by these monetary and fiscal parameters. In this model, monetary policy defines the nominal interest rate as a function of current inflation, while the fiscal authority choses a level of direct taxation in response to the rise in public debt. The parameters of fiscal policy rules determine the degree of independence of each source of revenue. The parameters associated with an active stance assume that fiscal policy does not respond to the conditions of constraint that must be applied in order to maintain equilibrium, i.e. the fiscal authority does not concern itself with public debt sustainability, but with increasing levels of economic activity, for example. Meanwhile, under the parameters of passive conduct by the fiscal authority, it would raise taxes when the deficit increases.

Conversely, the parameters of active monetary policy imply that the interest rates controlled by the central bank respond to the constraints that must be imposed to maintain equilibrium. The parameters of a passive stance by the monetary authorities would indicate no rise in the base rate when inflation rises; otherwise, the monetary stance is an active one, i.e. the monetary authority concerns itself mainly with maintaining price stability and not the level of activity or employment in the economy.

[1] Seigniorage revenue comes from two sources. The first is the increase in the real monetary base in relation to revenue. The second stems from the fact that to keep real cash reserves constant, the private sector needs to increase the volume of the nominal reserve to a rate roughly equal to the increase in the monetary base.

[2] In a seminal work, Martins (1980) established that the prices of securities are equivalent to the price level and that the nominal interest rate is determined by the ratio between the debt stock and currency reserves.

Moreira, Souza and Almeida (2007) apply the Leeper model to quarterly data from 1995 to 2006 and find evidence that, in this period, the Brazilian economy underwent a regime of fiscal dominance. Starting from the hypothesis that policy rules in Brazil may have been subject to different regimes, this study uses the Leeper model (1991 and 2005) to establish the chronology of the activeness or passiveness of monetary and fiscal policy rules. Moreira (2009 and 2011) tests empirically whether Brazilian fiscal policy was active or passive. The empirical results show that the channels of transmission of fiscal policy are seen through the effects of the public debt to GDP ratio on money demand, the primary surplus, the nominal interest rate, investment and the output gap. Lastly, estimates based on the Leeper model show that the Brazilian economy is characterized by fiscal dominance, which describes the fiscal theory of the price level.

In this context, the contribution of this work is to identify the interaction between fiscal and monetary policies, on the basis of endogenous Markov regime-switching. In other words, policy rules or response functions are estimated using the Markov-switching model. The sample comprises monthly data from 2002 to December 2015. The results obtained support the affirmation that fiscal dominance occurred in 2010 and between 2013 and 2014. Monetary dominance was present during much of 2003 and in the period 2005–2007. The model also explains why the inflation rate continued to rise in 2015, despite the central bank's adoption of an active monetary policy.

The present article is divided into seven sections, including this introduction. The second section presents the broad lines of the Leeper model (1991). The third describes the Markov-switching model, which is used in the fourth and fifth sections to estimate, respectively, the fiscal and monetary response functions. The sixth section analyses the activeness or passiveness of monetary and fiscal policy rules in Brazil; the seventh offers concluding remarks.

II. The Leeper model (1991 and 2005)

The Leeper model (1991 and 2005) is based on a representative agent having a constant endowment y to consume c in each period. The government takes out $g < y$, generating no profit for the agent. The government also takes part τ of tax from y. The real reserve ratio m is $\frac{M}{p}$, where M is the stock of money and p is the price level. Agents have a government security B for a period obtaining a risk-free nominal yield R. Given an intertemporal discount rate $\beta \in (0,1)$, and taking y_t, p_t, R_t and τ_t as exogenous variables for each t, the agent faces the following problem:

$$\max_{\{c_t, b_t, m_t\}} \sum_{t=0}^{\infty} \beta^t \left[log(c_t) + log(m_t) \right]$$

$$\text{st. a } c_t + \frac{M_t}{p_t} + \frac{B_t}{p_t} + \tau_t = y_y + \frac{M_t}{p_t} + R_{t-1}\frac{B_{t-1}}{p_t} \tag{1}$$

Using first order conditions and the feasibility condition, $c_t = y_t - g_t$, it can be shown that the model is reduced to a defined system, respectively, by the Fisher and currency demand equations (2)-(3):

$$\frac{1}{R_t} = \beta E_t \left[\frac{1}{\pi_{t+1}} \right] \tag{2}$$

$$m_t = c_t E_t \left[\frac{R_t}{R_t - 1} \right]^{-1} \tag{3}$$

where π_{t+1} is the inflation rate in $t + 1$ and $m_t = \frac{M_t}{p_t}$. Taking $b_t = \frac{B_t}{p_t}$, the government budget constraint obeys the following identity:

$$b_t + m_t + \tau_t = \frac{R_{t-1} b_{t-1} + m_t}{\pi_t} \quad (4)$$

Fiscal policy is defined by a rule that we denominate the fiscal response function, such that:

$$\tau_t = \gamma_0 + \gamma b_t + \psi_t \quad (5)$$

The monetary policy rule or response function followed by the central bank is identified as follows:

$$R_t = \alpha_0 + \alpha \pi_t + \mu_t \quad (6)$$

Leeper (1991) takes ψ_t and μ_t as non-correlated first order autoregressions. A priori, the author does not propose any restrictions for α and γ.

Equations (2)-(4), (5) and (6) can be reduced to a recursive system in the variables π_t and b_t whose roots $\alpha\beta$ and $\beta^{-1} - \gamma$ determine the system's stability. Two situations of interest occur.

1. Monetary dominance: $|\alpha\beta| > 1$ and $|\beta^{-1} - \gamma| < 1$

This is the case of a single equilibrium. In this region, monetary shocks produce expected trajectories and fiscal shocks are irrelevant. In other words, in region I, monetary policy has no constraints and may actively pursue price stability, responding strongly to inflation. Fiscal policy obeys the constraints imposed by the behaviour of the private sector and by monetary policy, and adjusts passively to the collection of direct taxes to balance the budget. Ricardian equivalence obtains here. In this case, monetary policy is active and fiscal policy is passive. This means that monetary policy is effective at determining the price level and the monetary authority need not concern itself with the budget constraint, because the fiscal authority can choose a tax level to keep debt sustainable at any given time. Leeper (2005) shows that equilibrium inflation is an entirely monetary phenomenon and that fiscal shocks do not affect inflation or the nominal interest rate. This is the ideal region for policymakers to establish an inflation target by controlling the rate of interest. More specifically, there is no restraint of any kind on monetary policy and it can actively pursue price stability. Fiscal policy obeys the constraints imposed by monetary policy and the private sector and adjusts passively to achieve budget equilibrium.

2. Fiscal dominance: $|\alpha\beta| < 1$ and $|\beta^{-1} - \gamma| > 1$

In this region, monetary policy responds weakly to inflation ($|\alpha\beta|<1$) while fiscal policy does not respond strongly to debt ($|\beta^{-1} - \gamma|>1$). This regime also generates a single equilibrium. This is equivalent to the situation described by Sargent and Wallace (1981) when they coined the expression "unpleasant monetarist arithmetic". In this case, monetary policy is passive and fiscal policy active. Now, the monetary authority obeys the constraints imposed by fiscal policy.

There are two possible cases. The first arises when the two roots have modulus less than 1, i.e. each authority is acting passively. Without an additional constraint imposed by one of the authorities to take an active stance, there are many equilibrium-compatible money supply increase processes that lead to price level indeterminacy, an outcome remarked by Sargent and Wallace (1975). In the second case, the two roots have modulus greater than 1, so that both authorities are acting actively. Unless shocks ψ_t and μ_t are supposed to be correlated, there is no process of increase in the money supply that ensures that agents will finance government securities.

In light of the foregoing, some brief remarks are warranted on coordination between monetary, fiscal and indeed exchange-rate policies, although the Leeper model (1991) does not address the

last of these. Bearing in mind the trade-off between inflation and unemployment and the fact that in 1999 Brazil adopted an inflation-targeting system that implicitly admitted the prevalence of a monetary dominance regime, a number of conjectures may be made.

If the central bank pursues lower inflation, even at the cost of higher unemployment, and the Ministry of Finance pursues long-term public debt sustainability, the central bank will respond by raising the Selic rate if inflation expectations rise. Similarly, fiscal policy will always seek to maintain a large enough primary surplus to maintain public debt sustainability. This is an indication of coordination between fiscal and monetary policymakers.

In other words, this is the policy that can ensure monetary dominance. Any other case must correspond to a lack of coordination or, worse, a conflict of interest between policies. For example, if the central bank tries to raise the base rate in order to keep inflation close to the target and fiscal policy prioritizes increasing employment (a smaller surplus to boost aggregate demand) even at the expense of inflation, the policy aims are contradictory. The opposite case, and cases in which both policies are active or both passive, speak to policy conflicts, suggesting a lack of coordination between policymakers.

It may also be said that a deliberate policy of excessive build-up of foreign reserves can generate adverse effects: on the one hand, it increases the monetization of the economy as a result of foreign-exchange buying by the central bank, which pushes up inflation. On the other hand, to maintain price stability, the central bank will be forced to issue repurchase agreements, which increases public debt. The pass-through effect must also be borne in mind, whereby part of the exchange-rate variation —whether rise or fall— is passed on to the rate of inflation.

III. Response function modelling with regime-switching

The previous section presented the Leeper model (1991), which may be used to obtain the conditions to determine whether policy is active or passive. From a practical point of view, it is necessary to ascertain the fiscal and monetary policy rules, and on that basis to verify the stability of the model. On the basis of the Leeper model (1991), Moreira, Souza and Almeida (2007) found evidence that Brazil underwent a regime of fiscal dominance from 1995 to 2006.

The present study takes that literature further, taking as a basis the hypothesis that monetary and fiscal policies may have undergone different regimes during the sample period analysed. The existence of different regimes makes the conventional econometric techniques unsuitable to address the problem, even working with different subsamples. A specific model is therefore used to treat supposed structural breaks. That model allows the different stages undergone by monetary and fiscal policies since 2003 to be determined more clearly and accurately (Davig and Leeper, 2011). The model used to estimate fiscal and monetary policy rules is discussed briefly below.

1. Markov-switching model

When a linear relationship undergoes a structural break —which can occur in the coefficients of the variables, in the intercept and also in the variance of this relationship— the relevant parameters of the regression model vary over time, producing non-linearities and, usually, violations of the stationarity and normality hypotheses of the errors of conventional models. An alternative approach in this case is to treat structural breaks (and, thus, "regime switches") as exogenous, by introducing dummy variables into the conventional linear models. However, this procedure requires advanced knowledge of the

precise moment at which breaks occurred, which in practice is rarely known. Even in the unlikely case that the researcher "correctly guessed" the exact date of the relevant break or break, as well as their respective durations, by itself the introduction of dummy variables does not resolve the problems related to regime changes in the variance of the model errors. As Sims (2001) stated, it is a serious error to disregard these or any other cause of residual non-normality when considering changes in the parameters of the variables.

Markov-switching models explicitly assume that at any time there may be a finite (and generally small) number of "regimes" or "states", without knowing with certainty which obtains at that time. To cite an intuitive example, it appears reasonable to suppose that an economy in recession will behave differently (or have different parameters) to an economy that is growing rapidly. In this case, two "regimes" with quite different characteristics —one "recessionary" and the other "fast-growing"— could be considered to exist and to alternate every so often, without certainty as to which is occurring at each specific period.

Accordingly, Markov-switching models do not presume that "state switches" —for example, the passage from the "fast-growing" to the "recessionary" regime— are deterministic events. The hypothesis is rather one of "probabilities of transition" from one regime to another, which are endogenous estimated using Markov-switching models.[3] There is nothing to prevent regime switches from being "once and for all", in other words after a switch a given regime may remain indefinitely.

Non-linear time series modelling has been gaining increasing importance for some time now (Hamilton, 1989 and 1994; Krolzig, 1997; Kim and Nelson, 1999; Sims, 1999 and 2001; Franses and Van Dijk, 2000; Lütkepohl and Kratzig, 2004). In the present study we use the Markov-switching model to estimate fiscal and monetary response functions. We thus propose to specify each of these models as follows:

$$y_t = b_0(S_t) + \sum_{m=1}^{P} b_m(S_t)\chi_{mt} + \sigma(S_t)\varepsilon_t \qquad (7)$$

$$\text{with } \varepsilon_t \sim N\left(0, \sigma^2(S_t)\right);$$

where S_t is an unobserved stochastic variable which determines the state k that the model assumes in each period t.

Note that, ex hypothesis, the "latent variable" S_t is governed by a stochastic process known as the ergodic Markov chain and defined by matrix of transition probabilities whose elements are given by:

$$p_{ij} = Pr\left(S_{t+1} = j \mid S_t = i\right), \sum_{j=1}^{k} p_{ij} = 1 \quad \forall\, i,j \in \{1, \ldots, k\}$$

$$p_{ij} \geq 0 \text{ for } i,j = 1, 2, \ldots, K \qquad (7.1)$$

Here, p_{ij} represents the probability that, in $t + 1$, the chain will switch from regime i to regime j. The idea is thus that the probability of any regime S_t occurring in the present depends solely on the regime existing in the previous period, i.e. S_{t-1}. With k existing regimes, the probabilities of transition between states may be represented by the matrix of transition probability P, with the dimension (k x k).

The parameters of this model are estimated via maximization of the model's likelihood function by means of the expectation–maximization (EM) algorithm (Dempster, Laird and Rubin, 1977), an iterative technique for models with omitted or unobserved variables. It may be shown that the relevant likelihood function increases with each iteration of this process, which ensures that the final result will be

[3] More technically speaking, Markov-switching models fall within what Chib (1996) denominates "hidden Markov models". For a broad variety of these models, see Kim and Nelson (1999).

close enough to the maximum likelihood in the relevant vicinity.[4] However, it must be recalled that the likelihood function of a Markov-switching models has no global maximum (Hamilton, 1991 and 1994; Koop, 2003). Fortunately, the EM algorithm often yields a "reasonable" local maximum and pathological cases are relatively rare (Hamilton, 1994).

IV. Fiscal response function

Although relatively small compared to what is termed the "central bank response function" there is an analogous literature concerned with estimated the "fiscal response function" of the National Treasury (Bohn, 1998; Taylor, 2000; Galí and Perotti, 2003; Thams, 2007, among others).

Accurate estimation of the fiscal response function is important for analysis of macroeconomic policy for at least two reasons. The first concerns the sustainability of public debt. Here, it is important to ascertain whether the primary surplus reacts to variations in the public debt to GDP ratio in a manner that keeps that ratio at sustainable levels (Bohn, 1998). The second reason is that estimation of the fiscal response function serves to investigate whether fiscal policy pursues some other objective, such as supporting aggregate demand or helping the monetary authority to control inflation.

Given that we are using the Leeper model to test policy rules for Brazil, it is important to be aware of the specificities, legal aspects and, above all, the calculation methodologies of fiscal indicators. In this contest, Carvalho and Feijó (2015) perform a detailed study of the "below the line" methodologies used by the economic department of the central bank to calculate public sector financing needs, i.e. the primary and nominal balances and the net and gross debt of the public sector. In that work, the authors also describe the main characteristics of the method employed to calculate the fiscal balances used to renegotiate debt with federal bodies, developed on the basis of Act No. 9496 of 1997, and the implicit calculation methodology of the fiscal balance established in the Fiscal Responsibility Act – Complementary Law No. 101 of 4 May 2000.

For the case of Brazil, Mello (2005) estimates the fiscal response function according to various definitions of "public sector" using monthly data for the period 1995–2004 and observes that in all cases the primary surplus shows a strong positive response in the event of a rise in public sector net debt.[5] Mello also finds that output is weakly but positively correlated with several definitions of primary surplus, which suggests that Brazilian fiscal policy was non-cyclical or acyclical during this period. Mello (2005) acknowledges the possibility that structural breaks may occur in the series used and proposes to address these by working with different subsamples. However, this yields significant variations in relevant parameters, in particular a weakening of the primary surplus response to public sector net debt after 2002.

In order to address the uncertainty over the regime changes that may have occurred, Mendonça, Santos and Sachsida (2009) calculate the fiscal response function using the Markov-switching model, with monthly data from January 1995 to December 2007. Their results strongly suggest that fiscal policy in Brazil underwent two different regimes after the Real Plan, and that late 2000 is the most likely moment of transition between the two. The regime after 2000 shows a limited (or even nil) response by the primary surplus to variations in public sector net debt. By contrast, in the regime prior to 2000 (with greater volatility) the primary surplus showed quite an evident response to variations in public sector net debt. It was also seen that in both regimes the primary surplus seemed to respond positively to variations in output and that the government did not appear to have explicitly used fiscal policy to control inflation in either regime.

[4] In general, this method is robust when the starting values are chosen arbitrarily or inefficiently.

[5] The broadest concept of the public sector is the "consolidated public sector", which includes the union, the states, the municipalities and State enterprises. Mello also works with the primary surplus of the "union" (i.e. the federal public administration) and of the "regional governments" (i.e. all the state and municipal public administrations taken together).

1. Empirical analysis

The purpose of econometric analysis of the fiscal response function is to test the hypothesis that the primary surplus adjusts in response to variations in debt to ensure debt sustainability over the long term, or that fiscal policy is used as a tool to stabilize output or inflation. Thus, in accordance with the empirical literature on the subject (Bohn, 1998; Galí and Perotti, 2003; Thams, 2007), we propose to estimate the fiscal response function using a Markov-switching model, specified as follows:

$$PRIM_t = b_0(s_t) + b_1(s_t)DLSP_{t-1} + b_2(s_t)INFLA12_{t-1} + b_3(s_t)TXPIB12_{t-1} + \sigma(S_t)\varepsilon_t \quad (8)$$

where, in this research, we use monthly data from November 2002 to December 2015. The variables used in this study (whose graphics appear below) are described as follows:[6]

PRIM: primary balance of the consolidated public sector, not including 12-month cumulative exchange-rate appreciation divided by GDP (also 12-month cumulative).[7]

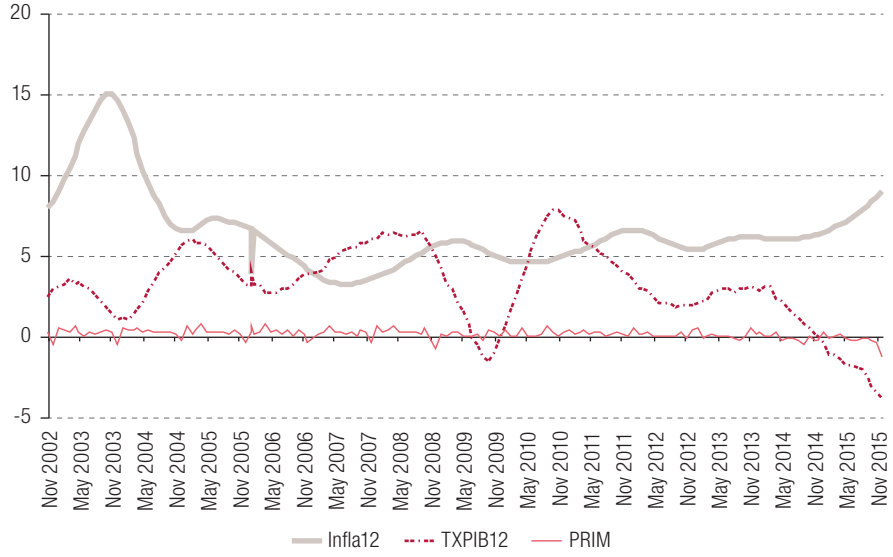
DLSP: ratio between the monthly value of the consolidated public sector net debt and GDP (12-month cumulative GDP adjusted by the general price index-domestic supply (IGP-DI)).[8]

INFLA12: rate of inflation measured by the broad national consumer price index (IPCA) over a 12-month period.[9]

TXPIB12: real GDP growth rate over the past 12 months.[10]

Figure 1 shows the evolution of the inflation rate and the real GDP growth rate, both in 12-month cumulative figures. It also shows the behaviour of economic growth in the Brazilian economy in the period between November 2002 and December 2015.

Figure 1
Brazil: evolution of the rate of inflation (Infla12), GDP growth (TXPIB12) and the primary surplus as a percentage of GDP (PRIM), annualized monthly data, November 2002–December 2015



Source: Institute for Applied Economic Research (IPEA).

6 Data may be requested directly from the authors.

7 Central Bank of Brazil.

8 Central Bank of Brazil.

9 Brazilian Institute of Geography and Statistics (IBGE).

10 Getulio Vargas Foundation.

The primary balance is defined by the difference between total income and total expenditure, excluding interest on the public debt, as a proportion of GDP. In this case, a positive primary balance means the generation of a primary surplus; a negative primary balance is a primary deficit.

Some relevant aspects may be observed concerning the evolution of the primary surplus, shown by the thin line. Until October 2008, the primary surplus was relatively stable at around 3% of GDP, then rose to 3.69% in November 2008. The primary surplus target initially adopted in Brazil was 3% of GDP. Figure 1 shows that fiscal policy austerity ceased to be applied systematically as from 2009. The empirical results, as will be seen below, show that the fiscal years of 2010, 2013, 2014 and 2015 were characterized by active fiscal policy (see table 5).

Notably, Brazil began to feel the effects of the subprime crisis more strongly in the last quarter of 2008. The annual growth rate (represented by the dashed line), which was 6.5% in September 2008, fell to 0.8% of GDP in June 2009. Between July and December 2009 growth rates were nil or negative. The federal government adopted countercyclical policies, including the reduction of the primary surplus, which averaged 1.90% of GDP during fiscal year 2009.[11] Although the primary surplus recovered up to August 2011, to 3.54% of GDP, fiscal policy showed a deterioration starting in mid-2011, so that in December 2015 Brazil was running a primary deficit of 1.88% of GDP. The empirical results show that fiscal policy was passive in the fiscal years from 2003 to 2009, and in 2011 and 2012. In 2010, 2013 and 2014 there is empirical evidence of fiscal dominance (see table 5).

In fiscal year 1999, Brazil adopted an inflation-targeting regime, which was one of the stages of the Real Plan that had begun in mid-1994, as a policy aimed at stabilizing prices and improving the country's macroeconomic fundamentals.[12] The Real Plan was based on a macroeconomic tripod of monetary stability, fiscal responsibility and a floating exchange rate. In this context, the period covered by the present work was governed by a system of inflation-targeting, fiscal policy geared towards achieving a fiscal surplus and a dirty currency float, in which the central bank tried to avoid excessive exchange-rate fluctuation. However, starting at the time of the subprime crisis, economic policymakers began to gradually dismantle the macroeconomic tripod. See more details in Moreira and Soares (2012) and Moreira, Souza and Ellery (2013).

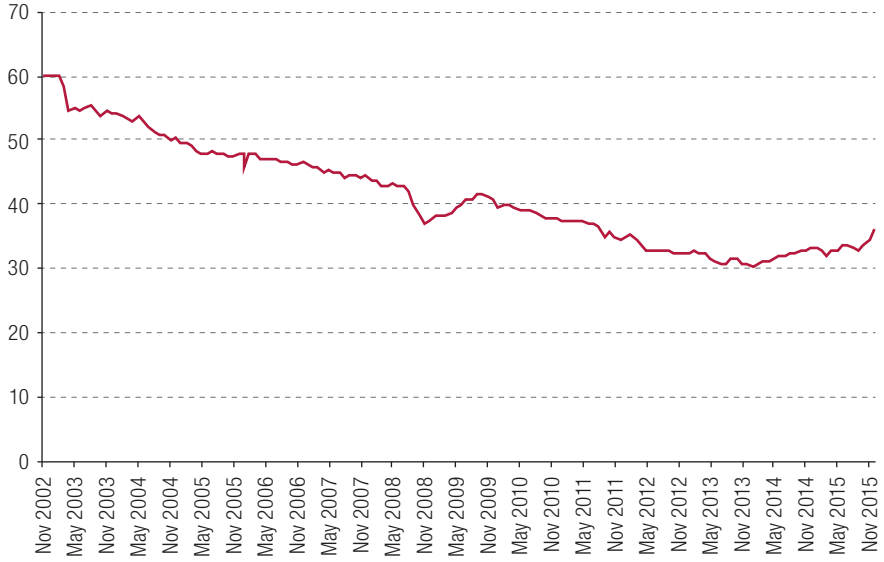
Figure 1 also shows a steep rise in the inflation rate, represented by the thick line, between November 2002 (8.03%) and October 2003 (15.06%), followed by a downtrend until July 2007 (3.29%). Starting in mid-July 2007, inflation trends upwards, to reach 9.03% December 2015. The growth rate began to fall sharply in 2014, however, from 3% December 2013 to -3.8% December 2015. The primary balance went from a surplus of 1.72% of GDP in December 2013 to a deficit of -1.88% in December 2015. In this same period, inflation rose from 6.20% to 9.03%. Lastly, the inflation rate and the GDP growth rate went from 5.44% and 2.3% of GDP in February 2013, respectively, to 9.03% and -3.8% in December 2015.

Figure 2 shows the pattern of the net debt of the consolidated public sector as a proportion of 12-month cumulative GDP. The ratio between debt and GDP falls between 2002 (59.85%) and November 2008 (36.96%). However, with the subprime crisis, the debt climbed to 40.99% in November 2009. Between May 2012 and November 2014, the debt stabilized between 30% and 32% of GDP. From the end of 2014, the public sector's net debt trended upwards, to 36.19% of GDP in December 2015.

[11] For a better understanding of countercyclical policies in this period, see Moreira and Soares (2012).

[12] The inflation-targeting system in Brazil uses the base rate of interest, the Selic rate, as an instrument to control money supply, making it endogenous. The central bank sets an inflation target (4.5% annual rate) with a 2% inflation band on each side. Thus, the ceiling of the band for annual inflation is 6.5% and the floor is 2.5%.

Figure 2
Brazil: evolution of public sector net debt, November 2002–November 2015
(Percentages of GDP)



Source: Institute for Applied Economic Research (IPEA).

Instead of the primary surplus, some studies analysing policies of fiscal or monetary dominance make use of other variables as fiscal policy tools. Leeper (1991 and 2005) uses direct taxation revenue, as do Moreira, Souza and Almeida (2007) in a study for Brazil. Meanwhile, Davig and Leeper (2011) use net government revenues.[13] Like Mendonça, Santos and Sachsida (2009), the present work treats the primary surplus as the most suitable variable to reflect fiscal policy. Leeper's theoretical model (1991 and 2005) uses real debt, while the empirical studies generally use the debt to GDP ratio, as we do here.

A number of remarks are called for before moving on to the econometric results. A positive relationship is expected between the primary balance, PRIM, and net debt (i.e. that $b_1 > 0$), given that when debt rises it is prudent to increase revenues or the primary surplus in order to ensure a sustainable debt trajectory.

On the basis of Leeper (1991 and 2005), if fiscal policy is committed to maintain a sustainable debt trajectory in public debt, the policymaker must act passively, that is, concern itself only with adjusting the ratio between the primary surplus and GDP to give a strong enough positive response to a rise in the public debt to GDP ratio to keep that ratio under control. In this context, a passive fiscal policy, in line with a monetary dominance model, should not respond to other variables such as inflation or output growth. Fiscal policy should adjust passively to monetary policy decisions. If this does not happen, it will mean that the fiscal authority is adopting an active stance, in other words, it is concerned more with controlling aggregate demand to tackle unemployment, for example, than with controlling the trajectory of public debt. By reducing the ratio between the primary surplus and GDP to raise economic activity levels, an active fiscal policy generates two unwanted side-effects: inflationary pressure and a rise in the public debt to GDP ratio. These side-effects undermine the effectiveness of the central bank's response function based on the Taylor rule.

[13] In the case of Brazil, net revenues of the central government are defined as total revenues excluding income from social security, minus grants and net interest on the public debt, the Workers' Support Fund (FAT) and unemployment insurance.

If fiscal policy is passive —by maintaining a primary surplus compatible with a sustainable public debt trajectory— then it will already by cooperating passively with the central bank by not generating inflationary pressure.

In a monetary dominance regime, the primary balance is thus not expected to react to changes in price levels or output. In a monetary dominance regime compatible with an inflation-targeting system, the central bank is only expected to adjust the base rate of interest in response to changes in the (expected) rate of inflation or in the output gap. In this sense, the monetary authority assumes an active monetary policy, as should occur in an inflation-targeting system.

The fiscal response function adopted here is backward-looking in nature.[14] It bears noting that the estimation of the above response function can be defended even when the model variables show a unit root. The spurious regression problem can be avoided by introducing lagged variables I(1) among the explanatory variables of the regression (Hamilton, 1994; Sims, Stock and Watson, 1990). In effect, Hamilton (1994, pp. 561 and 562) notes that this procedure ensures a consistent calculation for the model without regime-switching. It can also be shown that in this case the t-statistics for the individual coefficients are asymptotically normal.

Another argument against overemphasizing the order of integration of the variables in question is that Brazil's macroeconomic variables were subject to strong regime breaks[15] in the sample period, which (at least potentially) introduces considerable bias in the results of the conventional unit root tests.

2. Econometric results

This section presents the results of the fiscal response function estimations based on the Markov-switching model. Table 1 presents the estimations of the parameters with p-values[16] from equation (8) for a specification of the Markov-switching intercept autoregressive heteroskedasticity (MSIAH) model,[17] while annex A1 shows the graphics of the smoothed probabilities or, in order words, the chronology of regimes.[18] After evaluating several competing models, the two-state or two-regime model was found to be the best fit with the data, based on the different specification tests.[19] In effect, application of the likelihood-ratio (LR) test rejected the null hypothesis of linearity (LR = 189.65,X2(7) = [0.000]** e X2(8) = [0.000]**).[20]

[14] Galí and Perotti (2003) use a forward-looking specification. However, this distinction is not particularly relevant in the case of single-equation models, as it can be proved that, in this case, the forward-looking specification always has backward-looking equivalents (Sims, 1999 and 2001).

[15] Not least the global economic crisis of 2007–2008, which naturally had repercussions on the Brazilian economy.

[16] Standard error statistics were computed numerically using the Hessian matrix of maximum log likelihood function. Unfortunately, these approximations can be somewhat imprecise.

[17] A specification that allows changes in the intercept (I), the parameters of variables (A) and variances (H) in each egime. This terminology was adopted by Krolzig (1997).

[18] Smoothed probability takes into account information from the whole sample and is defined as follows: $p_r[S_t=j|\Psi_T]$, where Ψ_T is the complete set of information up to moment T. Filtered probability is an optimal inference on the state of the variable at time t considering the information up to t, while predicted probability considers the information up to t-1.

[19] No major specification problem was found upon conducting traditional Durbin-Watson serial correlation, normality and autoregressive conditional heteroskedasticity (ARCH) tests. Introducing a larger number of regimes led to issues with the numerical optimization routine, making the transition probability matrix non-ergodic, thereby violating one of the main hypotheses of the model.

[20] The likelihood-ratio (LR) test shows a non-standard distribution and cannot be characterized analytically as the transition probabilities are not identified under the linearity hypothesis. It is possible, however, to show that this distribution can be approximated, as it is in the interval between two chi-squares. We derive from this that if the distribution rejects the null hypothesis, the LR test must do so as well. Conversely, if neither rejects the hypothesis of linearity, then the LR test will not do so either. In any other situation there is nothing to be said (Davies, 1977).

Table 1
Model MS(2)-AIH(1)
Dependent variable: PRIM

	Regime 1	Regime 2
Constant	-1.333 (0.183)	-1.7741 (0.317)
DLSP(-1)	0.221 (0.284)	0.299 (0.000)
INFLA12(-1)	0.453 (0.093)	0.065 (0.000)
TXPIB12(-1)	0.637 (0.000)	0.341 (0.000)
Standard deviation	0.123 (0.0000)	0.048 (0.000)
Observations	156	
Likelihood	197.923	

Source: Prepared by the authors, on the basis of data from the Central Bank of Brazil.
Note: *p*-value in brackets.

The results shown in table 1, as well as the smooth probability graphics in annex A1, support the affirmation that there is a clear difference in the conduct of fiscal policy between the two regimes. Analysis of the results in table 1 yields the following remarks. A clear difference is seen in the response of the primary balance with respect to debt between the two states. Although net public sector debt has a positive sign in both regimes, it is only significant in regime 2. This means that the fiscal authority reacted to the rise in debt in this regime, which supports the interpretation that it pursued a fiscal target in regime 2. Conversely, in regime 1 fiscal policy did not respond to the rise in public debt, showing an active fiscal policy.

To further defend this thesis, annex A1 also includes the graphic for the ratio between net debt and GDP (public sector net debt). Comparing this graphic with the chronology of regimes, it may be seen that in December 2013 the downtrend in public sector net debt was reversed. In that period, regime 1 comes into play, where the Treasury ceases to treat net debt as a fiscal policy objective. In fact, between December 2013 and December 2015 public sector net debt rose by six percentage points. Between end-2002 and early 2009 regime 2 predominated, in which public sector net debt was statistically significant. It is interesting to note that public sector net debt trended strongly downward almost throughout this period.

Coming back to the analysis of table 1, in both regimes public sector net debt responds positively to output, TXPIB12, which seems to indicate that fiscal policy was countercyclical. However, the fiscal authority responds less strongly to output growth in regime 2 than in regime 1. In this case, there are signs that during regime 1 the fiscal authority may concern itself more with economic performance than with fiscal targets, which suggests an active fiscal policy in regime 1 and a passive one in regime 2.

Although the computed coefficient of inflation is positive in both regimes, its level of significance in regime 1 is low, as it is marginally significant at 10%, while in regime 2 it is statistically significant at 1%. However, the response to inflation by the fiscal balance is much lower in regime 2.

Given the foregoing, the results show empirical evidence that in regime 2, the share of the fiscal surplus in GDP reacts strongly to increases in the ratio between public debt and GDP, while in regime 1 the fiscal indicator shows no response to changes in that ratio. In addition, in regime 2 responses by the primary surplus/GDP indicator to the rate of inflation and to output growth are much weaker than in regime 1. It may thus be observed that although fiscal policy adopts a passive stance in regime 2 —insofar as the coefficient between debt and GDP is positive— it cannot be said to be 100% passive, as it responds less to changes in the rate of inflation and output growth than in regime 1. Symmetrically, regime 1 shows a strongly active stance: this is a necessary but not a sufficient condition to identify a regime of fiscal dominance. For that, monetary policy would have to be passive during the same period of regime 1, following fiscal policy.

Moving to analysis of the transition probability matrix (see table 2), it may be seen that once the economy is within one of the two regimes, it has a high probability of remaining there. In this case, the null hypothesis supposes that migration can occur from one regime to another. However, if the fiscal policy rule is present in regime 1, the computed probability of moving back to regime 2 is very small. Nothing can be said of the opposite case, because the *p*-value of the computed probability of transition from regime 2 to regime 1 is not significant. The fact that the probability of return to regime 2 is small when the fiscal rule obtains in regime 1 suggests that deterioration of the fiscal framework may become structural and ingrained, and thus difficult to reverse.

Table 2
Probabilities of transition

$P_r(S_t = 1 \mid S_{t-1} = 1)$	$P_r(S_t = 1 \mid S_{t-1} = 2) =$
0.973	0.018
(0.000)	(0.156)
$P_r(S_t = 2 \mid S_{t-1} = 1) =$	$P_r(S_t = 2 \mid S_{t-1} = 2) =$
0.023	0.982
(0.000)	(0.000)

Source: Prepared by the authors.
Note: *p*-value in brackets.

V. Monetary response function

This section estimates the monetary policy rule followed by the Central Bank of Brazil to determine whether its main policy instrument, the Selic rate, responds to the inflation rate for the period between November 2002 and December 2015. The same Markov-switching model used hitherto is employed, in which regime alternance is determined by means of a Markov chain to model possible deviations from a simple linear response function. As noted earlier, this procedure has the advantage of overcoming uncertainty over the dates on which changes in the parameters occurred.

The discussion concerning the existence of a rule by which the central bank of the United States (the Federal Reserve System) guides its monetary policy began with Taylor (1993 and 2000) and led to the study of how monetary policy can be analysed by means of a response function. Taylor pointed to a strong relationship between changes in the interest rate set by the Federal Reserve System in response to variations in price levels and in output in the United States economy. In other words, the policy instrument, mainly the base rate of interest, has risen in periods of rising inflation. The interest rate also tends to rise when output is well above its potential. This procedure commonly adopted by central banks is aimed at avoiding future rises in the inflation rate.

In the case of Brazil, the literature on the topic computes the response function of the central bank closely following the Taylor rule or a variant of it. There are many works that study the Taylor rule for Brazil. Lima, Maka and Mendonça (2007) note that the main differences between these studies have to do with the econometric methodology used for the estimation and the dependence of the policy rule on current or expected inflation.

Minella and others (2002) estimate the central bank response function with data from July 1999 to June 2002 and show that the institution responded strongly to expectations of inflation and there was a high degree of interest-rate smoothing. The authors discovered that neither the output gap nor exchange-rate variation were statistically significant in the central bank response function. Holland (2005) found that the central bank adopted an aggressive stance of inflation control starting with the adoption of the targeting regime.

Salgado, Garcia and Medeiros (2005) use a threshold autoregressive (TAR) model) to explain the movement of the nominal interest rate after the adoption of the Real Plan. They conclude that Brazilian monetary policy underwent two different regimes after the Real Plan. The first was associated with times of international turbulence, such as the Asian crisis and the Russian crisis, which affected Brazil through the loss of international reserves. In the second regime, the central bank concerned itself with the movement of the usual domestic variables.

Policano and Bueno (2006) estimate a policy rule for Brazil using a time-varying parameter (TVP) model and conclude that, between 1995 and 2005, Brazilian monetary policy may be divided into two regimes. In the first, associated with a fixed exchange rate, the interest rate responded strongly to output and to international reserves. In the second, the establishment of the Selic rate was linked more to inflation-targeting.

Teles and Zaidan (2010) use the state-space model to estimate a forward-looking central bank response function. This study finds that rigorous central bank control of inflation occurs only from 2003 onward, when inflation expectations converge towards equilibrium.

Lima, Maka and Mendonça (2007) use a Markov model to estimate the central bank response functions between July 1996 and June 2007. Their results show substantial differences in the conduct of monetary policy before and after August 1999, which indicates that monetary was policy substantially affected by the change in the exchange-rate regime with the migration to a currency float.

On the basis of a time-varying vector autoregressive (VAR) model, Balbino, Colla and Teles (2011) attempt to identify differences in the conduct of monetary policy between the administrations of Armínio Fraga and Henrique Meirelles. Their results show no significant differences between the two administrations. Starting in 2003, the interest rate remained higher than was necessary for inflation convergence. During the term of Armínio Fraga, inflation remained above target, owing to the effect of exogenous shocks and not conflict with the stabilization rule in the crisis of 2002.

With a similar aim, Moreira, Souza and Ellery (2013) analyse the degree of tolerance to inflation by the presidents of the Central Bank of Brazil in the period 2001–2012. Their results show that Henrique Meirelles was the least tolerant to higher inflation, compared with Armínio Fraga. In turn, Alexandre Tombini adopted a more tolerant stance than Armínio Fraga.

1. Econometric results

Clarida, Galí and Gertler (2000) estimate the monetary response function with a forward-looking specification, where current policy actions depend on expected inflation in the future. As seen in the previous section, several studies treat expected inflation as a monetary policy target in Brazil. Expected inflation could also thus reasonably be treated as a variable to consider in computing the central bank response function. However, according to Sims (1999 and 2001), forward-looking specifications have a backward-looking equivalent. The following specification is thus adopted as a functional manner of computing the monetary response function:

$$SELIC_t = b_0(s_t) + b_1(s_t)INFLA12_{t-1} + b_2(s_t)TXPIB12_{t-1} + \sigma(S_t)\varepsilon_t \quad (9)$$

where $SELIC$ is the annualized base rate of interest set by the Central Bank of Brazil. The other variables were defined earlier, in section IV.

Below, we examine the results of monetary response function computation also estimated using the Markov-switching model. The results are shown in table 2. Taking into account the different specification tests, the three-regime model was the best fit for the data.[21] In effect, application of the likelihood-ratio (LR) test rejected the null hypothesis of linearity (LR = 241.45,X2(11) = [0.000]** e X2(12) = [0.000]**).[22] The graphics of smoothed probability that illustrate the chronology of regimes are presented in annex A2.

Table 3 shows that, whatever the regime, the Selic rate is set taking into account not only inflation but also output growth. In all cases, the coefficients of the variables are significant, and the signs are as expected.

According to the Taylor rule, the central bank should raise the interest rate by more than one unit for a given rise in inflation (or expected inflation), in order to ensure stability of singularity and of equilibrium. Thus, in keeping with the Taylor rule, monetary policy is active or restrictive if the coefficient of inflation from equation 9 is equal to or greater than 1, and passive or accommodative if the coefficient is less than 1 (Woodford, 2003).

Following the Taylor rule, table 3 verifies the existence of two regimes of lesser tolerance to inflation (regimes 2 and 3), while a third regime of central bank stance on monetary policy is accommodative (regime 1). It should be noted, however that regime 2 refers only to sporadic moments of monetary policy in Brazil. Conversely, regime 1 is long-lasting, as it ran from late 2007 to December 2014, and mostly coincided with the administration of Alexandre Tombini, who headed the Central Bank of Brazil from December 2010. It is interesting to note that, although the inflation rate has eased on several occasions since then, it shows a structural uptrend. Only after the second half of 2014 did the Central Bank of Brazil begin to respond more strongly by gradually raising the Selic rate. Throughout 2015, the central bank took a tight monetary policy stance, according to the analysis of regime 3. As will be seen in the following section, the reason why inflation has continued to rise is related to the lack of control on the part of fiscal policy and also to tariff shocks occurring just after the presidential elections of late 2014.

Table 3
Model MS(3)-AIH(1)
Dependent variable: Selic rate

	Regime 1	Regime 2	Regime 3
Constant	0.025 (0.000)	0.029 (0.000)	0.169 (0.008)
INFLA12(-1)	0.955 (0.000)	1.295 (0.000)	1.780 (0.000)
TXPIB12(-1)	0.600 (0.000)	0.651 (0.000)	0.811 (0.000)
Standard deviation	0.013 (0.000)	0.001 (0.000)	0.011 (0.000)
Observations		156	
Likelihood		462.137	

Source: Prepared by the authors, on the basis of data from the Brazilian Institute of Geography and Statistics (IBGE) and the Getulio Vargas Foundation.
Note: *p*-value in brackets.

Before Alexandre Tombini, Henrique Meirelles chaired the Central Bank of Brazil from 2003, with a restrictive monetary policy that marked a major difference with respect to his predecessor. In addition, during the term of Meirelles the Treasury's fiscal policy was compatible with debt sustainability.

[21] See note 12.

[22] See note 13.

Table 4 shows the matrix of transition probabilities between states assumed by the monetary rule. Given that regime 2 occurs only occasionally, for simplicity's sake, the table shows the probabilities of transition between regimes 1 and 3. A point to remark is that the probability of switching from state 1 to state 3, and vice versa, is zero, while the sum of probabilities in each column of the matrix of transition is less than 1. This raises the question of whether the transition between these two states will not occur without a shock in the Selic rate.

Table 4
Transition probabilities

$P_r(S_t = 1 \mid S_{t-1} = 1)$	$P_r(S_t = 1 \mid S_{t-1} = 3) =$
0.979	0.000
(0.000)	(0.000)
$P_r(S_t = 3 \mid S_{t-1} = 1) =$	$P_r(S_t = 1 \mid S_{t-1} = 3) =$
0.000	0.962
(0.000)	(0.000)

Source: Prepared by the authors.
Note: *p*-value in brackets.

VI. Determination of fiscal and monetary dominance

Tables 1 and 3 showed the parameters estimated for the fiscal and monetary response functions, respectively, to compute the absolute values of the roots of the Leeper model (1991). As was seen in section II, characterization of the roots of the system indicates when monetary or fiscal policy behaves actively or passively. In this context, assuming an intertemporal discount rate $\beta = 0.95$, the four situations presented in the Leeper model (1991) can be identified, once the computed values of α and γ are known for each of the policy (monetary and fiscal) response functions, considering also the respective regimes.

To determine the period corresponding to each of the four possible combinations of active and passive policies, we compare the graphs shown in annexes A1 and A2. For each pair of policy rules (fiscal and monetary) seen in table 5, we observe the intersection between the shaded areas that relate a given monetary authority function with a given regime of the fiscal authority function.

For example, consider regime 1 of the Treasury response function and regime 3 of the central bank response function, where $\gamma = 0.000$, $\alpha = 1.781$, considering $\beta = 0.95$, which is naturally the same for all cases. It may be observed that $|\alpha\beta| = 1.691$ and $|\beta^{-1} - \gamma| = 1.052$. On the basis of the Leeper model (1991), considering the parameters computed, the results show that in this case both monetary policy and fiscal policy were active, that is, monetary policy prioritized pursuit of the inflation target, but fiscal policy did not prioritize pursuit of a primary surplus in alignment with public debt sustainability. But in what period did this situation occur? Comparison of the shaded areas of annex figure A1.1 with those of annex figure A2.3 shows that the two policies were active only in fiscal year 2015.

Table 5 helps to explain why the inflation rate continued to rise in 2015, even when the central bank took an active monetary policy stance. The fact is that, even though monetary policy was restrictive, fiscal policy also took an active position instead of accommodating by seeking budget equilibrium. This is an explosive situation, in which agents will demand higher and higher interest to take on government securities and ever-rising interest rates will drive up expectations of inflation, putting inflation control in jeopardy. Thus, in 2015 both monetary policy and fiscal policy are seen to be active.

Table 5
Brazil: definition of policies as active or passive on the basis of Leeper (1991)

	Parameters Central bank response function		
Parameters Treasury response function	Regime 1 $\alpha = 0.955$	Regime 2 $\alpha = 1.295$	Regime 3 $\alpha = 1.781$
Regime 1 $\gamma = 0.000$	$\lvert\alpha\beta\rvert = 0.907$ $\lvert\beta^{-1} - \gamma\rvert = 1.052$ FD Periods: 2010; 2013 and 2014	$\lvert\alpha\beta\rvert = 1.225$ $\lvert\beta^{-1} - \gamma\rvert = 1.052$	$\lvert\alpha\beta\rvert = 1.691$ $\lvert\beta^{-1} - \gamma\rvert = 1.052$ Active fiscal and monetary policies: 2015
Regime 2 $\gamma = 0.299$	$\lvert\alpha\beta\rvert = 0.907$ $\lvert\beta^{-1} - \gamma\rvert = 0.721$ Passive fiscal and monetary policies: end-2003, 2004, 2008, 2009, 2011 and 2012	$\lvert\alpha\beta\rvert = 1.225$ $\lvert\beta^{-1} - \gamma\rvert = 0.721$ MD	$\lvert\alpha\beta\rvert = 1.691$ $\lvert\beta^{-1} - \gamma\rvert = 0.721$ MD Periods: most of 2003, 2005–2007

Source: Prepared by the authors, on the basis of E. Leeper, "Equilibria under 'active' and 'passive' monetary and fiscal policies", *Journal of Monetary Economics*, vol. 27, No. 1, Amsterdam, Elsevier, 1991.
Note: $\beta = 0.95$; FD: fiscal dominance, MD: monetary dominance.

This may explain to some extent why the term of Tombini was marked by an accommodative position, even when inflation approached the ceiling of the band, indicating that it could "get out of control". Should the Central Bank of Brazil have taken a more active stance at that point, increasing interest rates more steeply?

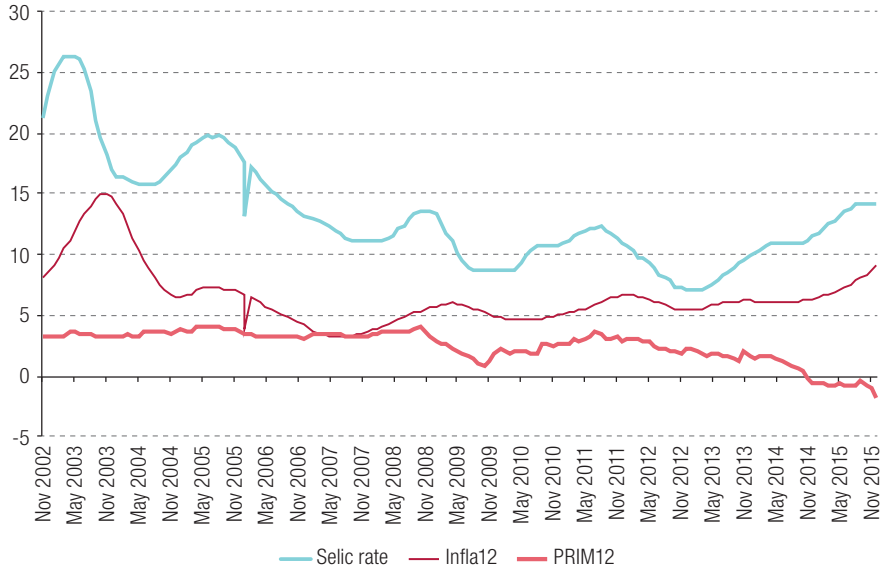
As noted by Sargent and Wallace (1981), in a situation of loose fiscal policy, the adoption of tight monetary policy leads to an increase in the money supply and, thus, higher inflation in the future. The question about how the central bank should administer monetary policy must therefore take into account how fiscal policy is being conducted. The action of the monetary authority can thus be seriously compromised if fiscal policy does not act to ensure public debt sustainability, as appears to be the case in Brazil's fiscal policy since 2013.

The two policies are also seen to have acted passively at the end of fiscal 2003, at the end of fiscal 2004 and in the period 2008–2012 (except 2010). That period is obtained from the intersection between the shaded areas of the graph for regime 2 with respect to the fiscal policy response function and of regime 1 with respect to the monetary policy response function. This means that fiscal policy followed a sustainable path in relation to public debt. In the same period, however, the Central Bank of Brazil did not respond adequately to the increases in the inflation rate. On the basis of table 5 and observing the graphs of the chronology of regimes in annexes A1 and A2, it is apparent that there was fiscal dominance in 2010 and between 2013 and 2014. Monetary dominance obtained for much of 2003 and in the period 2005–2007.

As shown in figure 3, in late 2014 the Brazilian economy began to run primary deficits. This is strongly characteristic of an active fiscal policy and tighter monetary policy in the same period, since the Selic rate[23] rose from 10.92% in October 2014 to 14.15% in December 2015. The results show empirical evidence of active conduct of both monetary policy and fiscal policy in 2015.

[23] The Selic rate is the base rate of interested used by the Central Bank of Brazil as a monetary policy instrument. The data source is the Central Bank of Brazil.

Figure 3
Brazil: evolution of the inflation rate, the Selic rate and the primary surplus (as a percentage of GDP), annualized monthly data, November 2002–September 2015



Source: Institute for Applied Economic Research (IPEA).

The Selic rate came down sharply from mid-2003 and during much of 2004, and from the last quarter of 2008 to mid-2009. It then held steady at 8.65% until the first quarter of 2010 (subprime mortgage crisis). From mid-2011 to mid-2013, the Selic declined considerably, in the context of a high rate of inflation, around 6%. Although the interest rate then rose until the end of 2013 and remained relatively stable in 2014, this rise was evidently not enough to slow the inflation rate. This may suggest that monetary policy could have been more active, as these are indications of a passive monetary policy.

The empirical results presented suggest that, in the ex post analysis, there are indications of coordination or attempted coordination between fiscal and monetary policies, as well as signs of lack of coordination between them, especially when there is a clear conflict of interest between the two. As an example of lack of coordination between fiscal and monetary policies, in mid-2013 the Central Bank of Brazil began to reverse its successive cuts in the Selic rate and to gradually increase it to try to reduce inflation. At the same time, the federal government continued to reduce the primary surplus in order to boost economic activity, which put upward pressure on inflation. The results of this conflict of interest between economic policies were recession, fiscal deterioration and high rates of inflation.

VII. Final remarks

This article has evaluated the monetary and fiscal policies implemented in Brazil in the period between November 2002 and December 2015. In this context, considering that monetary and fiscal policy rules in Brazil may have undergone different regimes, the present study used the Leeper model (1991 and 2005) to establish the chronology of policy rules in terms of their active or passive nature.

Policy rules are estimated by means of a Markov-switching model in which the regimes are generated endogenously. The results support the affirmation that fiscal dominance occurred in 2010 and between 2013 and 2014. Monetary dominance obtained for much of 2003 and in the period 2005–2007. During the rest of the period, monetary and fiscal policies were seen to be conducted sometimes actively (2015) and sometimes passively (end-2003, 2004, 2008, 2009, 2011 and 2012).

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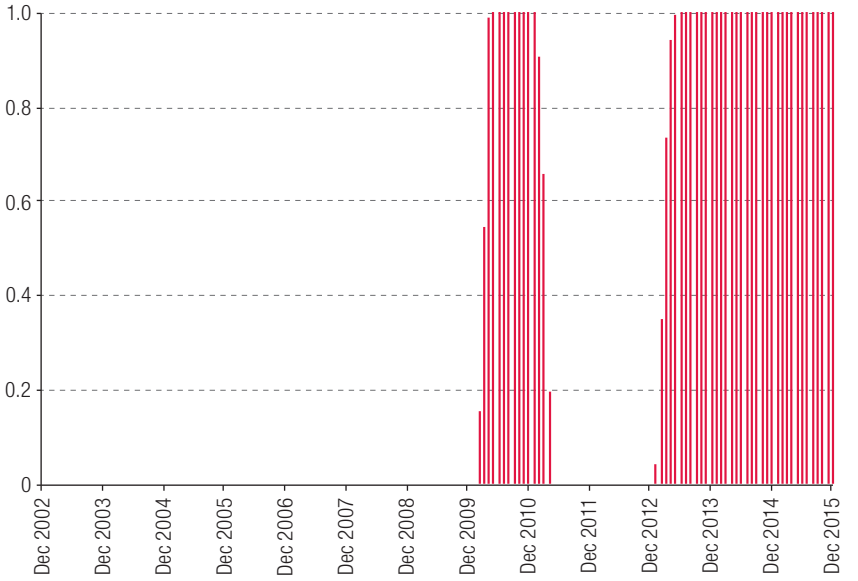
Annex A1. Fiscal response function

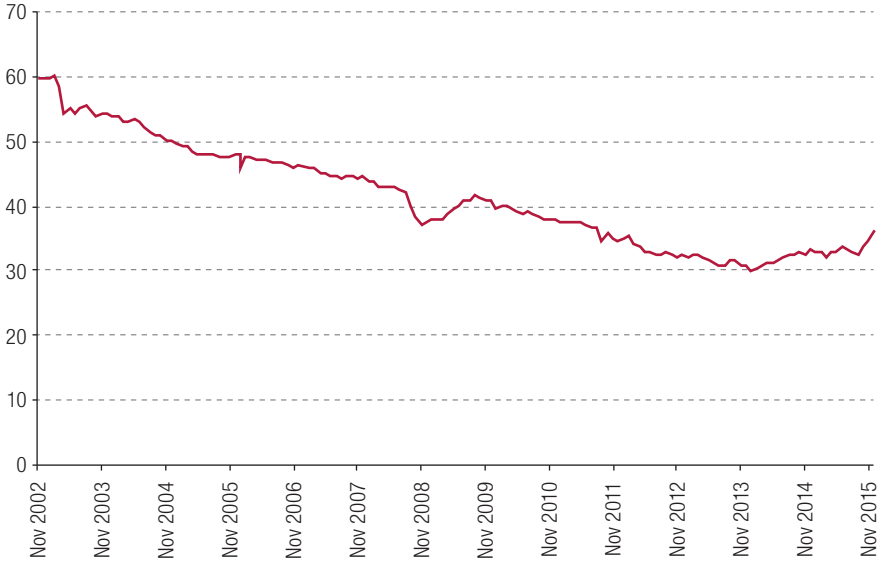
Smoothed probability of regimes

Figure A1.1
Regime 1



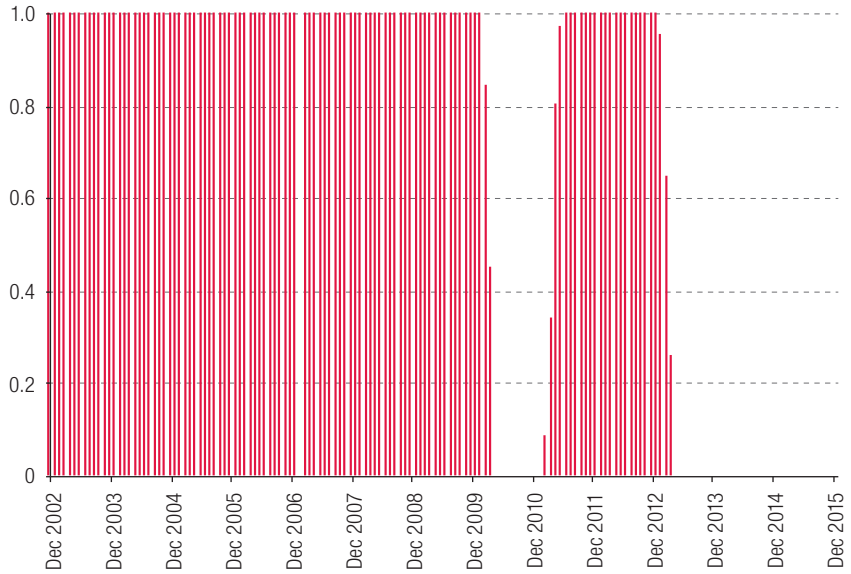
Source: Prepared by the authors.

Figure A1.2
Public sector net debt
(Percentages of GDP)



Source: Prepared by the authors.

Figure A1.3
Regime 2

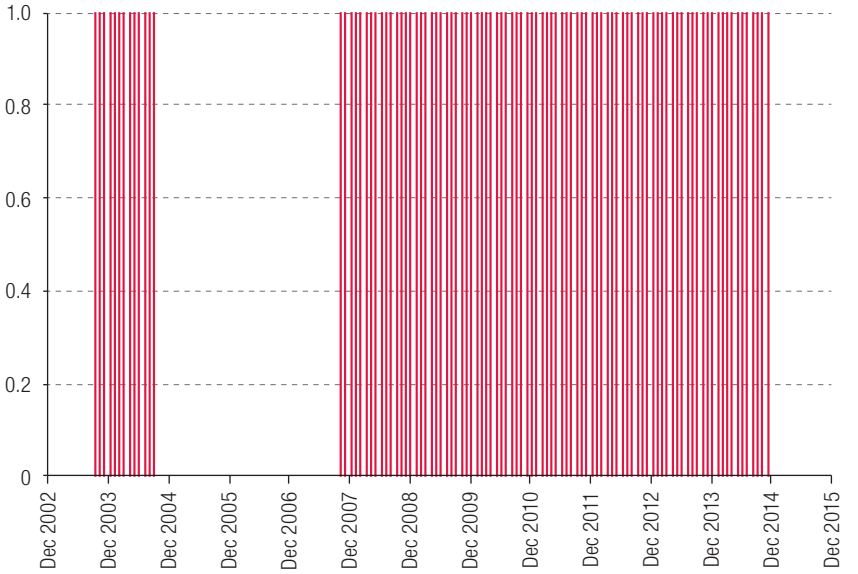


Source: Prepared by the authors.

Annex A2. Monetary response function

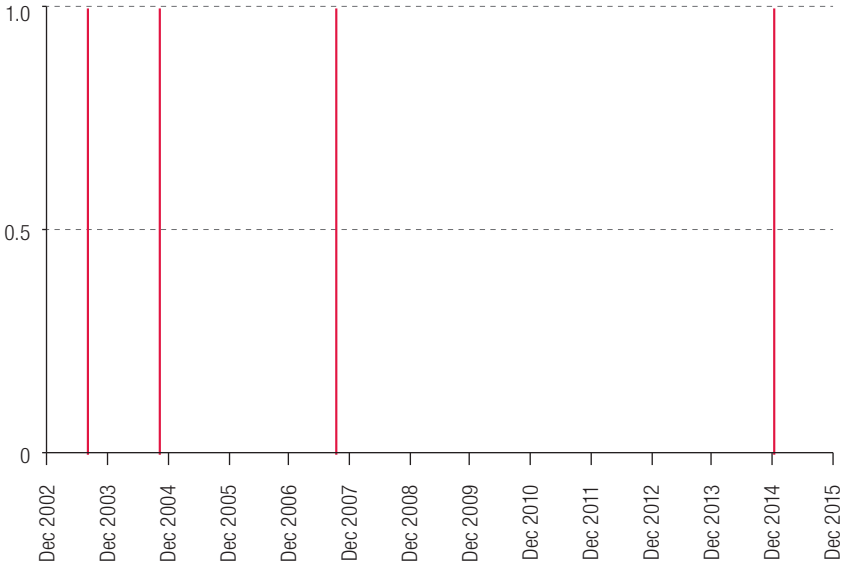
Smoothed probability of regimes

Figure A2.1
Regime 1



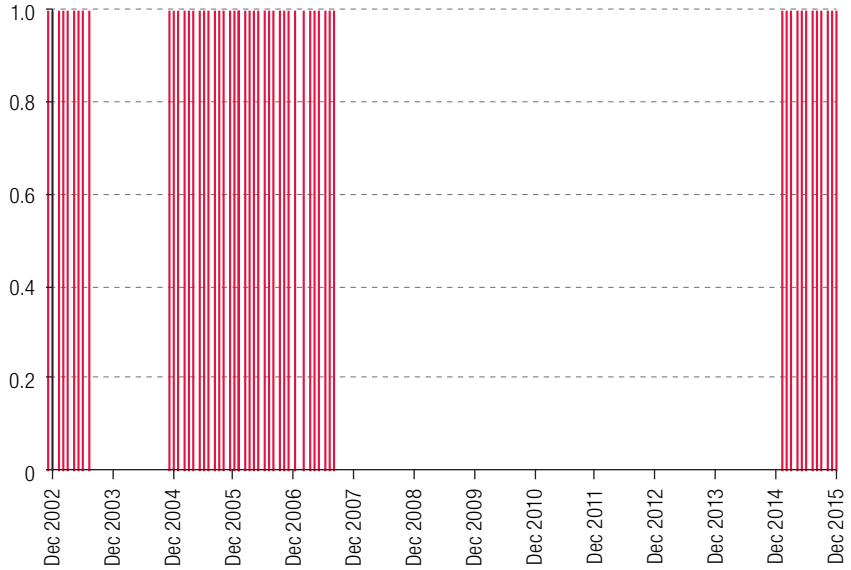
Source: Prepared by the authors.

Figure A2.2
Regime 2



Source: Prepared by the authors.

Figure A2.3
Regime 3



Source: Prepared by the authors.

Figure A2.4
Inflation
(Percentages)

Source: Prepared by the authors.

Exchange rate regimes, structural change and capital mobility in a developing economy

Stefan Wilson D'Amato and Luciano Dias de Carvalho

Abstract

This paper proposes to develop a balance-of-payments-constrained growth model to analyse the importance of the relationship between real exchange rate misalignment and the share of industry in output. Building on the work of Gabriel, Jayme and Oreiro (2016), the model is expanded to address: (i) the influence of price competitiveness on net exports; (ii) capital mobility; (iii) nominal exchange rate flexibility; (iv) the nominal wage as a fraction of the value of labour productivity; and (v) a quadratic relationship between the growth rate of the share of industry in output and exchange-rate misalignment. An important result is that both flexible and fixed exchange rate regimes are compatible with a balanced growth path.

Keywords

Monetary policy, foreign exchange rates, capital movements, industrial sector, gross domestic product, economic growth, developing countries

JEL classification

E12, E51, E22

Authors

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I. Introduction

The aim of this study is to explore new channels of influence between the real exchange rate and the share of industry in output and their importance for sustainable growth in developing economies, based on the model developed by Gabriel (2016) and Gabriel, Jayme and Oreiro (2016). Emphasis is placed on the influence of fixed and floating exchange rate regimes in determining the long-term stability of such economies, specifically when the presence of capital flows and a profit-driven accumulation regime is taken into account.

Rodrik (2009) and Szirmai (2012) highlight the role of industry as an "engine" of long-term economic growth. According to Szirmai (2012), there is a transfer of resources from the agricultural sector to the industrial sector, which gives rise to a "bonus" from structural change, due to higher labour productivity in industry. As a result, as aggregate productivity and per capita income increase, structural change becomes central to economic growth.

Thirlwall (1979) argues that, as a rule, long-term growth tends to be constrained by the balance of payments. Consequently, the author proposes that long-term economic growth be defined by the relationship between the rate of growth in exports and the income elasticity of imports. Thus, according to Thirlwall (2011), balance-of-payments equilibrium plays a key role in economic growth in developing countries.

Kaldor (1966 and 1970) discusses the role of exports as a core component in increasing the share of industry in the output of an economy. This increase contributes to the rise in aggregate productivity due to the presence, inherent to this sector, of dynamic returns to scale. As a result, capital accumulation and economic growth tend to intensify.

According to Frenkel and Rapetti (2014), for the share of industry in the South to increase,[1] the real exchange rate must be stable and undervalued, so that the level must necessarily be equal to or higher than the industrial-equilibrium real exchange rate.[2] Thus, the real exchange rate must remain above its competitive level (as determined by the industrial equilibrium exchange rate), where it stimulates the production and sale of goods with a greater technological component. This productive specialization is accompanied by structural change in the developing economy and, consequently, by economic growth.

Palley (2002) notes that the demand-led, balance-of-payments-constrained model of economic growth can pose obstacles to growth. First, the author argues that the world economy can be regarded as a closed system, in which not all countries in the world will export at the same time. Thus, such models are better suited to smaller open economies, which engage in trade and financial operations with the rest of the world.

Another important argument highlighted by the author concerns the failure of such models to consider the supply side. If the rate of productivity growth is higher than the rate of demand growth, there will be a steady increase in potential supply and unemployment in the economy. Indeed, Palley (2002) argues that, in the long run, demand and supply must grow together.

Gabriel (2016) and Gabriel, Jayme and Oreiro (2016) build on the argument developed by Palley (1996 and 2002) to examine the interaction between the real exchange rate and industry's share of gross domestic product (GDP) in the presence and absence of changes in the technology gap.

In particular, those papers show a linear relationship between the share of industry in GDP and the real exchange rate; i.e., the more depreciated the real exchange rate, the higher the share of industry in GDP. To be sure, this simplification does not seem to be the most apposite to reflect the true relationship between these two variables. When there is an excessive depreciation of the real exchange rate, sectors intensive in imported inputs and capital goods will tend to lose competitiveness to a greater extent than the gains of export-oriented sectors, thus reducing the share of industry in GDP.

[1] In the tradition of structuralist centre-periphery models, developed countries are referred to as the North, and developing countries, as the South.

[2] The real exchange rate at which a company operating at the technological frontier is internationally competitive.

The balance-of-payments-constrained economic growth model that will be developed assumes an economy with capital mobility and a nominal exchange rate susceptible to variation. Thus, the balance-of-payments equilibrium equation, which makes up the structural equations of the model, depends on the growth rate of capital flows and changes in the terms of trade and the nominal exchange rate.

In contrast to Gabriel (2016) and Gabriel, Jayme and Oreiro (2016), it will be assumed that the nominal wage in the South depends on the value of labour productivity. Thus, this present model will move away from the assumption of wage parity between Northern and Southern nations by measuring in the same currency and assume instead that the change in the nominal wage is always less than the change in the value of productivity. This assumption in turn assumes the existence of a profit-based accumulation regime.

One of the contributions of this paper is the formulation of an equation that represents the growth rate of industry's share of GDP as a quadratic function of the deviation of the real exchange rate from the industrial-equilibrium real exchange rate. Indeed, after the point considered critical, any increase in the exchange-rate imbalance will lead to a reduction in the growth rate of industry's share in GDP. Thus, this equation allows the formation of a stable long-term equilibrium path for developing economies.

Another relevant point concerns exchange rate regimes. This paper looks at the importance for developing economies of the type of exchange rate regime adopted as a development strategy. Thus, when analysing the model with the flexible exchange rate, the long-run equilibrium will trace a stable path when the economy has a sufficiently depreciated real exchange rate and the share of industry in GDP is relatively low. On the other hand, by keeping the exchange rate fixed, the model will present a stable equilibrium path over the long term. This path will be consistent with a sufficiently depreciated real exchange rate and a relatively higher industry share of GDP than under a flexible exchange rate.

The paper is divided into four sections, including this introduction. The second section sets out the concepts necessary for the development of the proposed model and highlights economic growth, structural change, capital mobility and exchange rate regimes. The third section presents and develops the balance-of-payments- and supply-constrained North-South economic growth model, which assumes capital mobility, structural change, partially endogenous currency supply and a flexible exchange rate. The fourth and final section presents the main conclusions.

II. Structure of the model

It is assumed, as in Palley (1996 and 2002), that the rate of growth in productive-capacity utilization is constrained on both the demand and supply sides. Demand is constrained by the balance of payments, while supply is bounded by the Harrod condition, according to which the current growth rate must be equal to the growth rate of potential output.

The long-term structure of the Southern model will be presented as:

$$\hat{x}_s = a_0 g_N + a_1\left(\hat{e} - \hat{p}_s\right) \quad a_0 > 0 \text{ and } a_1 > 0 \tag{1}$$

$$\hat{m}_s = b_0 g_s + b_1\left(\hat{p}_s - \hat{e}\right) \quad b_0 > 0 \text{ and } b_1 > 0 \tag{2}$$

$$\hat{p}_s + \hat{x}_s + \hat{f} = \hat{m}_s + \hat{e} \tag{3}$$

$$\hat{\lambda}_s = c_0 + c_1 h_s g_s \quad 0 < c_0 < 1 \text{ and } 0 < c_1 < 1 \tag{4}$$

$$g_s = \hat{\lambda}_s + \eta_s \tag{5}$$

Where $\hat{x}_s$ $(\hat{m}_s)$ corresponds, respectively, to the growth rate of exports (imports) from the South; a_0 (b_0) is the income elasticity of exports (imports); $a_1(b_1)$ represents the price elasticity of exports (imports); g_N (g_s) corresponds to the growth rate of the North (South); $\hat{p}_s$ is the inflation rate in the South; $\hat{e}$ represents the growth rate of the nominal exchange rate; $\hat{f}$ is the growth rate of capital flows; c_0 is the autonomous parameter that captures variables affecting labour productivity growth other than GDP growth in the South; c_1 represents the Kaldor-Verdoorn coefficient; h_s is the industry share of output in the South; $\hat{\lambda}_s$ corresponds to the rate of growth of labour productivity in the South; and, lastly, η_s is the growth of the workforce.

Expressions (1), (2) and (3) follow the work of Thirlwall and Hussain (1982). Thus, in equation (1), economic growth in the North and the rate of change of the real exchange rate have a positive impact on the growth rate of exports from the South.[3] In equation (2), economic growth in the South and the appreciation of the real exchange rate lead to an increase in the growth rate of imports from the South. Equation (3) expresses the intertemporal balance of payments equilibrium.

Equation (4) was based on the work of Gabriel (2016) and Gabriel, Jayme and Oreiro (2016), which corresponds to the Kaldor-Verdoorn law, since it captures the sensitivity of productivity growth to the growth of Southern domestic product (Dixon and Thirlwall, 1975; Fingleton and Mccombie, 1998; Harris and Liu, 1999; León-Ledesma, 2000; Ciriaci, 2006). However, the Kaldor-Verdoorn effect tends to be stronger as the industry share of domestic output in Southern countries increases.

Equation (5) demonstrates the existence of a balanced growth path from the moment when the rate of growth in labour productivity added to population growth (or labour force growth) equals the rate of economic growth in the South. Thus, this equation uses the assumption that the unemployment rate is constant over time.

Like Kalecki (1954), equation (6) assumes that the price of the good produced in the South is a function of a profit margin rate on unit production costs.[4]

$$p = \left(1 + \mu\right)\left(\frac{W}{\lambda}\right) \qquad \mu > 0 \tag{6}$$

Where μ is the profit margin rate and λ is labour productivity.

It is explicitly assumed that the price is determined by the unit labour cost plus a margin on that cost. Thus, it is implicitly assumed that there are no imports of intermediate goods.

The Southern inflation equation used by Dixon and Thirlwall (1975), León-Ledesma (2000) and Ciriaci (2006) for the North-South model suggests:

$$\hat{p}_s = \hat{z}_s + \hat{w}_s - \hat{\lambda}_s \tag{7}$$

Where $\hat{z}_s$ corresponds to the profit margin growth rate; $\hat{w}_s$ represents the nominal wage growth rate, $\hat{\lambda}_s$ is the labour productivity growth rate and the subscript s denotes the economy of the South.

In a context where country risk is zero and, on average, the expectation of exchange rate depreciation is also zero, the growth rate of the nominal exchange rate is determined exclusively by the difference between real interest rates in the North and the South. The assumption is that any deficits or surpluses in the trade balance are compensated by the central bank.

$$\hat{e} = \varepsilon_0\left(r_N - r_s\right) \tag{8}$$

[3] For simplicity, the growth rate of inflation in the North is assumed to be zero $\left(\hat{p}_N = 0\right)$. Thus, the profit margin rate of the North is constant and, consequently, wage growth is equal to labour productivity growth.

[4] The profit margin rate is used as a proxy variable for companies' market power. Thus, a value equal to zero for this rate describes a market structure with perfect competition. In addition, it is appropriate to define $Z \equiv 1 + \mu > 1$.

Where $\hat{e}$ represents the growth rate of the nominal exchange rate; r_s (r_N) is the real interest rate in the South (North) and ε_0 is a positive coefficient that measures the prevailing exchange rate regime. Indeed, if the sensitivity of the real exchange rate to the interest differential is equal to zero (greater than zero) the exchange rate will be fixed (flexible). Where the sensitivity of the real exchange rate to the interest differential tends to infinity, the exchange rate will be flexible and there will be perfect capital mobility.

According to Krugman and Obstfeld (2003) and Romer (2012), the Fisher equation shows that the real interest rate is approximately equal to the nominal interest rate minus the inflation rate, as shown below for the case of the Southern economy:

$$r_s = i_s - \hat{p}_s \tag{9}$$

Where: i_s corresponds to the nominal interest rate in the South.

Under the above conditions, the growth rate of capital flow is:

$$\hat{f} = \varepsilon_1 \left(i_s - \hat{p}_s \right) \tag{10}$$

Where ε_1 is a positive coefficient. It was assumed, without loss of generality, that the real interest rate in the North is zero.

The behaviour equation that will present the endogeneity of the nominal interest rate in the South can be described as follows:

$$i_s = j_0 + j_1 u_s \tag{11}$$

Where j_0 is an autonomous parameter; u_s is the degree of utility of productive capacity; j_1 is the sensitivity of the nominal interest rate in the South to effective demand/credit.[5]

According to Bresser-Pereira, Oreiro and Marconi (2014), the rate of profit margin growth varies according to the exchange rate misalignment, understood as the difference between the real effective exchange rate and the industrial equilibrium exchange rate. The expression that represents it is as follows:

$$\hat{z}_s = \alpha\varphi = \alpha\left(\theta - \theta^{ind} \right); \qquad \alpha > 0 \tag{12}$$

Where φ is the exchange rate misalignment, understood as the difference between the real effective exchange rate (θ) and the industrial equilibrium exchange rate (θ^{ind}) and α is a sensitivity coefficient of the growth rate of the profit margin in the South relative to the exchange rate misalignment.

In the labour market, firms are assumed to have a certain market power that prevents the nominal wage from being equal to the value of labour productivity, as shown below:

$$W_s = \left(\Lambda_s P_s \right)^{\phi} \tag{13}$$

Where ϕ is the elasticity of the nominal wage with respect to the value of labour productivity in the South ($0 < \phi < 1$) and Λ_s is marginal labour productivity in the South.

Therefore, the nominal wage growth rate in the South is:[6]

$$\hat{w}_s = \phi\left(\hat{\lambda}_s + \hat{p}_s \right) \tag{13.1}$$

[5] Here u acts as a proxy for credit demand and, for simplicity, j_1 will be assumed to be equal to one.

[6] Equation (13.1) shows that functional relationship (13) is consistent with a profit-based accumulation regime.

Thus, the South's nominal wage growth rate $(\hat{w}_s)$ depends on the sum of the labour productivity growth rate $(\hat{\lambda}_s)$ and the South's inflation rate $(\hat{p}_s)$, both weighted by elasticity ϕ.

Substituting equations (1), (2), (4), (7), (8), (9), (10), (11) and (12) in (3) gives the expression for demand.

$$u_s = \frac{1}{c}\left[\alpha\varphi A - \left(c_0 + c_1 h_s g_s\right)B + a_0 g_N - b_0 g_s\right] - j_0 \tag{3.1}$$

Where:

$$A \equiv \frac{1-\left(a_1 + b_1\right)\left(1-\varepsilon_0\right)-\left(\varepsilon_0+\varepsilon_1\right)}{1-\phi}$$

$$B \equiv 1-\left(a_1 + b_1\right)\left(1-\varepsilon_0\right)-\left(\varepsilon_0+\varepsilon_1\right)$$

$$C \equiv \varepsilon_0\left(a_1+b_1\right)-\left(\varepsilon_0+\varepsilon_1\right)$$

To find the supply side equation it is necessary to substitute equation (4) in expression (5) This gives the economic growth rate in the South, which is equal to the natural economic growth rate in the South (g_{ns}). Thus, the function is written as:

$$g_s = g_{ns} = \left(\frac{c_0+\eta_s}{1-c_1 h_s}\right) \tag{5.1}$$

Looking at the above expression, the industry share has a positive impact on the rate of growth. Thus, the higher the value of the industry share of output weighted by the Kaldor-Verdoorn coefficient, the higher the natural rate of growth. The equation described above is in line with the arguments defended by Kaldor (1966 and 1970), who stresses the role of industry as an "engine" of long-term economic growth.

By substituting expression (5.1) in equation (3.1), the obstacles to economic growth in the balance-of-payments-constrained models described by Palley (1996 and 2002) are avoided.

$$u^*_s = \frac{1}{c}\left[\alpha\varphi A - c_0 B - \left(\frac{c_0+\eta_s}{1-c_1 h_s}\right)\left(c_1 h_s B - b_0\right) + \alpha_0 g_N\right] - j_0 \tag{3.2}$$

For the parameters A and B to be positive, the sum of the price elasticities of exports and imports (Marshall-Lerner condition) must be sufficiently small or the sensitivity of the nominal exchange-rate variation to the interest differential, associated with capital mobility, must assume suitably small values. For the parameter C to assume positive values, the sum of the price elasticities of exports and imports must be greater than the ratio of the capital flow elasticity (corresponding to the real interest rate in the South) over the nominal exchange rate elasticity (relative to the difference between the North and South real interest rates), plus one, i.e. $a_1 + b_1 > \frac{\varepsilon_1}{\varepsilon_1} + 1$.

The difficulty in presenting concrete results regarding the values of the price elasticities of a nation's exports and imports is due to the great variability of values found in the empirical literature. After analysing the work of Zini Jr. (1988), Fullerton, Sawyer and Sprinkle (1999), Castro and Cavalcanti (1997), De Campos and Arienti (2002), Skiendziel (2008), Dos Santos and others (2011) and Kawamoto, Santana and Fonseca (2013), different values corresponding to the price elasticity of exports and imports were found.

III. Dynamic equations

Since industry has increasing returns to productive scale and, in addition, injects dynamism into the economy through technological progress, learning and spillovers into other economic sectors, industrialization becomes a key element for recovery and convergence in the North-South model (Szirmai, 2012; Felipe and others, 2007).[7]

In his empirical work, Rodrik (2009) notes that the accelerated growth that took place in developing economies from the 1960s onwards was due to the transfer of productive resources between sectors. This, because the growth of developing nations requires that the global economy be able to rapidly absorb their supply of tradable goods. Thus, for developing countries, the strategy that still exists is exchange rate depreciation, whereby export quantity increases, and that in turn stimulates industrialisation. It can be concluded, therefore, that industrial activities, operating with increasing returns to scale, have become the "engine" of long-term economic growth.

Szirmai (2012) highlights industrial participation as a key element for long-term economic growth. According to that author, as the transfer of resources and labour from the agricultural to the industrial sector takes place, there is a structural change bonus due to the fact that labour productivity in the agricultural sector is lower than labour productivity in industry.

According to Felipe and others (2007), the industrial sector is considered to have the greatest impact on economic growth, followed by the services sector and manufacturing. According to those authors, this is due to the linkages that the industrial sector provides to the economy. In their study, the activities responsible for those linkages were the electricity and infrastructure sectors.

According to Gabriel (2016), the dynamics of the industry's growth rate in the South's output is a function of the difference between price competitiveness and non-price competitiveness. Moreover, by assuming that the exchange rate is overvalued with respect to the industrial-equilibrium exchange rate, the share of industry in output is reduced, given that there is a transfer-out of productive activity abroad (Bresser-Pereira, Oreiro and Marconi, 2014).

Thus, the overvaluation of the exchange rate generates a negative change in the structure of the economy, causing what Palma (2005) calls "premature deindustrialization".[8] Frenkel and Rapetti (2014) show that for the share of industry in the South to increase, the exchange rate must be stable and undervalued, with a level at or slightly above the industrial-equilibrium real exchange rate.

According to the above arguments, the dynamics of the industry share in the South is given by a non-linear (quadratic) function of exchange rate misalignment.

$$\hat{h}_s = \sigma\left(\varphi - \varphi^2\right) \tag{14}$$

Where σ represents the sensitivity of exchange rate misalignment to industrial sector development policies.

Thus, the growth rate of the industry share of output tends to increase as the real effective exchange rate depreciates relative to the industrial-equilibrium exchange rate. Beyond a certain critical point, any depreciation of the real effective exchange rate tends to reduce the industry share of output. This functional relationship thus captures the dual effect of exchange rate misalignment on industry's share

[7] On this subject, there are other authors who analyse the laws developed by Kaldor, namely: Fingleton and McCombie (1998), Harris and Liu (1999), and Leon-Ledesma (2000), among others.

[8] Other texts describing the consequences of exchange rate overvaluation and deindustrialisation include Bresser-Pereira (2007) and Marconi and Rocha (2011).

of GDP. For exchange rate misalignment values below (above) the critical value, price competitiveness gains more than offset (do not offset) the increase in imported input costs. This causes the increase (decrease) in the industry share of output.

Under the assumption that inflation in the North is zero, the growth rate of the real exchange rate is as follows:

$$\hat{\theta} = \hat{e} - \hat{p}_s \tag{15}$$

By substituting equations (3.2), (7) and (13.1) in (15) it is possible to find the expression that describes the growth rate of the real exchange rate compatible with the balance of payments equilibrium and the equilibrium between aggregate demand and supply.

$$\begin{aligned}\hat{\theta} = &-\alpha\varphi\left[\varepsilon_0\left(\frac{A}{C}-\frac{1}{1-\phi}\right)+\frac{1}{1-\phi}\right]+c_0\left[1+\varepsilon_0\left(\frac{B}{C}-1\right)\right]+\\ &\left(\frac{c_0+\eta_s}{1-c_1 h_s}\right)\left\{\varepsilon_0\left[c_1 h_s\left(\frac{B}{C}-1\right)-\frac{b_0}{c}\right]+c_1 h_s\right\}-\frac{\varepsilon_0 a_0 g_N}{c}\end{aligned} \tag{15.1}$$

From the above equation, it can be seen that the growth rate of the real exchange rate is positively affected by the profit margin and the industry share of GDP. Thus, assuming a positive change in exchange rate misalignment or in the industry share of GDP, there will be a depreciation of the real exchange rate growth rate.

Equations (14) and (15.1) form a two-dimensional system of non-linear differential equations.

1. Dynamic analysis with capital mobility and a floating exchange rate

The equation representing the location of $\hat{h}_s$ is described below:

$$\left(1+2\theta^{ind}\right)\theta-\theta^2=\theta^{ind}+\theta^{ind^2} \tag{16}$$

Deriving equation (16), which corresponds to the locus of the industry share of GDP with respect to the real exchange rate, gives the slope, the concavity of the curve and the critical point. As can be seen below:

$$\frac{\partial\hat{h}_s}{\partial\theta}=-2\theta+1+2\theta^{ind} \tag{16.1}$$

$$\frac{\partial^2\hat{h}_s}{\partial\theta^2}=-2<0 \tag{16.2}$$

Thus, it can be seen that the curve corresponds to a parabola with the concavity oriented downwards. This parabola presents a critical point for the real exchange rate, which turns its influence on the growth rate of the industry share of GDP from positive to negative, depending on whether it is above or below that critical level.[9]

[9] The critical value of the exchange rate is: $\theta^{cri}=\frac{1}{2}+\theta^{ind}$.

In addition, there are two distinct roots that make the locus of the industry share of GDP zero.[10] The values of the roots could only be determined after normalising the equilibrium exchange rate to be equal to one ($\theta^{ind} = 1$). Therefore, multiple equilibria will be found in the plane $(\hat{h}_s, \theta)$.

In contrast, the locus of $\hat{\theta}$ occurs when the change in the real exchange rate is constant $(\hat{\theta} = 0)$. The expression representing is as follows:

$$\theta^{\cdot} = \frac{1}{D}\left\{c_0\left[1+\varepsilon_0\left(\frac{B}{C}-1\right)\right]+\left(\frac{c_0+\eta_s}{1-c_1h_s}\right)\left\{\varepsilon_0\left[c_1h_s\left(\frac{B}{C}-1\right)-\frac{b_0}{c}\right]+c_1h_s\right\}-\frac{\varepsilon_0 a_0 g_N}{c}\right\}+\theta^{ind} \qquad (17)$$

Where: $D \equiv \alpha\left[\varepsilon_0\left(\frac{A}{C}-\frac{1}{1-\phi}\right)+\frac{1}{1-\phi}\right]$

The slopes of the loci $\hat{h}_s = 0$ and $\hat{\theta} = 0$ are, respectively:

$$\frac{\frac{\partial\theta^{\cdot}}{\partial\hat{h}_s}}{\hat{h}_s} = 0 \qquad (16a)$$

$$\frac{\frac{\partial\theta^{\cdot}}{\partial\hat{h}_s}}{\hat{\theta}} = \frac{c_1\left(c_0+\eta_s\right)}{D\left(1-c_1h_s\right)^2}\left[\varepsilon_0\left(\frac{B}{C}-1-\frac{b_0}{C}\right)+1\right] \qquad (17a)$$

As can be seen, the derivative (16a) will present a line that will be parallel to the plane h_s since its slope is zero. To verify the slope of the locus of the exchange rate growth rate with respect to the industry share of GDP (17a), it is necessary to analyse the value of the parameter (D) and the term $\frac{B}{c}-1$. Like the other parameters, (D) will also be positive.

Therefore, for the Marshall-Lerner condition to be fulfilled,[11] it is necessary that $\frac{B}{c}-1 < 0$. In addition, $C\left[\varepsilon_0\left(\frac{B}{c}-1-\frac{b_0}{c}\right)+1\right] < \varepsilon_0 b_0$ better satisfies the assumed conditions. Thus, the higher the Marshall-Lerner condition, the greater the chance that the slope of the locus $\hat{\theta} = 0$ will be negative and concave.

The system of equations comprising equations (14) and (15.1) will be derived with respect to h_s and θ, in order to reveal the elements composing the Jacobian matrix, as shown below:

$$\begin{bmatrix}\hat{h}_s\\ \hat{\theta}\end{bmatrix} = \begin{bmatrix} 0 & \sigma\left(\theta^{cri}-\theta\right)\\ \frac{c_1\left(c_0+\eta_s\right)}{D\left(1-c_1h_s\right)^2}\left[\varepsilon_0\left(\frac{B}{c}-1-\frac{b_0}{c}\right)+1\right] & -(D)\end{bmatrix}\begin{bmatrix}h_s-h^*{}_s\\ \theta-\theta^*\end{bmatrix} \qquad (18)$$

According to equation (18) and recalling the assumption that the parameter (D) is positive, it is observed that: (i) the trace is negative (–D) and (ii) the determinant can have both negative and positive values. This is because it depends on the derivative of the growth rate of the industry share in the South relative to the exchange rate ($elementJ_{12}$) and the growth rate of the real exchange rate relative to the South's industry share ($elementJ_{21}$).[12] The conditions of the terms are as follows.

[10] The distinct real roots are: θ' = 1 and θ" = 2.

[11] The depreciation of the real exchange rate will generate an increase in net exports if, and only if, the sum of the price elasticities of exports and imports is, in modulus, greater than one unit.

[12] According to Gandolfo (1997) and Chiang (2005).

Thus, based on the conditions shown in table 1 and knowing that the value of the trace is negative, the determinant for a long-run equilibrium path must necessarily be positive. Thus, by assumption, the value of the term J_{21} will be positive, since the term $\frac{B}{c} - 1$ assumes the negative value. Therefore, analysis of the exchange rate regime is crucial for verifying the long-run equilibrium path.

Table 1
Possible values of J_{12} and J_{21}

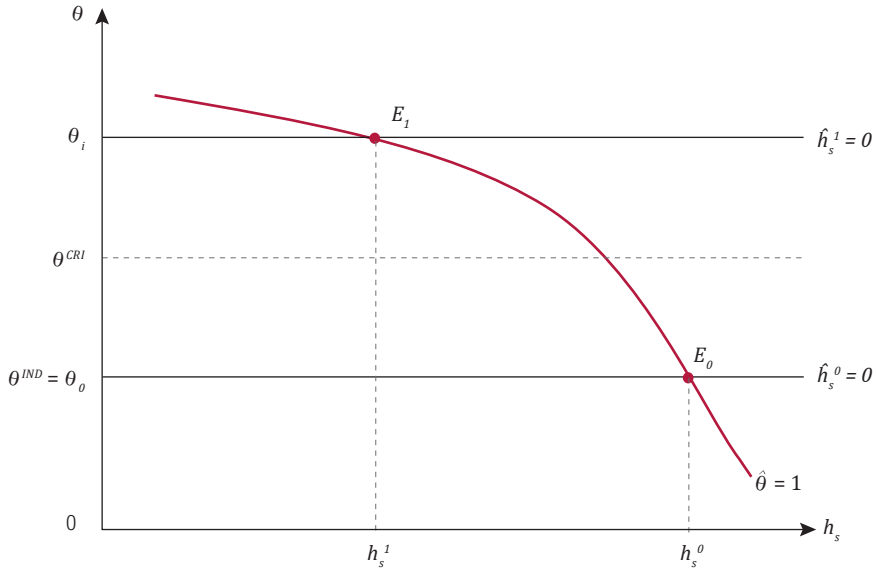
	Term sign	Necessary condition
(1)	$\sigma\,(1 + 2\theta^{ind} - 2\theta) > 0$	$\theta < \theta^{CRI}$
(2)	$\sigma\,(1 + 2\theta^{ind} - 2\theta) < 0$	$\theta > \theta^{CRI}$
(3)	$\left[\varepsilon_0\left(\frac{B}{C} - 1 - \frac{b_0}{C}\right) + 1\right] > 0 \; e \frac{B}{C} - 1 < 0$	$1 > \varepsilon_0\left(\frac{b_0}{C} - \frac{B}{C} + 1\right)$
(4)	$\left[\varepsilon_0\left(\frac{B}{C} - 1 - \frac{b_0}{C}\right) + 1\right] < 0 \; e \frac{B}{C} - 1 < 0$	$1 < \varepsilon_0\left(\frac{b_0}{C} - \frac{B}{C} + 1\right)$

Source: Prepared by the authors.

Also, the smaller the value of the nominal exchange rate sensitivity coefficient (ε_0), i.e., the less close the change in the nominal exchange rate is to the value equivalent to the fixed exchange rate regimefijo $(\varepsilon_0 = 0)$, the easier it is for condition (3) to be fulfilled. On the other hand, the higher the sensitivity of the nominal exchange rate, approaching one, similar to the case of the flexible exchange rate regime, the easier it becomes for condition (4) to be reached.

When the real exchange rate is lower than the critical real exchange rate, an unstable equilibrium path is found. Conversely, when the opposite is true, i.e. when the real exchange rate is higher than the critical real exchange rate, a stable long-run equilibrium path is observed. Therefore, two equilibria are found in figure 1.

Figure 1
Long-run equilibrium path for an economy with capital mobility and a flexible exchange rate



Source: Prepared by the authors.

Based on the above, the system is in stable equilibrium when the real exchange rate depreciates above the critical value. In this case the industry share of GDP is lower than in the second case. The latter presents the real exchange rate appreciated and below the critical level, with the industry share

of GDP quite high in the economy. Neither result is in line with the main hypothesis of the paper, where the real exchange rate and the industry share of GDP should be high.

In the case of the flexible exchange rate regime, the relationship between the real exchange rate and the industry share of GDP is inverse, so that an increase in the real exchange rate reduces the share of industry in the economy. Moreover, stable long-run equilibrium is found only when the real exchange rate is quite depreciated, and the industry share of GDP is low.

It is also worth investigating the model with capital mobility and a fixed exchange rate, recalling that in this case the value of nominal exchange rate elasticity will be zero ($\varepsilon_0 = 0$). The loci of $\hat{h}_s$ and $\hat{\theta}$, the equilibrium dynamics and the phase diagram for an economy with capital mobility and a fixed exchange rate are analysed below.

2. Dynamic analysis with capital mobility and a fixed exchange rate

The equation for the locus of $\hat{h}_s$ when $\varepsilon_0 = 0$ is as follows:

$$\left(1+2\theta^{ind}\right)\theta-\theta^2=\theta^{ind}+\theta^{ind^2} \tag{19}$$

The locus of $\hat{\theta}$ can be verified as follows:

$$\theta^{\cdot}=\frac{1}{D}\left\{c_0+\left(\frac{c_0+\eta_s}{1-c_1h_s}\right)c_1h_s\right\}+\theta^{ind} \tag{20}$$

Where: $D \equiv \frac{\alpha}{1-\phi}$

The dynamics of the loci are shown in figure 2, which plots the relationship between the real exchange rate and the industry share of output in the South, as above:

$$\frac{\frac{\partial\theta^{\cdot}}{\partial\hat{h}_s}}{\hat{h}_s}=0 \tag{19a}$$

$$\frac{\frac{\partial\theta^{\cdot}}{\partial\hat{h}_s}}{\hat{\theta}}=\frac{c_1\left(c_0+\eta_s\right)}{D\left(1-c_1h_s\right)^2} \tag{20a}$$

As in the previous case, the derivative (19a) will be a horizontal line in the plane $(\hat{h}_s, \hat{\theta})$. Thus, no change in the industry share will affect the equilibrium exchange rate. When analysing the derivatives (20a), it is found that the slope will certainly be positive and convex.

The system consisting of equations (14) and (15.2) will be derived with respect to $\hat{h}_s$ and $\hat{\theta}$, assuming a fixed exchange rate regime. This can be obtained by assuming $\varepsilon_0 = 0$.

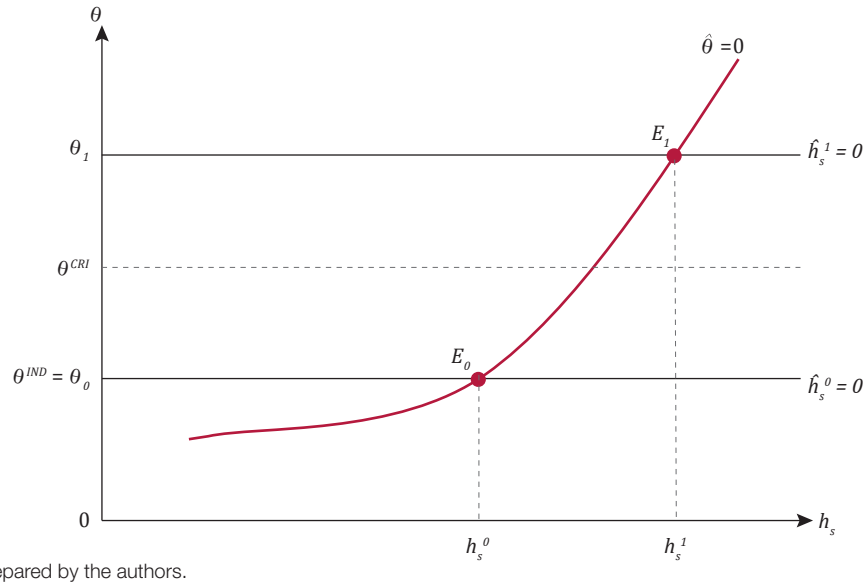
$$\begin{bmatrix}\hat{h}_s\\ \hat{\theta}\end{bmatrix}=\begin{bmatrix}0 & \sigma\left(\theta^{cri}-\theta\right)\\ \frac{c_1\left(c_0+\eta_s\right)}{D\left(1-c_1h_s\right)^2} & -\left(D\right)\end{bmatrix}\begin{bmatrix}h_s-h^*_s\\ \theta-\theta^*\end{bmatrix} \tag{21}$$

Looking at equation (21) and taking into account the negative value of the element J_{22}, it can be seen that the trace will be negative and the determinant depends on the ratio of the depreciation of the real exchange rate to the industrial equilibrium exchange rate (J_{12}).

Thus, unstable equilibrium occurs when the real exchange rate is lower than the critical real exchange rate, where the share of industry in GDP is relatively small. On the other hand, when the real exchange rate is sufficiently depreciated and the industry share of output in the South is relatively higher, the equilibrium will be stable in the long run. Thus, in the second case, when the exchange rate and the share of industry in GDP are high, the result converges to the hypothesis presented in this paper.

In this case, the model with capital mobility and a fixed exchange rate is shown in figure 2, which represents the long-run equilibrium path, since there are multiple equilibria.

Figure 2
Long-run equilibrium path for an economy with capital mobility and a fixed exchange rate



Source: Prepared by the authors.

When the economy has a fixed exchange rate regime and the exchange rate is depreciated, there is a high share of industry in the economy, which is the stable point in the long-run equilibrium path. Thus, the relationship between the real exchange rate and the share of industry in GDP is positive. However, when the real exchange rate falls below the critical point, the path becomes unstable in the long run.

IV. Conclusions

The aim of this paper was to analyse the interactions between different exchange rate regimes and the share of industry in GDP, in order, by that means, to verify the conditions for self-sustaining economic growth in a developing economy.

The model proposed in this paper indicates different long-run equilibria depending on the exchange rate regimes used. Assuming a flexible (fixed) exchange rate regime, the equilibrium relationship between the real exchange rate and the share of industry in output is inverse (direct).

Thus, with a flexible exchange rate, the long-run equilibrium will have a stable path when the real exchange rate is depreciating above the level of the critical real exchange rate and, at the same time, the industry share of output is relatively low. On the other hand, with a fixed exchange rate, the equilibrium will be stable when the real exchange rate is above the level of the critical real exchange rate and, at the same time, the share of industry in the economy is relatively high.

Thus, the model developed with capital mobility and fixed exchange rate fulfilled the initial hypothesis better, since it assumes a depreciated real exchange rate, as observed in the two cases presented, but with a high industry share of GDP, found only in the case where the exchange rate is considered fixed. Thus, monetary agents should set the value of the nominal exchange rate and depreciate the real exchange rate above the critical exchange rate in order to have a long-run equilibrium path.

The depreciation of the real exchange rate increases equilibrium effective demand, since depreciation stimulates net exports. The industry share of GDP in the South has an ambiguous effect. If the income elasticity of imports is sufficiently high (low), the increase (decrease) in industry's share tends to increase (reduce) the equilibrium installed capacity utilisation.

A particularly interesting result of the model is the importance of price elasticities of exports and imports for long-term stability. Once the Marshall-Lerner condition is satisfied, the locus $\hat{\theta} = 0$ will certainly be negative in the plane $(\hat{h}_s, \hat{\theta})$ in the presence of a fixed exchange rate. If the sum of the price elasticities of exports and imports is high, there will be a greater chance that the locus $\hat{\theta} = 0$ will be negatively tilted in the plane $(\hat{h}_s, \hat{\theta})$ when a floating exchange rate is adopted.

Finally, multiple long-run equilibria were verified for the two exchange rate regimes proposed. In particular, it was observed that under the flexible (fixed) exchange rate regime, stable equilibrium is found when the industry share of GDP in the South is relatively low (high).

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The demand for cash: stylized facts and substitution by electronic means of payment[1]

Luis Cabezas and Alejandro Jara

Abstract

This article analyses the impact of the increasing use of electronic means of payment on the demand for cash (banknotes and coins). It estimates two models: one with panel data and the other with cross-sectional data. The two methodologies offer complementary views for evaluating the degree to which electronic means of payment act as a determinant of currency in circulation. The study identifies an intense substitution process between cash and electronic means of payment, which is common to most of the economies analysed. However, there are also a number of idiosyncratic factors that explain the high degree of heterogeneity in the demand for cash that exists between countries. In emerging economies, electronic payment is still incipient, so the demand for cash is likely to continue to decline. However, this does not mean that these economies will become "cashless societies" in the near future.

Keywords

Money, supply and demand, money supply, electronic commerce, Internet, information technology, communication technology

JEL classification

E41, E42, E5

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[1] The opinions expressed in this article are the authors' sole responsibility and, therefore, do not represent the opinion of the institutions to which they are affiliated. The authors are grateful for comments made by an anonymous referee, which resulted in substantive improvements being made to the article.

I. Introduction

Households demand cash (banknotes and coins)[2] mainly for three motives: for transactional purposes; to hold as a store of value; and for precautionary reasons. Data from recent years shows that the amount of cash circulating in the economy, as a percentage of the M1 monetary aggregate,[3] has declined in most countries, and that this decline has even been accentuated in emerging economies. The smaller demand for cash as a proportion of M1 is explained mainly by the increasing use of electronic means of payment, as cash transactions compete, for example, with the use of credit cards, debit cards and Internet payments.[4] This process poses major challenges for monetary policy and financial regulation. Recent research suggests that greater use of electronic means of payment increases the elasticity of the demand for money with respect to interest rate changes (Attanasio, Guiso and Jappelli, 2002), which could potentially affect overall price stability (Carstens, 2018). This makes it important to understand the factors driving the increased use of electronic means of payment and how these have contributed to the evolution of the demand for physical money in a broad range of countries.

Although the global trend shows that electronic payment has increased at the expense of banknotes and coins in virtually all economies, there are still significant differences between countries (Jobst and Stix, 2017; Bech and others, 2018). In particular, most economies use electronic means of payment considerably less than the Nordic countries (Sweden, for example), which have been leaders in the digitalization of the means of payment at the retail level. The increased use of electronic payment has been driven by innovations in both financial markets and information technologies, in a transformation process that has been under way for several decades. Humphrey, Pulley and Vesala (1996) analyse the payment systems of 14 developed countries and identify a substitution effect of around 68% between cash and other means of payment. This means that a 10% reduction in cash holdings is associated with a 6.8% increase in the use of other means of payment. This trend towards electronic payment is also present in less developed countries, where cell phones are increasingly being used to make payments (Bagnall and others, 2016). However, international data show that the substitution between the use of banknotes and coins and electronic means of payment varies over time and, consequently, is not perfect (Jonker and others, 2017). Moreover, in some countries, cultural and institutional factors favour the use of cash (Bagnall and others, 2016). For example, households hold a considerable portion of their assets as cash, particularly for low-value transactions. Stix (2013) further shows that lack of trust in banks, the memory of past financial crises, and the weakness of the tax collection system may hinder the process of cash being replaced by electronic means.

This article presents a series of stylized facts on the demand for physical currency and the role of electronic means of payment as a potential substitute for cash in a group of advanced and emerging economies in 2000–2016. The factors that have contributed to the decline in the demand for cash as a percentage of M1 are analysed through econometric estimations of panel and cross-sectional data. These emphasize the role of factors that could encourage the replacement of cash by electronic means —traditionally associated with greater access to the financial system, greater use of payment

[2] In this article, the terms “cash”, “banknotes and coins in circulation” and “currency in circulation” are used interchangeably, to refer to banknotes and coins circulating outside the banking system.

[3] M1 is a narrow measure of the money supply that includes physical currency, demand deposits, traveler’s checks, and other checkable deposits.

[4] The above, however, contrasts with the observed trend of cash as a percentage of GDP, which has increased in most countries. This is partly due to the growth of the informal economy, increased precautionary demand for cash, and the demand for banknotes and coins as a store of value (Goodhart and Ashworth, 2017; Jobst and Stix, 2017).

via the Internet, and the desire to make government transfers and wages received by the public more conducive to the use of electronic media.[5]

The results of the panel and cross-sectional estimations reveal the potential impact of different factors on the demand for cash. The estimations performed show that, on average, if all the countries included in the panel sample had similar attitudes towards the use of electronic payment as those of 2014 Sweden (the country with the least demand for currency at the time of the study), the demand for currency as a percentage of the monetary aggregate M1 would fall from 30% to 23%. The main implication of this is that the increased use of electronic means of payment would reduce the use of cash as a proportion of M1; but this does not mean that it would disappear. This result is consistent with what has been documented in the literature, in which data from surveys on means of payment use are applied to estimate causal inference models with a view to analysing means of payment innovations and payment decision models (see Fung, Huynh, and Sabetti, 2014 and Wakamori and Welte, 2017).

Section II of this article makes a detailed analysis of the trends in the demand for circulating currency in emerging and advanced economies in 2000–2016. It also reviews the results of the World Bank's Global Findex means of payment survey. Section III presents the main results of the econometric estimations of the model used in the present study with panel and cross-sectional data. Lastly, section IV presents the conclusions.

II. Data and stylized facts

1. The data

This section presents a set of stylized facts in relation to the demand for banknotes and coins and the use of electronic means of payment in a selected group of economies. The different measures of the use of cash are analysed by combining data published by the Center for Latin American Monetary Studies (CEMLA), the Bank for International Settlements (BIS) and the World Bank, for 2000–2016. This database includes 21 countries, of which 13 are emerging economies (Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay), and eight are advanced economies or groupings of economies (Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the eurozone).

The analysis of the use of electronic means of payment is based on data for 2014 published by the World Bank in the Global Findex database.[6] This database covers 170 economies from different geographic areas and levels of development, but the data are available only for a small number of years. The stylized facts based on this information presented in the following section consider information on these 170 economies. The cross-sectional estimates presented in the next section, which are based on Global Findex data, are limited by the availability of complementary macrofinancial data used in the regressions and, consequently, are based on a subset of 54 economies.

Table 1 provides a detailed description of the variables considered in the analysis, indicating the sources used in each case.

[5] This article does not consider the potential implications of the recent development of digital currencies (cryptocurrencies) on the demand for cash, because this is still considered incipient and because digital currencies are not currently widely used as a means of payment by the population (BIS, 2018). However, it is reasonable to assume that in the future their effect on the demand for cash will be significant.

[6] For further details on the contents of this database see Demirguc-Kunt and Klapper (2012).

Table 1
Description of the variables considered in the analysis

Variable name	Description	Source
Cash	Banknotes and coins (currency) in circulation, amount at year-end expressed as a percentage of the M1 monetary aggregate and as a percentage of GDP.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
GDP per capita	GDP divided by mid-year population.	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators.
Automatic teller machines	ATM terminals located in the country: number of terminals per million inhabitants, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Credit cards	Cards with a credit function issued in the country: number of cards per inhabitant, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Debit cards	Cards with a debit function issued in the country: number of cards per inhabitant, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Financial depth	Domestic credit granted by the financial sector (as a percentage of GDP).	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators.
Monetary policy rate	Monetary policy interest rate.	Bank for International Settlements (BIS) monetary policy interest rate statistics.
Inflation	Inflation, consumer prices, annual percentage.	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators.
Account in a financial institution	Percentage of population over 15 years of age with an account in a financial institution.	Global Findex, database published by the World Bank.
Uses credit card	Percentage of the population over 15 years of age that used a credit card in the past year.	Global Findex, database published by the World Bank.
Uses debit card	Percentage of population over 15 years of age that used a debit card in the past year.	Global Findex, database published by the World Bank.
Transactions through cell phones	Percentage of the population over 15 years of age that made transactions at a financial institution using a cell phone.	Global Findex, database published by the World Bank.
Internet use	Percentage of the population over 15 years of age using the Internet to pay bills and make purchases.	Global Findex, database published by the World Bank.
Government transfers in cash	Percentage of population over 15 years of age that receives government transfers in cash.	Global Findex, database published by the World Bank.
Wages received in cash	Percentage of population over 15 years of age that receives wages in cash.	Global Findex, database published by the World Bank.

Source: Prepared by the authors.

2. Stylized facts

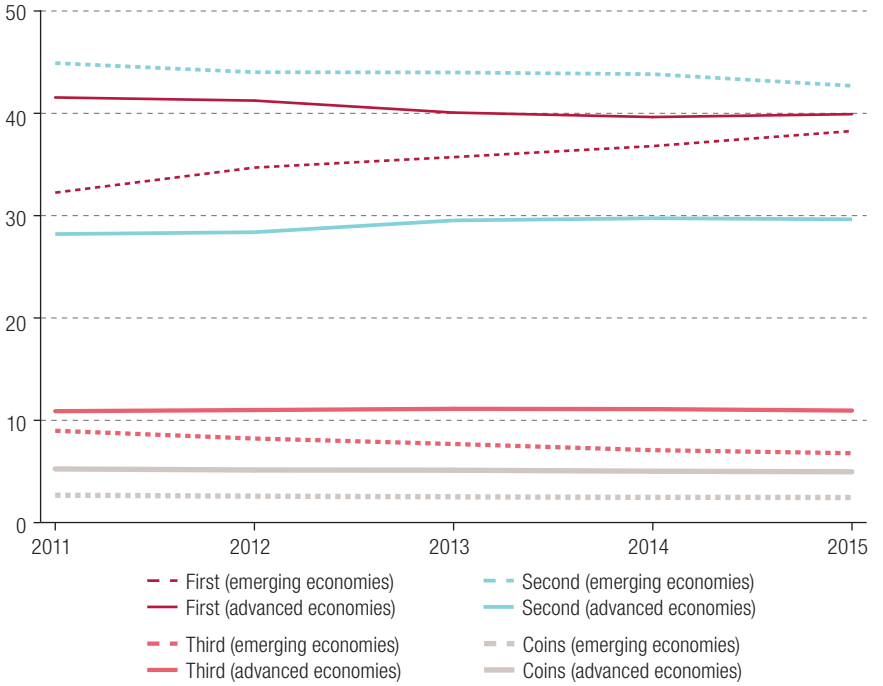
The relative importance of the use of banknotes and coins in circulation in an economy can be measured in several ways. At the aggregate level, currency is traditionally measured in dollars, as a percentage of the population, as a percentage of GDP and as a percentage of one of the monetary aggregates, typically M1. At the micro level, the relative share of cash as a means of payment (in terms either of amount or of the number of transactions) is measured by surveys that track household payment behaviour.[7]

[7] These surveys also make it possible to evaluate the use of cash as a store of value.

(a) Denomination of banknotes and coins

A first stylized fact that emerges is that higher-denomination banknotes and coins account for a larger share of total cash holdings in advanced and emerging economies alike. Figure 1 shows the average shares of banknotes listed by denomination.[8] On average, in advanced economies, the highest denomination accounts for over 40% of the stock of banknotes and coins in circulation, while in emerging economies the second highest denomination has the largest share. The relative importance of higher-denomination banknotes in emerging economies has increased in recent years, whereas coins in circulation account for a much smaller proportion of the total.

Figure 1
Composition of currency in circulation in emerging and advanced economies, 2011–2015
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

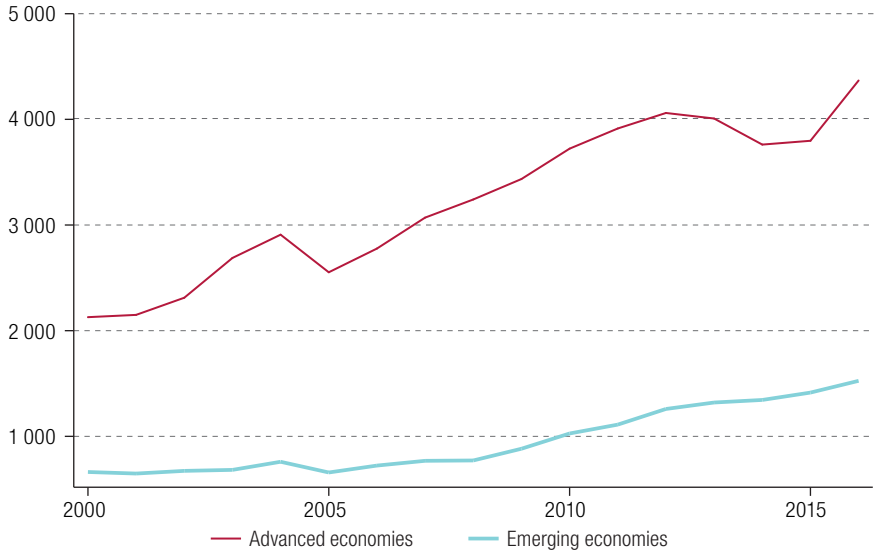
Note: The calculation of the composition of currency in circulation also includes cash balances held by banks. The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United States, the United Kingdom and the euro area. The term "First" corresponds to the highest denomination banknotes; "Second" and "Third" correspond to the second and third highest denomination banknotes, respectively.

(b) Currency in circulation per capita

Secondly, the demand for cash relative to population (currency per capita) has grown significantly in both groups of countries. In advanced countries, although the level of currency per capita is higher than in emerging countries, it is growing at a slower pace (see figure 2).

[8] The highest-denomination banknotes are grouped in the variable "first" and those with the second highest denomination in "second".

Figure 2
Currency in circulation per capita in emerging and advanced economies, 2000–2016
(United States dollars)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.
Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

(c) Currency in circulation as a percentage of GDP

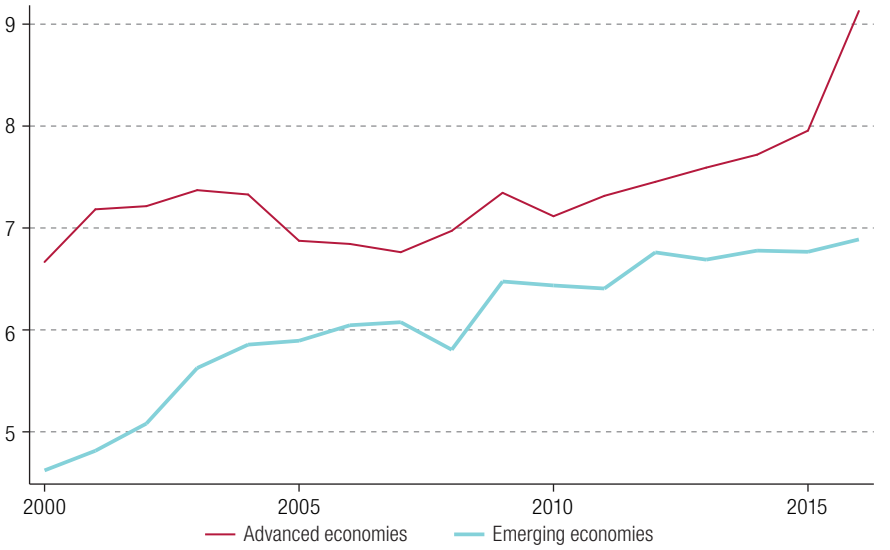
The value of banknotes and coins in circulation as a percentage of GDP increased in both emerging and advanced economies between 2000 and 2016, and most significantly in developed countries in the latter part of that period (see figure 3). The ratio of cash to GDP also increased in most countries in the last decade,[9] albeit with some exceptions. In Sweden, South Africa, India and China, the cash-to-GDP ratio fell sharply. In India and China, this reflected explicit policies that have reduced the circulation of high denomination banknotes, partly as a way of combating illegal trade.[10] Nonetheless, in both cases, the ratio remains at relatively high levels (around 8% and 10%, respectively).

Another salient point, which can be discerned in figure 4, is that the cash/GDP ratio displays high dispersion across countries. In Japan, for example, cash in circulation represents about 20% of GDP, while the most recent data from Sweden puts the equivalent indicator below 2%.

[9] One of the main limitations when comparing the demand for cash in economies such as the United States and Europe concerns the role of the United States dollar and the euro as foreign exchange. There is a demand for foreign exchange that goes beyond the volume of the United States or European economies, which is affected by factors such as tourism and international reserve investment.

[10] See the case of India in Dasgupta (2017).

Figure 3
Currency in circulation in emerging and advanced economies relative to GDP, 2000–2016
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

Figure 4
International comparison of currency in circulation as a proportion of GDP in 2005 and 2016
(Percentages)

Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies included are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), the United States (US), the United Kingdom (GB) and the euro area (EA).

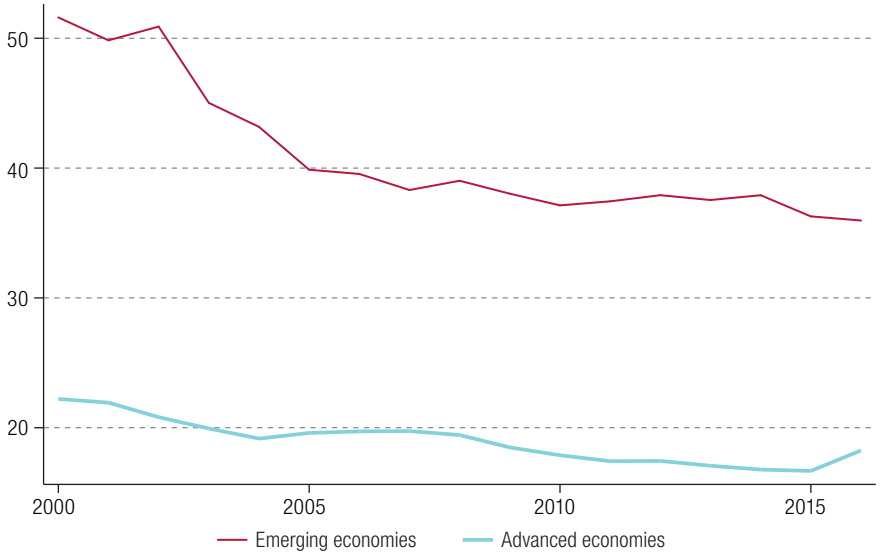
The growth of cash relative to GDP in most economies can be explained partly by its use as a store of value —particularly in the case of high denomination banknotes. In a context of low interest rates and fewer investment alternatives, as has prevailed globally in recent years, people choose to hold a higher proportion of their wealth in the form of banknotes (Jobst and Stix, 2017). Compounding this, mistrust of banks, the memory of past banking crises and the diminished capacity to collect taxes all increase the demand for precautionary cash holdings (Stix, 2013; Esselink and Hernandez, 2017).

The second reason is the role of the shadow economy. The anonymity of cash transactions encourages the use of banknotes and coins as a way to evade taxes and thus be able to engage in illicit activities (Goodhart and Ashworth, 2017). In particular, Goodhart and Ashworth (2014) emphasize this role in the case of the United Kingdom, where they estimate that the shadow economy has expanded by about 3% since the global financial crisis.

(d) Currency in circulation as a percentage of M1

Currency in circulation as a percentage of the M1 monetary aggregate in emerging and advanced economies shows a diametrically opposite picture to that presented by cash relative to GDP, since in the first case the ratio falls in both groups of countries between 2000 and 2016. This indicator displays a sustained decline over time, although less pronounced in the most recent period, when there was even a slight increase in the average of advanced economies in recent years (see figure 5).

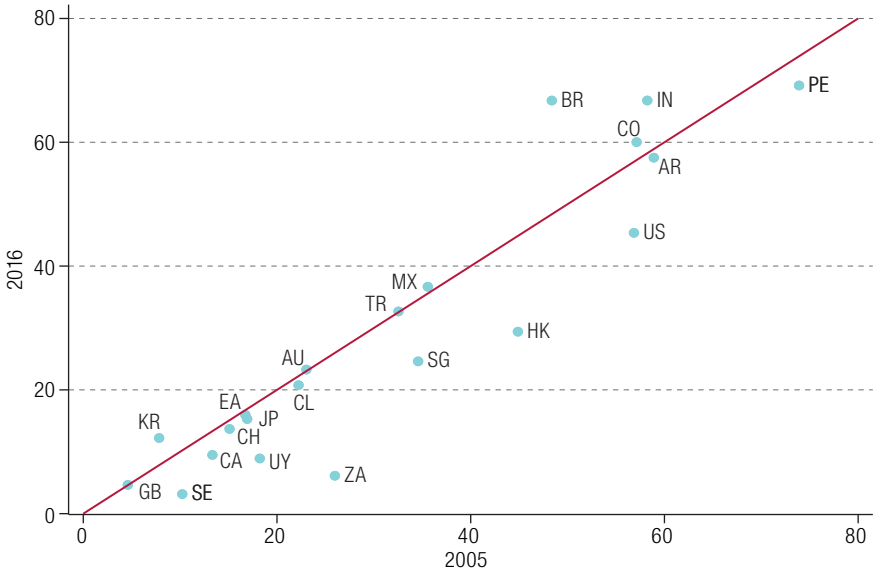
Figure 5
Currency in circulation in emerging and advanced economies as a proportion of M1, 2000–2016
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.
Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

The observed reduction is common to the vast majority of economies, although the level of currency in circulation as a proportion of M1 varies greatly from one country to another (see figure 6). Whereas in Sweden currency in circulation represented less than 4% of M1 in late 2016, in Peru the figure was 70%.

Figure 6
International comparison of currency in circulation as a proportion of M1, 2005 and 2016
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

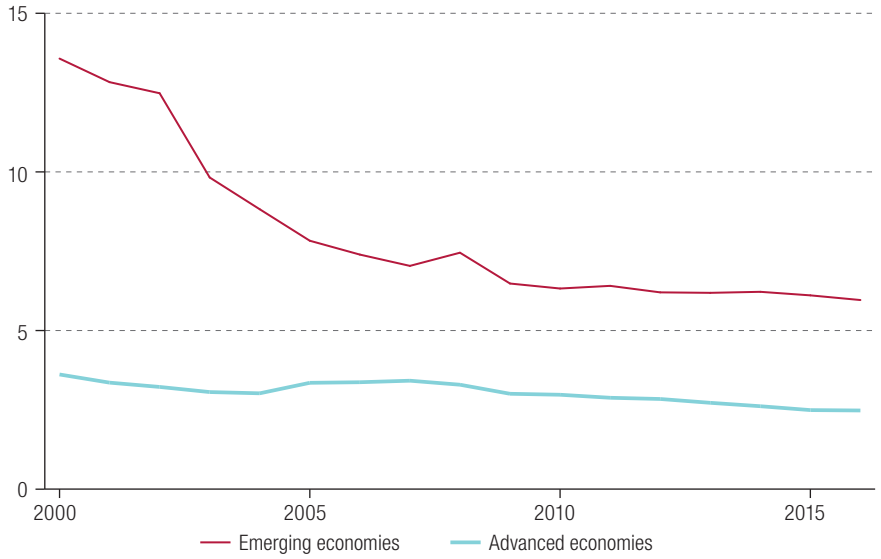
Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), the United Kingdom (GB), the United States (US) and the euro area (EA).

The reduction in circulating currency as a proportion of M1 is compatible with its increase relative to GDP, if the velocity of circulation (V), postulated by the classical quantity theory of money, is not constant.[11] While there is conclusive evidence that the relationship between the demand for money and the interest rate is stable in the long run (Benati and others, 2017), significant deviations can occur over shorter timespans. Empirically, it has been shown that the velocity of circulation is not constant over time. Figure 7 shows that the velocity of circulation of money has fallen in both emerging and advanced economies since 2000; and it is considerably lower in advanced economies than in emerging ones.

Figure 8 illustrates this differentiation at a disaggregated level. The advanced economies are grouped in the lower portion of the graph, while the emerging economies are distributed in the upper part.

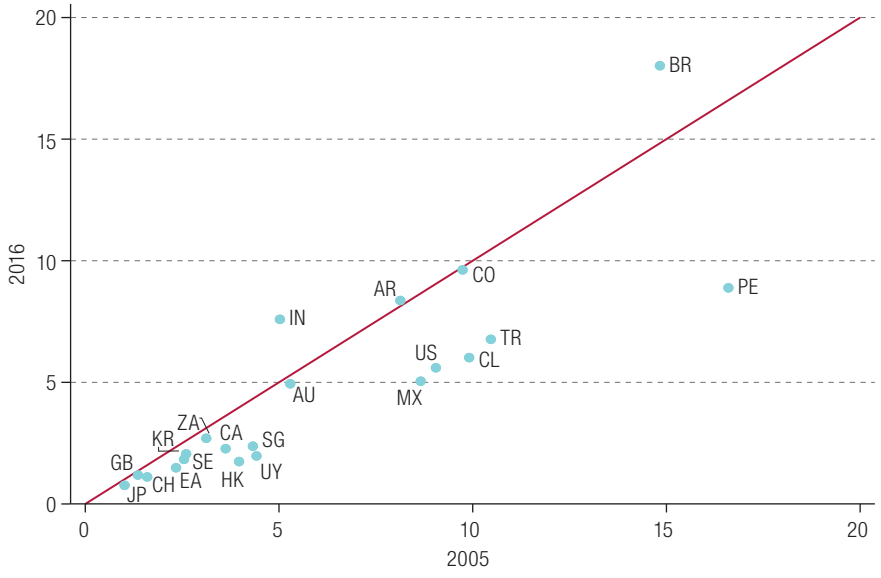
[11] From the quantity theory of money, the velocity of circulation can be reformulated as follows: V = (C/M1)/(C/GDP), where C is cash in circulation, V the velocity of circulation, and GDP is nominal gross domestic product.

Figure 7
Velocity of circulation of money in emerging and advanced economies, 2000–2016



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.
Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, the United States, Japan, Sweden, Switzerland, the United Kingdom, the United States and the eurozone.

Figure 8
International comparison of the velocity of circulation in 2005 and 2016



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.
Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies included are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), United Kingdom (GB), the United States (US) and the euro area (EA).

(e) Stylized facts gleaned from surveys

The following are some of the most relevant stylized facts gleaned from various surveys about the use of cash as a means of payment:[12]

(i) Frequency and use of cash for transactional motives

Although there is a trend towards greater use of electronic payment for transactions, the demand for cash remains strong. The available data show that the main motive for households to demand cash is for transactions, and that cash is also the most frequently used means of payment.

(ii) Share of cash in the amount and number of transactions

In Europe, 79% of the number of transactions and 54% of their value involve cash payments. However, the situation varies greatly between economies. While in Germany cash is used in over 80% of transactions, in the Netherlands and Finland the figure is less than 50%. Similarly, in Australia 46% of transactions are cash-based, while in Denmark cash accounts for 20% of total retail transactions.

(iii) Reasons why households use cash

The two main characteristics of cash that contribute to its use as the principal means of payment in transactions are its ability to provide liquidity and the fact that cash is a highly acceptable means of payment.

(iv) Effect of transaction size

Although there is no linear relationship, the use of electronic means of payment increases with transaction size. International data are unequivocal in this respect: small transactions are mostly carried out with cash. However, this trend is not absolute, since the development of technologies such as payment through cell phones, or the use of contactless cards, has shown that electronic payment can also compete with cash in smaller transactions.

(v) Effect of demographic factors on the use of electronic means of payment

Although there are differences in the cross-sectional comparison, the use of electronic means of payment has increased in all cohorts. It is not a phenomenon that is confined to the younger age brackets, or higher education or income groups.

(vi) The role of cash as a store of value

The demand for high-denomination banknotes has increased in advanced economies, probably associated with the increase in the demand for cash as a store of value, given the low interest rates prevailing in these economies in recent years.

(vii) Other factors

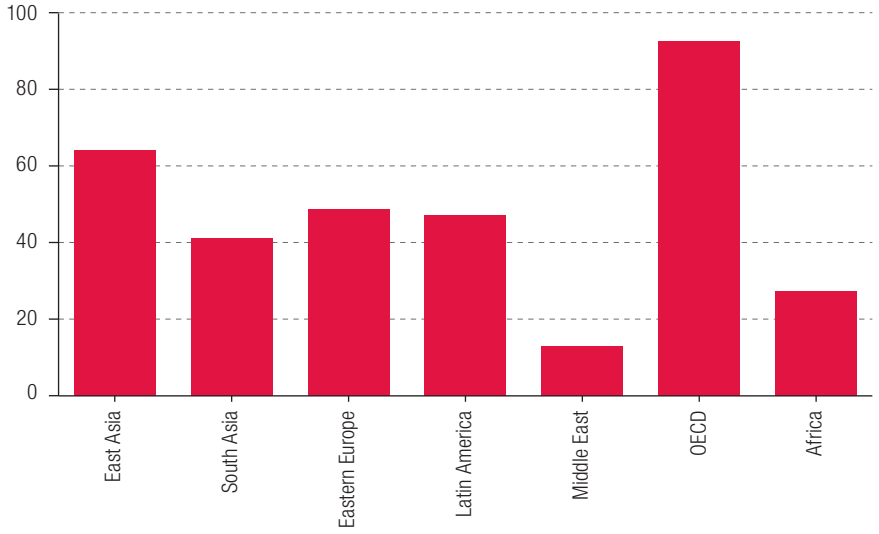
Other factors that contribute to a higher demand for cash are associated with the anonymity of the parties in cash transactions, particularly the growth of the informal economy and activities associated with organized crime.

The Global Findex survey, which the World Bank applied to a broad set of economies and was published in 2011, 2014 and 2017, makes it possible to compare the use of electronic means of payment in a variety of countries (see figures 9, 10 and 11). First, the data show that the economies that are members of the Organisation for Economic Co-operation and Development (OECD) have substantially higher levels of use and access to electronic means of payment than other economies. This can be seen both in the percentage of the population that has an account in a financial institution and in the percentage that has used a debit card in the past year (see figures 9A and 9B, respectively).

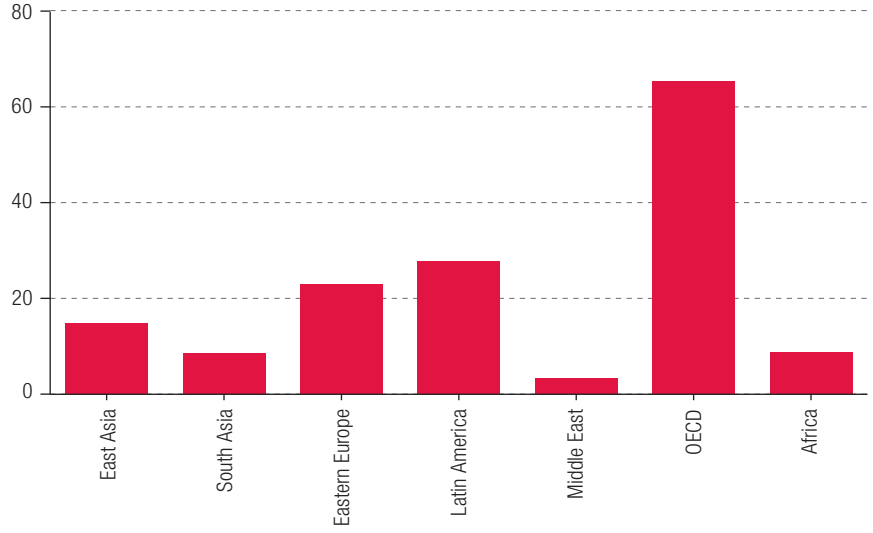
[12] For further information, see Esselink and Hernández (2017).

Figure 9
Availability and use of electronic means of payment, average of 2011, 2014 and 2017[a]

A. Population over 15 years of age with an account in a financial institution
(Percentages)



B. Population over 15 years old that used a debit card in the past year
(Percentages)

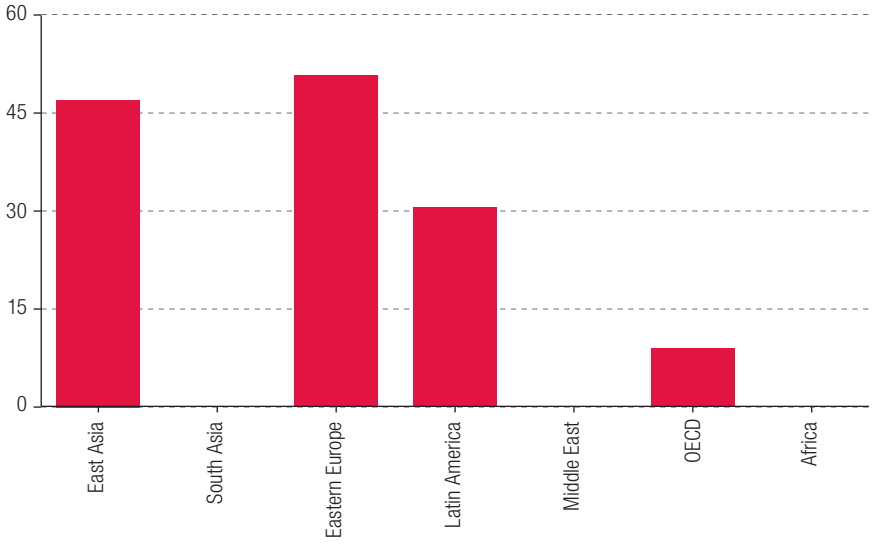


Source: World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.
Note: Country classifications correspond to those reported by the World Bank.
[a] Averages include the years indicated depending on the availability of information in each case.

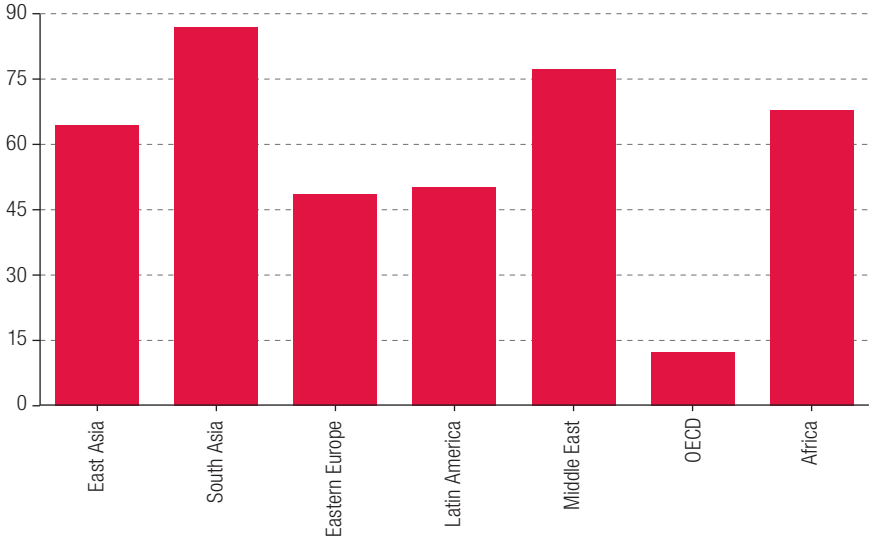
In the emerging economies, in contrast, the proportion of the population receiving government transfers wages in cash form is substantially higher than in OECD countries (see Figures 10A and 10B, respectively). In the latter case, while around 10% of wage-earners in OECD economies receive their pay in the form of banknotes and coins, the figure averages 90% in the South Asian economies.

Figure 10
Use of cash to receive income, average 2014 and 2017

A. Population over 15 years of age receiving government transfers in cash
(Percentages)



B. Population over 15 years of age receiving wages in cash
(Percentages)

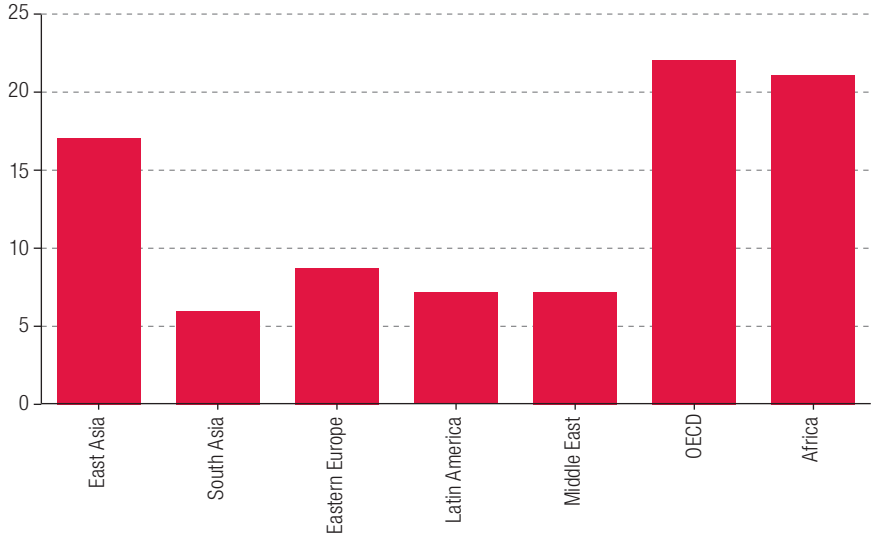


Source: World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.
Note: Country classifications are those reported by the World Bank. No information is available for South Asia, Middle East and Africa for panel A.

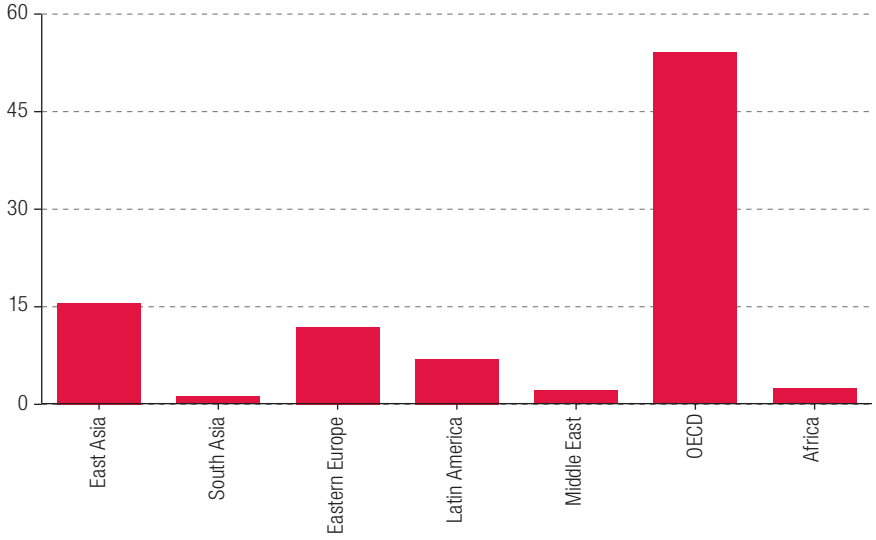
Payment via cell phone is widespread in the economies of Africa and East Asia, with rates that are close to those of the more advanced economies. In contrast, the use of the Internet to pay bills and make purchases still lags far behind in the emerging economies (see figures 11A and 11B, respectively).

Figure 11
Role of technological advances in payment methods, 2014 and 2017 average

A. Population over 15 years of age that made transactions from an account in a financial institution using a cell phone
(Percentages)



B. Population over 15 years old that used the Internet to pay bills and make purchases
(Percentages)



Source: World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.
Note: Country classifications correspond to those reported by the World Bank.

III. Demand for cash and substitution by electronic means of payment

This section analyses the degree of substitution that could exist between circulating currency and the use of electronic means of payment, based on a series of panel and cross-sectional estimations of cash in circulation as a percentage of M1.

1. Panel estimations

This subsection reports a series of panel estimations, with country and time fixed effects, for the level of circulating currency as a percentage of M1 in 2000–2015. The following equation is estimated:

$$ln\left(\frac{C}{M1}\right)_{it} = \alpha_i + \beta Z_{it} + \gamma_t + \varepsilon_{it} \quad (1)$$

where $(C/M1)_{it}$ represents banknotes and coins in circulation as a percentage of M1 of country i in year t; α_i corresponds to the country-i fixed effect; and Z_{it} corresponds to the set of determinants of cash in circulation, including the following: (i) financial depth, (ii) income per capita, (iii) the number of ATMs, (iv) the number of credit cards per capita, and (v) the number of debit cards per capita. Lastly, γ_t and ε_{it} represent the time fixed effect and the error term, respectively.[13]

These estimations were based on data from 21 economies. The panel is unbalanced and contains a total of 229 observations. Table 2 reports the main descriptive statistics of the variables used in the panel regressions. The lower level of cash as a percentage of M1 and the greater financial depth in advanced economies are clearly visible.

Table 2
Descriptive statistics of the variables used in panel estimation, 2000–2015

	Cash *(% M1)*	Cash *(% GDP)*	Number of ATMs	Number of credit cards per capita	Number of debit cards per capita	Financial depth	GDP per capita *(US$)*
Total sample							
No. of observations	229	229	229	229	229	229	229
Mean	28.9	6.4	713.4	1.0	1.1	123.9	28 697
Median	21.8	4.9	484.3	0.7	0.9	117.1	27 770
Standard deviation	19.8	3.8	551.3	1.0	0.8	72.7	20 694
Emerging economies							
No. of observations	123	123	123	123	123	123	123
Mean	38.7	5.8	517.4	0.7	0.9	73.4	13 539
Median	36.9	5.1	332.8	0.6	0.7	71.0	10 243
Standard deviation	18.9	2.7	564.6	0.6	0.7	35.4	12 241
Advanced economies							
No. of observations	106	106	106	106	106	106	106
Mean	17.5	7.2	940.9	1.4	1.3	182.6	46 286
Median	15.5	4.6	1.015.6	1.0	1.1	166.9	42 593
Standard deviation	13.7	4.7	438.5	1.1	0.8	59.7	13 202

Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Before the estimation results are presented, it is necessary to consider whether the dependent variable (currency in circulation as percentage of M1) has a unit root.[14] Since the panel is unbalanced, the Im, Pesaran and Shin (2003) and Fisher tests are applied, as proposed by Choi (2001).[15] The results of these unit root tests are reported in the tables in annex A1. In particular, column (1) of table A1.1

[13] To measure the robustness of the estimations, alternatives were considered that included inflation and the monetary policy interest rate as determinants of cash in circulation. The results of these estimates are consistent with those presented in table 3 and can be obtained from the authors by email.

[14] The intuition of the test relates to the extent to which lagging the variable of interest provides information for understanding its dynamics. If the lag is important for understanding the dynamics, the series is said to be mean-reverting and, consequently, stationary. In this case, the null hypothesis that the series has a unit root is rejected. Otherwise, when the lag does not provide information and, consequently, the coefficient that accompanies the lag in the autoregressive process is not different from zero, the series is said to be non-stationary. Consequently, the null hypothesis of a unit root cannot be rejected.

[15] The alternative unit root tests proposed by Levin-Lin-Chu (2002) and Hadri (2000), among others, are only applicable to balanced panels.

shows that the null hypothesis that all panels contain unit roots is rejected at 1% when the average fixed effect per panel (*demean*) and the time trend (*trend*) are included, and it is assumed that the errors are not serially correlated. Column (2) of table A1.1 shows similar results when the assumptions on the inclusion of *demean* and *trend* are maintained, but this time considering the possibility of lags in the order of the autoregressive process in the augmented Dickey-Fuller (ADF) specification of the errors.[16] The estimations shown in table A1.2 of annex A1 report a set of statistics associated with the Fisher-type panel unit root test. The statistics presented differ in terms of the distribution used to calculate the confidence values, while the specifications in columns (1) to (4) differ in terms of the inclusion or otherwise of *demean* and *trend* and whether or not the variable displays drift.[17] [18] The results are consistent in most of the statistics, in the sense that the null hypothesis that all panels have unit roots is rejected at a high level of confidence.

Consequently, the results of the estimation of equation (1) are presented in table 3. Seven different specifications are shown, which differ in terms of the inclusion or otherwise of the time fixed effect, and the inclusion or otherwise of variables that are not statistically significant. The standard errors are clustered by country.

Table 3
Determinants of the demand for currency in circulation as a percentage of M1

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
Financial depth (ln)		-0.2620*		-0.3006***	-0.1625*	-0.2966***	-0.1963**
GDP per capita (ln)		-0.1353*		-0.0542	0.1889		
ATMs (ln)			0.0517	0.1446*	0.1348	0.1182**	0.2031*
Credit cards			-0.4011***	-0.3608***	-0.3276***	-0.3839***	-0.2587***
Debit cards			-0.0452	0.0254	0.1956		
year = 2001							-0.0552
year = 2002							-0.0518
year = 2003							-0.0884
year = 2004							-0.1368**
year = 2005							-0.2215***
year = 2006							-0.2174***
year = 2007							-0.2042***
year = 2008							-0.1870***
year = 2009							-0.2205***
year = 2010							-0.2475***
year = 2011							-0.2525***
year = 2012							-0.2419***
year = 2013							-0.2647***
year = 2014							-0.2744***
year = 2015							-0.2904***
R^2	0.959	0.967	0.971	0.974	0.980	0.974	0.978
Adjusted R^2	0.956	0.964	0.969	0.971	0.976	0.972	0.974
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	No	No	No	No	Yes	No	Yes
Standard errors	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster

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

[16] The optimal number of lags for each panel is obtained from the Akaike information criterion (AIC).

[17] Maddala and Wu (1999) find that Fisher tests with critical values based on the bootstrap method perform better. Consequently, they are the preferred choice when testing for unit roots in panel estimations.

[18] The presence of drift seems a reasonable assumption, since the variable to be tested (cash in circulation as a percentage of M1) has a non-zero mean.

The results presented in table 3 give rise to the following conclusions:

- *Role of financial depth.* Greater financial depth (measured by bank credit as a percentage of GDP) is associated with smaller demand for cash relative to M1, in a stable and consistent manner across all estimations.
- *Role of per capita income.* The relation between this variable and the demand for cash is negative, but not significant. This partly reflects the dominance of variables that capture the level of financial development more effectively. Also, certain more developed economies have a higher demand for banknotes and coins, either because their currency is used as foreign exchange or because the precautionary demand for cash is relatively higher in these countries.
- *Role of the number of ATMs.* In the estimations made in this study, this variable is always positive, but its statistical significance is not stable. This is reasonable because, although a larger number of ATMs is associated with the possibility of obtaining cash, its effect also depends on geographical factors that determine the distance people have to travel to reach an ATM to withdraw cash. It is also noted that in an initial stage of the expansion of banking services the number of ATMs increases, but in more advanced stages of financial development the number declines.
- *Role of credit cards.* The number of credit cards per capita is negatively associated with the demand for cash. The estimated coefficient is stable and statistically significant at 1% in all specifications.
- *Role of debit cards.* The number of debit cards shows no statistically significant relation with the demand for cash as a percentage of M1. This is partly because debit cards can be considered as either a substitute or a complement for cash as a means of payment. The latter is exemplified when people receive their income electronically, but owing to their payment habits they withdraw a large proportion of their income to make their payments in cash.
- *Role of fixed effects*. Column (1) of table 3 shows that much of the inter-country variation observed in demand for cash as a percentage of M1 is due to idiosyncratic factors that are not captured in the estimation. This can be attributed to both cultural factors and specific policies that affect the demand for cash as a means of payment.[19] There are also many relevant structural variables that cannot be measured over time. This point is discussed further below in the context of cross-sectional estimations.[20] Column (7) of table 3 reports the details of the coefficients and the statistical significance of the time fixed effects on the demand for cash as a percentage of M1. The sign and statistical significance of the variables highlighted in columns (1) to (6) of table 3 (financial depth, credit cards and ATMs) are robust to the inclusion of time fixed effects in the estimation. The time fixed effects are negative and particularly significant from 2004 onwards — a period in which the size of the coefficient, and consequently the significance of the unobservable time factor, have been increasing over time.

The exercises included in table 3 show a high degree of model fit (adjusted R^2>0.95), which is largely explained by the relevance of the idiosyncratic effects of each country. This is an expression of the high degree of heterogeneity existing in the demand for cash across countries, which is also

[19] In Sweden, for example, businesses are not required to receive cash, even though banknotes and coins issued by the central bank are the only legal tender, as in most countries. Some countries also impose restrictions on the use of cash in certain government activities, which can have a significant impact on the demand for cash in these economies.

[20] See, for example, the discussion on the effect of payment through cell phones or the Internet and on the role of cash in wage payments and government transfers, in the comments on the cross-sectional estimations below (in subsection 3 of this section III).

observed within both emerging and advanced economies. It is important to note that, in addition to the variables included in the model, the prediction error reflects the relevance of country-specific factors over time.[21] In other words, the dynamics of the demand for cash in the countries considered reflect other factors in addition to the dynamics of financial depth, the number of credit cards, the number of ATMs and the fixed effect estimated in table 3.

Lastly, an exercise is performed to evaluate what the economic impact would be if all of the countries considered in the estimation reported in table 3 (column 7) had the characteristics of 2014 Sweden, the country with the lowest demand for cash in the sample. The results indicate that, in this hypothetical scenario, currency in circulation as a percentage of M1 would fall from an average of 30% to 23%. One implication of this result is that consumers have a preference for using cash.[22] This finding corroborates information obtained from causal inference models used to analyse innovations in means of payment, and from payment-decision models that use information obtained through surveys on the use of different means of payment. Fung, Huynh and Sabetti (2014) show that the use of contactless credit cards and prepaid cards reduces cash use. Moreover, Wakamori and Welte (2017) find that if all commercial outlets had to accept card payments, the use of cash would drop by about 8%. Huynh, Schmidt-Dengler and Stix (2014), using an inventory model, also find that the demand for cash would fall if cards were more widely accepted at points of sale.

2. Cross-sectional estimation

The following section uses data from the World Bank's Global Findex 2014,[23] covering a set of 54 emerging and advanced economies to assess the determinants of the demand for cash as a percentage of M1 in a cross-sectional estimation.[24]

The control variables used are grouped into three categories:

(i) Use of and access to electronic means of payment —specifically the percentage of the population over 15 years of age that: (i) has an account in a financial institution; (ii) used a credit card in the past year; and (iii) used a debit card in the past year.

(ii) Variables that determine how wages and government transfers are received. This includes the percentage of the population over 15 years of age that: (i) receives transfers from the government in cash; and (ii) receive their wage payment in cash.

(iii) Variables that capture the intensity of the use of technology-based means of payment (cell phones and Internet). This measures the percentage of the population over 15 years of age that: (i) carries out transactions paid through cell phones; and (ii) uses the Internet to pay bills and make purchases.

[21] Figure A1.1 in annex A1 reports the observed level of cash as a percentage of M1 (right scale), the prediction of the panel estimation in table 3 (column (7)) (right scale) and the prediction error (left scale) for all economies considered in the estimation (column 7).

[22] Wakamori and Welte (2017) state that this preference for cash applies mainly to small-value transactions. On the other hand, Huynh, Schmidt-Dengler and Stix (2014) report that precautionary motives or occasional large purchases also boost the demand for cash.

[23] This information is compiled in partnership with Gallup World Poll (GWP). The indicators are based on interviews held with a nationally representative sample of over 150,000 adults in more than 140 economies.

[24] The economies considered are: Afghanistan, Algeria, Argentina, Australia, Belize, Brazil, Bulgaria, Canada, Czech Republic, Chile, China, Colombia, Costa Rica, Denmark, the Dominican Republic, Egypt, Guatemala, Honduras, Hong Kong (China), Hungary, India, Indonesia, Iraq, Israel, Japan, Kazakhstan, Kenya, Latvia, Malaysia, Mexico, Morocco, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Paraguay, Peru, the Plurinational State of Bolivia, Poland, the Republic of Korea, the Republic of Moldova, the Russian Federation, Saudi Arabia, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, the United Kingdom, the United States and Uruguay.

Table 4 reports the descriptive statistics of these variables for a maximum of 54 economies for which the analysis described below was performed.

Table 4
Descriptive statistics of the variables used in the cross-sectional estimations

	Number	Average	Standard deviation	Minimum	Maximum
Cash in circulation *(% of M1)*	54	36	24	4	93
Account in financial institutions *(% of the population over 15 years of age)*	54	60	29	10	100
Use of credit card in the past year *(% of the population over 15 years of age)*	52	22	21	0	75
Debit card use in the past year *(% of the population over 15 ears of age)*	52	35	30	1	96
Transactions from cell phones *(% of the population over 15 years of age)*	49	15	11	0	40
Use of the Internet to pay bills and make purchases *(% of the population over 15 years of age)*	52	24	25	1	79
Government transfers received in cash *(% of the population over 15 years of age)*	37	28	26	0	93
Wages received in cash *(% of the population over 15 years of age)*	51	43	27	3	92

Source: Prepared by the authors.

Tables 5, 6 and 7 report a series of cross-sectional estimations to measure the relationship between the variables considered and the demand for cash as a percentage of M1.

Table 5 presents the analysis of the role of the variables measuring access to and use of electronic means of payment. The results can be summarized as follows:

- Role of access to the financial system: economies in which a higher percentage of the population has access to an account in the financial system have, on average, less demand for cash as a percentage of M1.
- Role of credit and debit cards: economies in which a higher percentage of the population uses these cards have on average less demand for cash as a percentage of M1.
- There is a high degree of collinearity between the variables of use and access to electronic means of payment, which is reflected in the loss of statistical significance when more than one of these variables is considered in the regression.

Table 5
Determinants of demand for cash: role of access to electronic means of payment

Variables	(1)	(2)	(3)	(4)	(5)
Account in financial institutions *(logarithms)*	-0.5940***			-0.1878	
Credit card used in the past year *(logarithms)*		-0.2242***		0.1579	0.1422
Debit card used in the past year *(logarithms)*			-0.3660***	-0.4400*	-0.5205***
No. of observations	52	52	52	52	52
R^2	0.225	0.149	0.258	0.276	0.272
Adjusted R^2	0.21	0.132	0.243	0.231	0.242

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

Table 6 analyses the effect of receiving wages and government transfers in cash. Economies in which a larger proportion of the population receive such payments in cash display a higher demand for cash.

Table 6
Determinants of demand for cash: role of the form in which income is received

Variables	(1)	(2)	(3)
Government transfers received in cash *(in logarithms)*	0.3225***		0.068
Wages received in cash *(in logarithms)*		0.5259***	0.4447**
No. of observations	37	37	37
R^2	0.284	0.361	0.365
Adjusted R^2	0.263	0.343	0.328

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

Lastly, table 7 analyses the role of technological advances in the demand for cash. Countries where a higher percentage of the population makes payments through cell phones or the Internet tend to have a smaller demand for cash. However, in contrast to the previous variables, the collinearity between these variables is less, since they continue to be statistically significant when considered together in the regression. This is explained by the fact that in certain less economically developed economies (for example, those located in Africa), cell phones have become widely used as a means of payment. However, both greater use of cell phones and greater use of the Internet are associated with a lower demand for cash.[25]

Table 7
Determinants of demand for cash: the role of technological advances

Variables	(1)	(2)	(3)	(4)
Transactions from financial institutions via cell phone *(logarithms)*	-0.5696***		-0.3516**	-0.3931**
Use of Internet for bill payment and purchases *(logarithms)*		-0.3855***	-0.2588***	
Account in financial institutions *(logarithms)*				-0.4523*
No. of observations	49	49	49	49
R^2	0.306	0.328	0.409	0.357
Adjusted R^2	0.291	0.313	0.383	0.329

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

3. Analysis of idiosyncratic factors

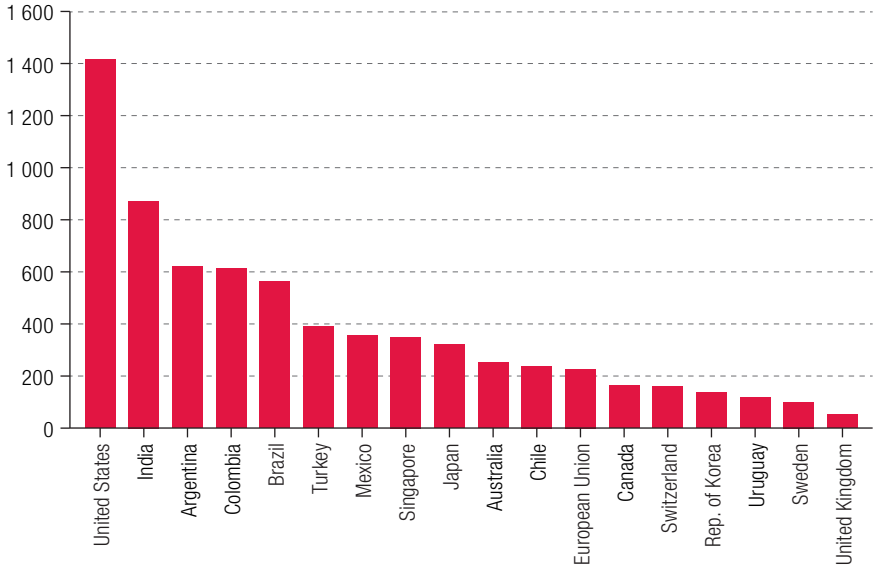
As noted above, the model in equation (1) generates a series of country-level fixed effects, which express an important idiosyncratic component that is not captured by financial depth, ATM availability or credit card ownership (see column (7) of table 3). In fact, the model incorporating only country-level fixed effects generates a goodness-of-fit of 95.9% (see column (1) of table 3), as opposed to time fixed effects, whose marginal contribution to the adjusted R^2 is less.

An important factor to take into consideration is the high degree of heterogeneity among the idiosyncratic factors of each country. Firstly, this heterogeneity is determined by the variance in the cash-to-GDP ratio discussed above. In this sense, the fixed effect is related directly to the value of this ratio (see figure 12). Secondly, heterogeneity is dominated by factors beyond the "fundamental" variables that were evaluated in the panel data model. Thus, the ranking of countries according to the ratio of each country's fixed effect to the observed value of cash relative to M1 is completely different from that observed when comparing only the fixed effects of each country. The ratio is much higher in countries that have institutional or cultural components that are very different from those of the average

[25] China's experience with the use of smartphones also shows how alternatives that facilitate money transfer can led to a reduction in the use of physical money. This phenomenon has been characterized by the massive use of smartphones as a transactions medium, which, combined with applications such as WeChat and Alipay (the equivalents of Whatsapp and Amazon in the Western hemisphere) and QR code (Quick Response) technology enables electronic transfers to be made instantaneously. Survey-based estimates indicate that WeChat and Alipay accounted for about 55% of the value of transactions in 2017 (Korella, 2017).

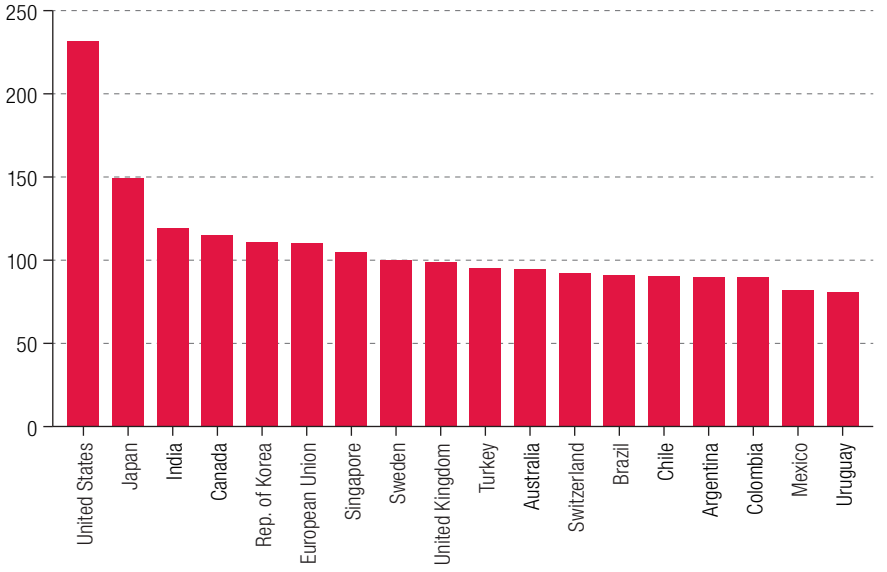
country, for example, Sweden, Japan or the United States, among others (see figure 13). In view of this, the possibility that the idiosyncratic variables reported by the World Bank survey could explain this heterogeneity was analysed.

Figure 12
Country fixed effects relative to Sweden, 2000–2015
(Percentages)



Source: Prepared by the authors on the basis of estimates of panel data of banknotes and coins in circulation.
Note: Statistically significant values at the 10% confidence level. The estimates are given as a percentage of the monetary aggregate M1, having as determinants the fixed effect of the country and time, the level of financial depth, the number of ATMs and the number of credit cards per capita.

Figure 13
Fixed effects of each country with respect to its ratio between currency in circulation and M1, 2000–2015
(Percentages)



Source: Prepared by the authors on the basis of estimates of panel data of banknotes and coins in circulation.
Note: Statistically significant values at the 10% confidence level. The estimates are given as a percentage of the monetary aggregate M1, having as determinants the fixed effect of the country and time, the level of financial depth, the number of ATMs and the number of credit cards per capita.

The previous sections used two models, one with panel data and the other with cross-sectional data. The advantage of the first model is the existence of a time trend in the structural variables that explain the demand for cash as a percentage of M1. The second case, in contrast, draws on a recent survey of payment behaviour in a large number of countries, but without a time span that would enable it to be complemented with the first approach.

The results presented in table 8 are quite striking. They show that each of the variables affects the idiosyncratic component in the same way as observed in the cross-sectional estimates. This can be understood as contributing to the explanatory power of cash as a percentage of M1. Thus, part of this fixed effect can be associated with the use of credit and debit cards, the receipt of wages in cash and the use of the Internet to pay bills, which are the variables of highest statistical significance. This finding poses a major challenge for further progress in understanding trends in cash usage, in which the generation of more precise information on economic agents' payment behaviour will be particularly important.

Table 8
Determinants of the idiosyncratic factor

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Account in financial institutions *(in logarithms)*	-0.6974						
	(0.4030)						
Credit card used in the past year *(percentages of the population over 15 years of age)*		-0.5481***					
		(0.1783)					
Debit card used in the past year *(% of the population over 15 years of age)*			-0.5968**				
			(0.2115)				
Transactions from cell phones *(% of the population over 15 years of age)*				0.1104			
				(0.1376)			
Use of the Internet to pay bills and make purchases *(% of the population over 15 years of age)*					0.3972**		
					(0.1350)		
Government transfers received in cash *(% of the population over 15 years of age)*						-0.5657**	
						(0.2171)	
Wages received in cash *(% of the population over 15 years of age)*							-0.4220***
							(0.1064)
No. of observations	14	14	14	11	14	14	14
R^2	0.200	0.441	0.399	0.067	0.419	0.361	0.567
Adjusted R^2	0.133	0.394	0.349	-0.0369	0.371	0.308	0.531

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

IV. Conclusions

During the last decade, the demand for cash has decreased considerably as a percentage of M1, while increasing relative to GDP. This article analyses factors that could explain the behaviour of currency in circulation as a percentage of M1. The results show that the growing use of electronic means of payment reduces the demand for cash. Nonetheless, there are hard-to-measure idiosyncratic factors, aside from the observable variables, which explain the differences across economies. One implication of the estimations is that the demand for cash is very far from approaching zero, largely because there are consumer preference factors that prevent it from doing so in the medium term.

In the case of the emerging economies, it is possible to identify several disparities in the use of electronic means of payment, and reducing them will contribute to a further decline in the demand for cash as a percentage of M1. In practice, there are several factors that could hasten this transition, such

as the increasing use of banking services that has occurred in some of these countries, as well as the increased use of smartphones to make payments. All of these factors could contribute to greater use of electronic means of payment in emerging economies and, consequently, to less use of cash. However, there are idiosyncratic and cultural factors that condition consumers' preferences for cash; and these are also present in more advanced economies. This is consistent with the fact that the use of banknotes and coins as a means of payment persists in advanced economies and is likely to continue to do so.

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Anexo A1

Table A1.1
Im, Pesaran and Shin unit root test on currency in circulation as a percentage of M1
(Logarithms)

	(1)		(2)	
	Statistic	p-value	Statistic	p-value
t-bar	-2.6721			
t-tilde-bar	-2.0093			
Z-t-tilde-bar	-4.0539	0.0000		
W-t-bar			-2.4685	0.0068
Panel average	Yes		Yes	
Time trend	Yes		Yes	
Lagged regressions in augmented Dickey-Fuller specification	No		Average 0.62 according to the Akaike Information Criterion (AIC)	

Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.
Note: The null hypothesis is that all panels contain unit roots, while the alternative hypothesis is that some panels are stationary. The total number of panels is 21, while the average number of periods is 15.19. In the Im, Pesaran and Shin test it is assumed that the autoregressive coefficient parameter is specific to each panel.

Table A1.2
Fisher's unit root test on currency in circulation as a percentage of M1
(Logarithms)

		(1)		(2)		(3)		(4)	
		Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Inverse Chi-Squared (42)	P	83.1011	0.0002	70.5694	0.0038	93.1937	0.0000	127.7282	0.0000
Inverse normal	Z	-1.2141	0.1124	-1.7425	0.0407	-2.8197	0.0024	-6.444	0.0000
Inverse logit t(104)	L*	-2.7154	0.0039	-2.4814	0.0073	-3.7323	0.0002	-6.6919	0.0000
Modified inverse Chi-squared	Pm	4.4845	0.0000	3.1172	0.0009	5.5857	0.0000	9.3537	0.0000
Panel mean		No		Yes		Yes		Yes	
Time trend		No		No		Yes		No	
Drift		No		No		No		Yes	
Lagged regressions in the augmented Dickey-Fuller specification		No		No		No		No	

Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.
Note: Estimates based on the augmented Dickey-Fuller test. The null hypothesis is that all panels contain unit roots, while the alternative hypothesis is that at least one panel is stationary. The total number of panels is 21, while the average number of periods is 15.19.

Figure A1.1
Estimated and observed currency in circulation as a proportion of M1, 2000–2015
(Percentages)

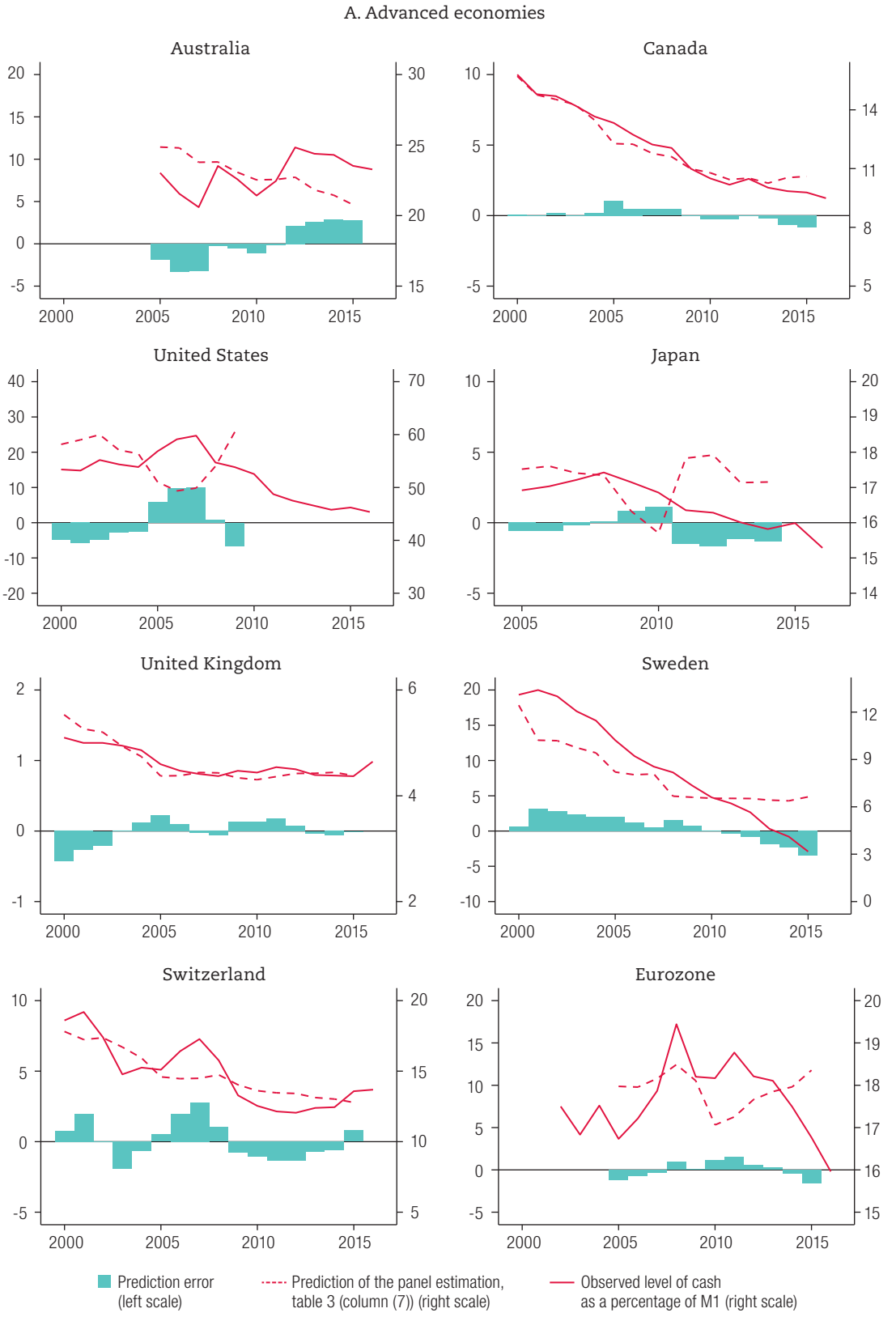
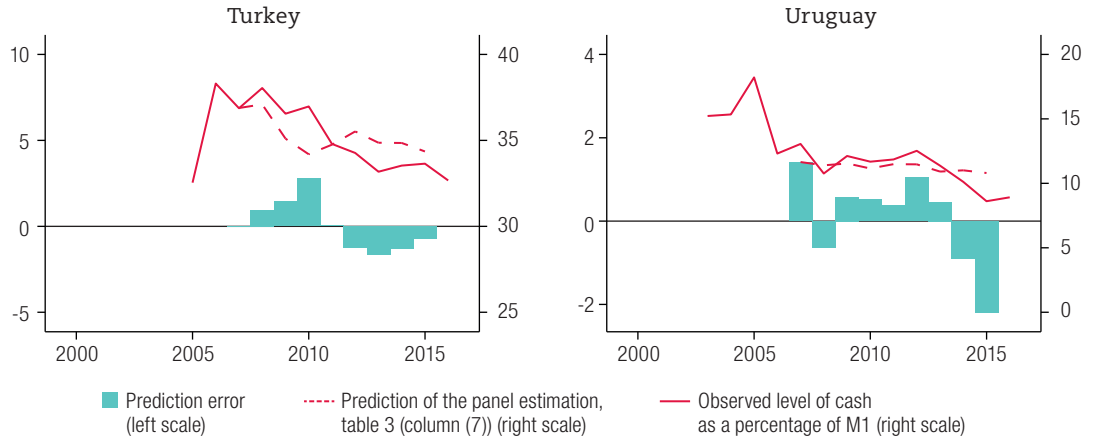


Figure A1.1 (continued)

Figure A1.1 (concluded)



Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.

Latin America and China: mutual benefit or dependency?[1]

Damares Lopes Afonso, Suzana Quinet de Andrade Bastos and Fernando Salgueiro Perobelli

Abstract

This article seeks to contribute to the debate on China-Latin America relations. It considers whether the trade relations that exist between China and the region are mutually beneficial or, instead, reinforce Latin America's dependency on the international scenario. The effects of Chinese growth on a group of Latin American countries are analysed using the computable general equilibrium model of the Global Trade Analysis Project (GTAP). Chinese growth was simulated through an expansion of the Chinese capital stock, thus mirroring the trend observed in recent decades. The results suggest a return to the commodity export model and a reduction in industrial activity in the Latin American countries analysed, particularly in the high-tech sectors. Nonetheless, well-being in Latin America also increased, mainly owing to improvements in the terms of trade (resulting from the commodity price boom).

Keywords

International economic relations, international trade, economic development, exports, imports, commodities, trade policy, economic dependence, industrialization, economic development, China, Latin America

JEL classification

F10, D58, F63

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I. Introduction

China is one of Latin America's main trading partners. Trade relations between China and the region are "strategic" because Latin America has abundant natural resources, such as soybeans, iron ore and oil, which are essential for Chinese industries. Moreover, Latin America represents a consumer market for Chinese products, which mostly consist of manufactured goods.

In addition to trade flows, China is intensifying its diplomatic and political relations with the governments of Latin American countries. Chinese representatives describe the mutual benefits of Latin America-China relations as a "win-win" situation.

In 2008, China published its first policy paper on Latin America and the Caribbean (also called the White Paper on Latin America and the Caribbean); and, in 2016, it published the second. Both documents identify areas in which there is potential for greater cooperation between China and the region, including greater political proximity, intensification of bilateral trade, investments in production infrastructure, financial assistance, support and exchanges in the social and cultural areas, cooperation in the international arena, and in peace and security agreements (MFA, 2016).

Chinese investments in Latin America are based on its participation in public utility concessions (energy, telecommunications and transport), and also on direct investments ranging from venture financing to consolidate road and rail networks and the extraction of mineral resources (Silveira, 2017).

However, this begs the question of whether the trade relations between China and the region are of mutual benefit, or whether, instead, they are reinforcing Latin America's dependency on the international scenario —as a region that has been characterized since colonial times as a commodity exporter and technologically reliant on the external market (Blázquez-Lidoy, Rodríguez and Santiso, 2006; Jenkins, Peters and Moreira, 2008; Ferchen, 2011; Cintra, 2013; Kim and Lee, 2014; Silveira, 2017).

Accordingly, this article seeks to evaluate the structure of interdependence prevailing in trade relations between China and a group of Latin American countries —Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Peru, the Plurinational State of Bolivia and Uruguay. This is done using the computable general equilibrium (CGE) model of the Global Trade Analysis Project (GTAP).

The empirical strategy entails simulating the effect of the growth of the Chinese economy as a result of a 10% expansion of its capital stock, which is equivalent to the average annual growth of its capital stock in recent decades, according to Penn World Table version 9.0 data (Feenstra, Inklaar and Timmer, 2015). The aim is to assess the impact of Chinese economic growth on sectoral production, exports and imports, and the variation in well-being in the selected Latin American countries, and also in China itself.

The hypothesis analysed is that, while China's economic growth has boosted trade relations with Latin America, mainly through its demand for commodities and improved terms of trade (commodity price boom), it has also contributed to the decline in Latin American industrial activity and an increase in its imports of manufactured goods "made in China". Thus, trade relations between China and the region could be aggravating Latin America's historical dependency on the international scenario, in contrast to Chinese discourse proclaiming the mutual benefits of these relations.

The section that follows this introduction offers some reflections on relations between Latin America and China. The third section describes the database, methodology and empirical strategy employed; and the fourth section presents the results of the model. The fifth and last section offers final thoughts.

II. Trade relations between Latin America and China

This section starts by analysing the data on trade between Latin America and China, before contextualizing the antagonistic nature of this relationship.

1. Latin America-China trade relations in figures

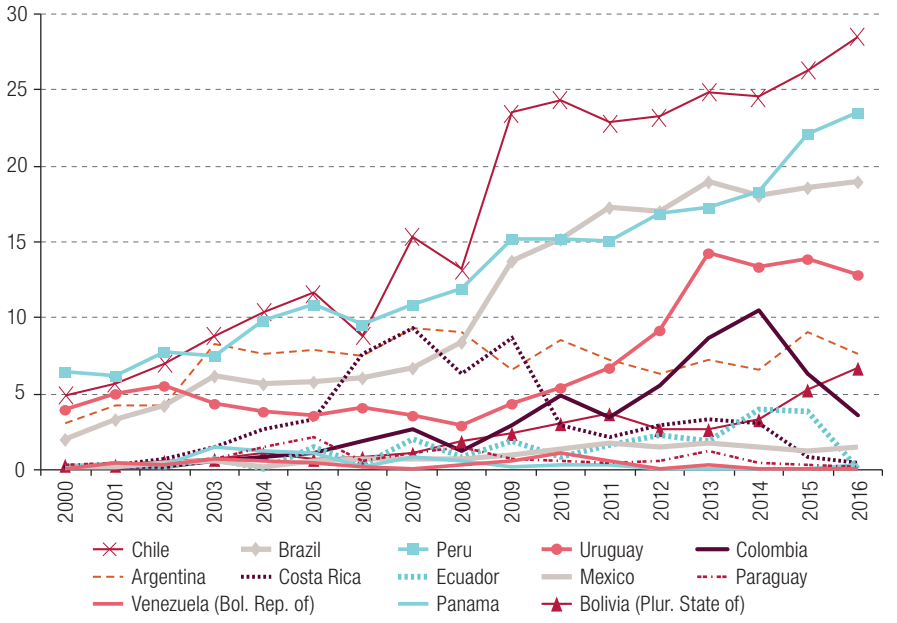
China's economic and social structure has undergone considerable changes, especially since the 1990s. Its industrial development is the result of planning. The famous comment made by China's leader, Deng Xiaoping, in 1978, that "it doesn't matter whether the cat is black or white, as long as it catches mice", illustrates the Chinese economy, which, as a hybrid between a centralized economy and a market economy, is currently the world's second largest in terms of production.

From a structural point of view, the factors responsible for China's success include: the creation of special economic zones (SEZs) —consisting of strategically concentrated production clusters near Hong Kong Special Administrative Region (SAR) of China— to attract foreign investment and take advantage of positive spillovers; gradual trade liberalization, intellectual appropriation of production techniques; and government investment in science and technology, along with other incentives (Nonnenberg, 2010).

In this context of expansion, China widened the scope of its trade and financial relations with a variety of countries, including several in Latin America. Trade relations between Latin America and China began to intensify from 2002, following the latter's admission into the World Trade Organization (WTO), and Hu Jintao's 2004 visit to the region, during which trade and investment agreements were signed (Medeiros and Cintra, 2015).

In 2000–2016, China's share of the exports of the countries analysed was heterogeneous. In some cases, such as the Bolivarian Republic of Venezuela, Colombia, Panama and Paraguay there is no defined export growth path. In others, however, such as Chile, Peru and Brazil, China's share of their total exports increased after the 2008 crisis (see figure 1).

Figure 1
Latin America (13 countries): China's share of total exports, 2000–2016
(Percentages)



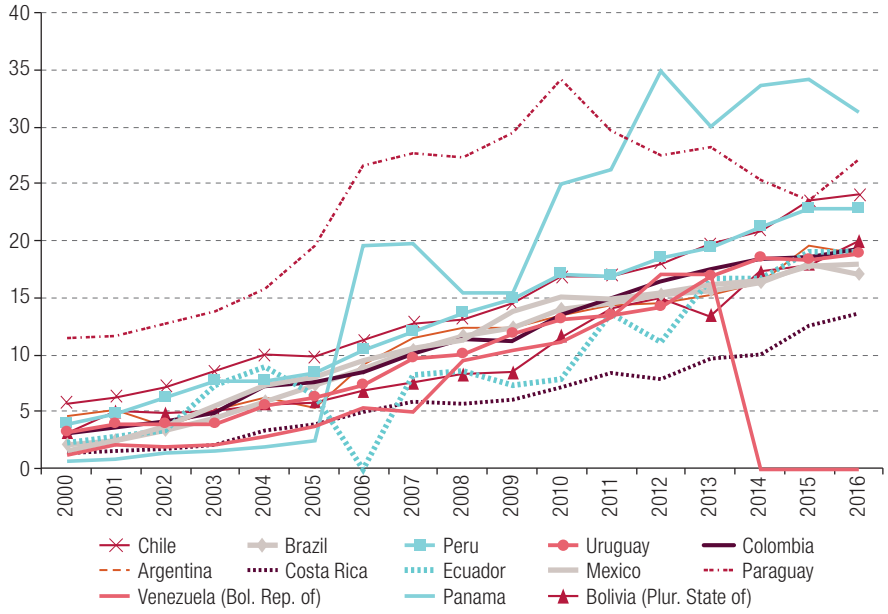
Source: Prepared by the authors, on the basis of United Nations International Trade Statistics Database (UN Comtrade) [online] https://comtrade.un.org/data.

Figure 2 shows that in the Latin American countries studied, China increased its share of their total imports in 2000–2016, in most cases supplying more than 10% of total imports since the 2008 crisis.[2]

[2] Data for the Bolivarian Republic of Venezuela for 2014–2016 are not available in the International Trade Statistics Database (UN Comtrade).

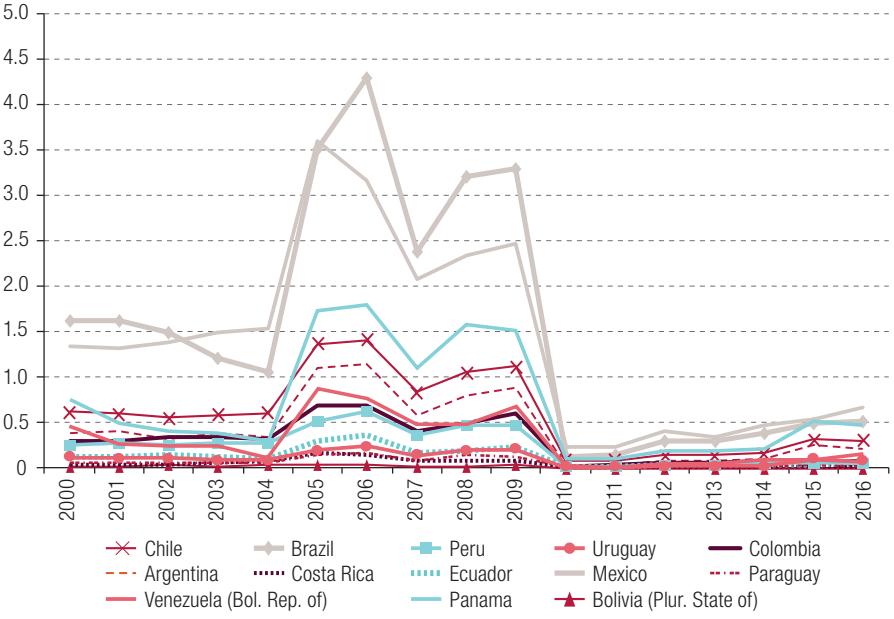
China's share in the total imports of the Latin American countries is greater than its share in the latters' exports. In general, as shown in figures 3 and 4, China is less "dependent" on Latin America in terms of trade flows.

Figure 2
Latin America (13 countries): China's share of total imports, 2000–2016
(Percentages)



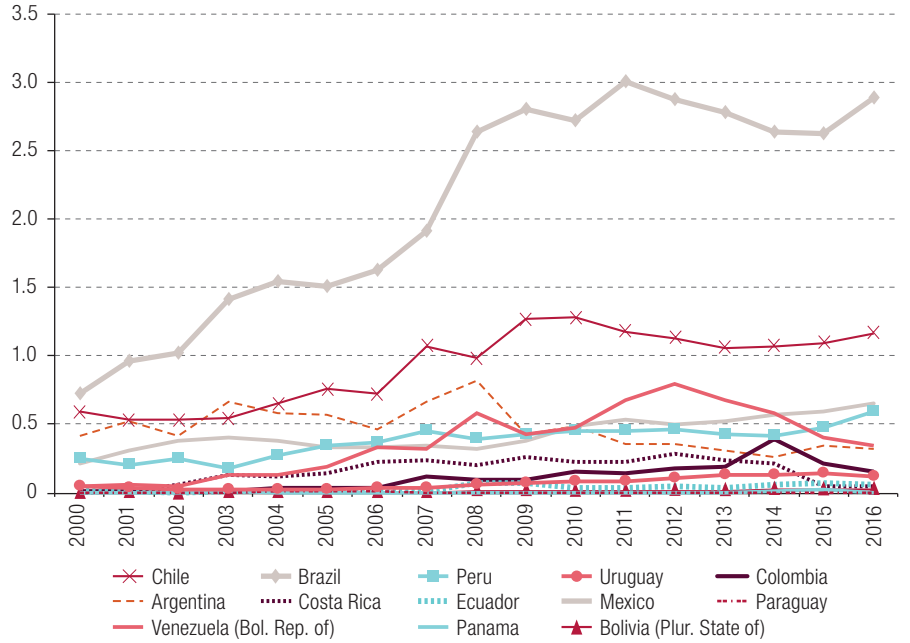
Source: Prepared by the authors, on the basis of United Nations International Trade Statistics Database (UN Comtrade) [online] https://comtrade.un.org/data.

Figure 3
China: exports to 13 Latin American countries, 2000–2016
(Percentage shares)



Source: Prepared by the authors, on the basis of United Nations International Trade Statistics Database (UN Comtrade) [online] https://comtrade.un.org/data.

Figure 4
China: imports from 13 Latin American countries, 2000–2016
(Percentage shares)



Source: Prepared by the authors, on the basis of United Nations International Trade Statistics Database (UN Comtrade) [online] https://comtrade.un.org/data.

The share of individual Latin American countries in the volume exported to and imported by China varies between 0% and 4.5%. Brazil, Mexico, Panama, Chile and Argentina are the leading destinations for Chinese exports; and Brazil and Chile are major suppliers of Chinese imports (see figures 3 and 4).

Since 2010, the share of China's exports destined for the Latin American countries studied has declined. This reflects an increase in the total exported by China to other countries and not by an absolute reduction in Chinese sales to Latin America, which grew significantly in the period following the 2008 crisis.

Costa Rica's sales to China fell sharply in 2015–2016, possibly linked to Intel's exit from Costa Rica in 2014.

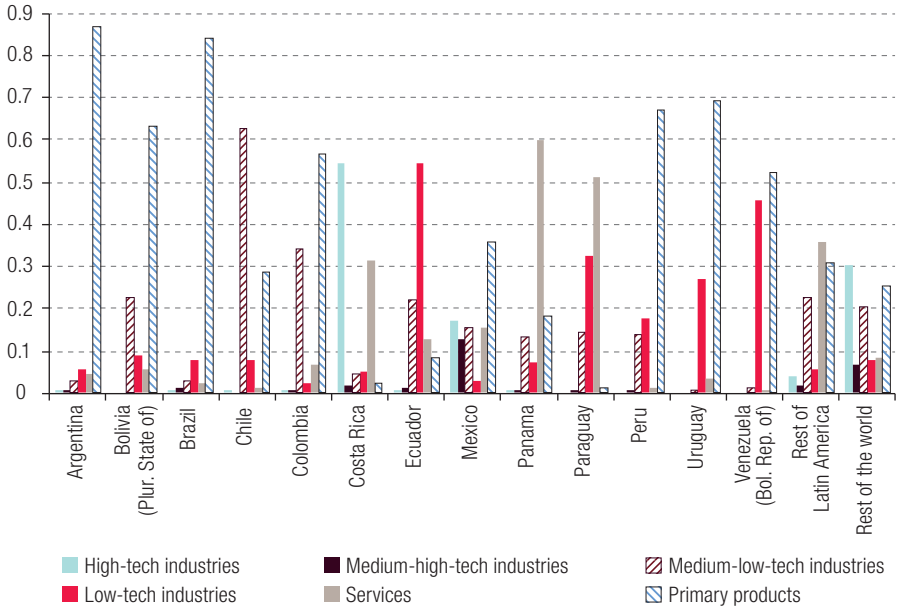
In addition to the differences in the quantities exported and imported, the trade patterns of both Latin America and China display qualitative differences, as shown in figures 5 and 6.[3] The data, which refer to 2011, are taken from the Global Trade Analysis Project, version 9 (GTAP 9) database.

With the exceptions of Costa Rica and Mexico, Latin American countries display a pattern of exporting commodities and medium-low technology-intensive industrial products to China (see figure 5). While commodities account for the bulk of exports from Argentina, the Bolivarian Republic of Venezuela, Colombia, Mexico, Peru and the Plurinational State of Bolivia, exports to China from Mexico and the rest of the world are more diversified, as they are more widely distributed among the different sectors of the economy. Costa Rica is the only country in which most exports to China come from the high-tech industrial sector.

In contrast, the technological pattern of the region's imports from China (see figure 6) is the opposite of that of its exports to that country, since they are mainly concentrated in the industrial sectors: high, medium and low-tech products. Commodities and services account for less than 10% of imports from China in the Latin American countries analysed.

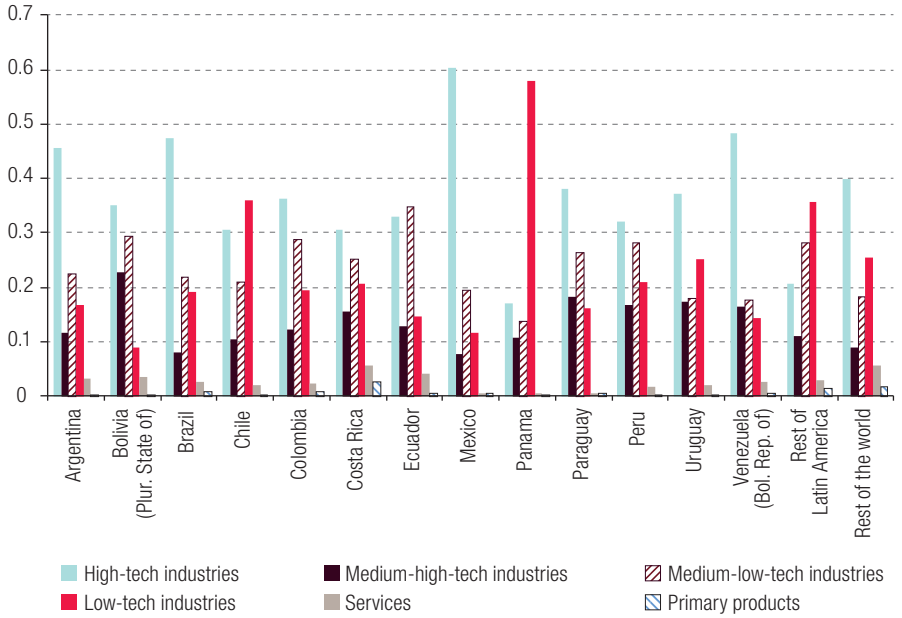
[3] For details of the sectoral aggregation, see table 1 in section III.3.

Figure 5
Latin America (selected countries) and the rest of the world: exports to China, 2011
(Percentages)



Source: Prepared by the authors, on the basis of A. Aguiar, B. Narayanan and R. McDougall, "An overview of the GTAP 9 database", *Journal of Global Economic Analysis*, vol. 1, No. 1, 2016 [online] https://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp.

Figure 6
Latin America (selected countries) and the rest of the world: imports from China, 2011
(Percentages)



Source: Prepared by the authors, on the basis of A. Aguiar, B. Narayanan and R. McDougall, "An overview of the GTAP 9 database", *Journal of Global Economic Analysis*, vol. 1, No. 1, 2016 [online] https://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp.

In general, trade with China is more important for Latin America than vice-versa. Moreover, the pattern of trade between China and the region displays an antagonism between Latin America's role as an exporter of commodities and as an importer of industrial and higher-tech products from China.

2. Mutual benefits or dependency?

Studies on the antagonism that pervades trade relations between Latin America and China date back to the "dependency" scholars, such as Raúl Prebisch and Celso Furtado, authors in the tradition of the Economic Commission for Latin America and the Caribbean (ECLAC).[4] The traditional ECLAC view saw the world economy organized in a centre-periphery system. The centres consist of countries that dominate capitalist production techniques, have diversified production structures and are mostly exporters of manufactured goods. The periphery, in contrast, comprises countries lagging behind in the mastery of production techniques, which are developed mainly in the commodity exporting sectors.

The ECLAC analysis recognizes the dynamic nature of the relations between the core and the periphery, which fosters the distinctions between these countries and acts as a mechanism of circular and cumulative causation (Myrdal, 1957). This dynamic is influenced directly by different rates of absorption of technical progress, since productivity growth is much higher in industrial economies (centre) than in economies that are specialized in primary products (periphery). This alone would lead to a secular differentiation of income in favour of the centre (Colistete, 2001).

In addition to this difference, the income elasticity of demand for the primary products exported by the periphery is lower than that of the industrial products exported by the centre. This generates a tendency towards external imbalance in the periphery, with direct effects on the terms of trade, boosting purchasing power in commodity boom periods and reducing it in periods of recession.

The key to reversing this mechanism was seen as industrialization of the "periphery" countries. Classical development authors consider industrialization and the consequent technological progress as drivers of a country's take-off and maturity (Rostow, 1990; Schumpeter, 1983). Thus, industrialization explains the different economic growth paths and external integration of Latin America and China.

Between the 1960s and 1980s, many Latin American countries industrialized through an import substitution process. However, owing to both domestic and external factors, such as the oil crises of 1973 and 1979, and growing indebtedness, they suffered a "lost decade" in the 1980s. Then, in the 1990s, Latin America's industrial policies were overtaken by the liberal wave.

In contrast, during the same period, China invested heavily in restructuring the production structure of its industrial sectors. It increased its production capacity on the basis of an extensive factor-use model —that is, by copious use of cheap labour and increased investment. China grew mainly because of high rates of investment, with gross fixed capital formation increasing from 29% of gross domestic product (GDP) in 1980 to 42% in 2010 (Beim, 2011).

Given its substantial growth in the 2000 decade, China not only expanded its trade relations with Latin America, but also increased its investments in the region, particularly after the 2008 crisis. According to ECLAC (2011), the sectoral destinations and amounts of foreign direct investment (FDI) in Latin America vary across recipient subregions and are higher in South America, where they are concentrated in natural resources and services.

China's trade and investment relations with Latin America are framed by South-South cooperation, which invokes the principle of mutual benefits for both regions. However, in terms of trade, these relations seem to strengthen the core-periphery trade pattern, which could harm Latin America's industrial and technological development in the long run.

[4] According to Tavares (2000), a theory of dependency could be inferred from Furtado's theory of underdevelopment, even before André Gunder Frank, Fernando Henrique Cardoso and Enzo Falleto developed their versions.

In this debate, Blázquez-Lidoy, Rodríguez and Santiso (2006) assess whether China is an "angel" or a "demon" for emerging economies. The authors note that, in the short term, China would have a positive influence on Latin America, particularly in the commodity exporting countries, through the "demand shock", which improved the terms of trade and increased the volume exported (a commodity price boom). The short-term negative effect would occur mainly in countries, such as Brazil, Costa Rica and Mexico, in which production and exports compete with Chinese products. However, the authors argue that the result in the long run is an incentive to re-primarize the production and export structure, which would make these economies more vulnerable to commodity price shocks (boom and bust).

Jenkins, Peters and Moreira (2008) also start by recognizing that trade between Latin America and China involves winners and losers. The authors question the thesis that producers and exporters of raw materials, such as the South American countries (Argentina, the Bolivarian Republic of Venezuela, Brazil and Chile), were the "winners" and that Mexico and the Central American countries, which specialize in commodity chains, were the "losers". They stress that, while the nature of bilateral trade between Latin America and China reproduces the core-periphery pattern, in which primary products are exchanged for manufactured goods, the long-term ecological, economic and social sustainability of this relationship is not taken into account.

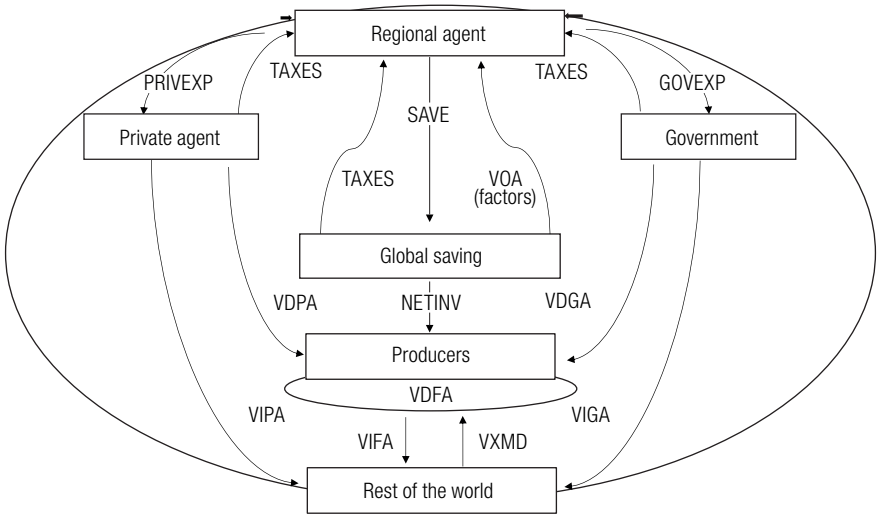
III. Database and methodology

1. The Global Trade Analysis Project (GTAP) model

Computable general equilibrium (CGE) models describe all economic activities, such as consumption, production, employment, taxes, domestic and external trade, and saving. These models involve two structures of equations obtained from the accounting relationships of the countries' social accounting matrices and the microfoundation of the economy, in order to characterize these matrices and make them compatible among the various agents (Castilho, 1994).

The GTAP model is a multiregional and multisectoral CGE model, which assumes perfect competition and constant returns to scale. Diagram 1 shows the structure of an economy modelled by GTAP.

Diagram 1
Multiregional open economy



Source: Prepared by the authors, on the basis of M. Brockmeier, "A graphical exposition of the GTAP model", *GTAP Technical Paper*, No. 8, West Lafayette, Purdue University, 2001.

At the top of the diagram is the "regional agent", which is responsible for capturing and distributing all of the economy's expenditures and incomes, which come from the payments made by firms for the use of factors of production (value of output at agents' prices (VOA)) and the collection of taxes (TAXES), which form regional income.

Regional income is distributed among private agents (PRIVEXP), government (GOVEXP) and aggregate saving (SAVE). Government demand is modeled using the Cobb-Douglas utility function, since price and income elasticities are assumed to be unitary: that is, they vary in the same proportion. Household demand is based on a non-homothetic constant difference of elasticities (CDE) function that is flexible with respect to price and income changes (Liu and others, 1998).

Another agent in the model is the goods and services production sector, whose income comes from the sale of its products to: private agents (value of domestic private households' expenditure evaluated at agents' prices (VDPA)); the government (value of government's expenditure on domestic tradable commodities, evaluated at agents' prices (VDGA)); producers (value of firms' purchases of domestic commodities, evaluated at agents' prices (VDFA)); and the rest of the world (value of exports of tradable commodities, evaluated at exporters' domestic prices (VXMD)). In addition, the production sector is financed by global saving (NETINV); the expenditures of the production sector are used to pay for the primary factors of production, land, capital and labour (VOA), and intermediate inputs, both domestic (VDFA) and imported (value of purchases of imported tradable commodities (VIFA)).

Enterprise production functions are modelled using Leontief-type technology, with constant elasticity of substitution, both for the demand for intermediate goods (inputs from other industries, or from their own) and for the primary factors of production (land, capital and labour) (Hertel, Tsigas and Narayanan, 2012). Substitution between intermediate goods and factors of production is not permitted owing to the separability hypothesis.

Bilateral trade in intermediate goods is characterized by the Armington assumption, which treats goods of different origins as imperfect substitutes. This makes the modelling more realistic, since it deals with different regions that have different consumption and production patterns.

The external sector of the economy also interacts with private agents and the government through the purchase of imported goods and services (value of expenditure on imported tradable commodity (VIPA) and value of government's expenditure on imported tradable commodity (VIGA), respectively).

The model also includes trade margins and taxes or subsidies on domestic or foreign production. Exports are valued free on board (FOB) and imports at cost, insurance and freight (CIF), which include insurance or freight costs, if any. Taxes on exports (XTAX) and on imports (MTAX) are also channelled to the regional agent.

In addition, GTAP features a global banking sector, which intermediates global saving and trade, leaving no imbalances between the supply of and demand for goods (Hertel and Tsigas, 1997).

The choice of endogenous and exogenous variables to close the model considers the capital stock as fixed. Although the standard model allows for variations in investment in different regions, this investment does not feed back into the economy since the model is a static one.

2. Database

The database is provided by the Global Trade Analysis Project (GTAP), coordinated by the Centre for Global Trade Analysis in Purdue University's Department of Agricultural Economics. The project has a standard multiregional, multisector CGE model; it uses the RunGTAP software and version 9 of the GTAP model, for which the base year is 2011 and which includes 140 regions, 57 sectors, and primary factors of production.

The 140 regions in the GTAP database were grouped into 16, as follows: Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Peru, the Plurinational State of Bolivia, Uruguay, the rest of Latin America, and the rest of the world. The regional aggregation is shown in table 1.

Table 1
Regional and sectoral aggregation of the database of the Global Trade Analysis Project, version 9 (GTAP 9)

Regional aggregation	Sectoral aggregation
Selected Latin American countries: Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Peru, Uruguay, Venezuela (Bolivarian Republic of). China **Rest of Latin America:** rest of South America, El Salvador, Guatemala, Honduras, Nicaragua, rest of Central America, and Dominican Republic. **Rest of the world:** Australia, New Zealand, rest of Oceania, Hong Kong (SAR) of China, Japan, Republic of Korea, Mongolia, Taiwan Province of China, rest of East Asia, Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Vietnam, rest of Southeast Asia, Bangladesh, India, Nepal, Pakistan, Sri Lanka, rest of South Asia, Canada, United States, rest of North America, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean, Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Slovenia, Portugal, Slovakia, Spain, Sweden, United Kingdom, Switzerland, Norway, rest of the European Union, Albania, Bulgaria, Belarus, Romania, Croatia, Russian Federation, Ukraine, rest of Eastern Europe, rest of Europe, Kazakhstan, Kyrgyzstan, rest of the former Soviet Union, Armenia, Azerbaijan, Georgia, Bahrain, Iran (Islamic Republic of), Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates, rest of Western Asia, Egypt, Morocco, Tunisia, rest of North Africa, Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, rest of West Africa, Central Africa, South Central Africa, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, United Republic of Tanzania, Uganda, Zambia, Zimbabwe, rest of East Africa, Botswana, Namibia, South Africa and rest of the world.	**Primary products:** rice, not husked (pdr), wheat and meslin (wht), other cereals (gro), vegetables and fruits (v_f), oil seeds (osd), sugar cane and beets (c_b), vegetable fibres (pfb), other crops (ocr), animal husbandry (ctl), other animal products (oap), raw milk (rmk), other animal products (wol), forestry (frs), fishing (fsh), coal (coa), petroleum and related services (oil), gas and related services (gas), other mining activities (oxt, formerly omn), meat: bovine, ovine, caprine, equine (cmt), other meat products (omt). **Low-tech industries:** vegetable oils (vol), dairy products (mil), processed rice (pcr), sugar (sgr), other food (ofd), beverages and tobacco (b_t), textiles (tex), clothing (wap), leather products (lea), sawn wood and wood and cork products (lum), paper and stationery products (ppp). **Medium-low-tech industries:** refined petroleum and coke (p_c), nonmetallic minerals (nmm), iron and steel (i_s), nonferrous metals (nfm), metal products (fmp). **Medium-high-tech industries:** chemicals, rubber and plastics (crp), motor vehicles (mvh), other transportation equipment (otn). **High-tech industries:** electronic equipment (ele), other machinery and equipment (ome), other manufacturing (omf). **Services:** electricity (ely), gas distribution (gdt), water (collection, treatment and distribution) (wtr), construction (cns), trade (trd), other transport (otp), water transport (wtp), air transport (atp), communication (cmn), financial services (ofi), insurance (isr), other business services (obs), recreation and other services (ros), public administration (osg), housing (dwe).

Source: Prepared by the authors, on the basis of A. Aguiar, B. Narayanan and R. McDougall, "An overview of the GTAP 9 database", *Journal of Global Economic Analysis*, vol. 1, No. 1, 2016 [online] https://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp.

The 57 sectors were grouped into six categories. The industrial sectors were divided into four categories of technological intensity: low, medium-low, medium-high and high-tech, based on the parameters of the Organisation for Economic Co-operation and Development (OECD, 2011). In addition, the service sector and the primary goods production sector are analysed separately. The products assigned to each sector are presented in table 1.

Primary factors of production are divided into three categories: land, labour and capital. Labour and capital are mobile factors of production, in which mobility is represented by a constant elasticity of transformation. The land factor is immobile and is only present in the primary goods production sector.

3. Empirical strategy

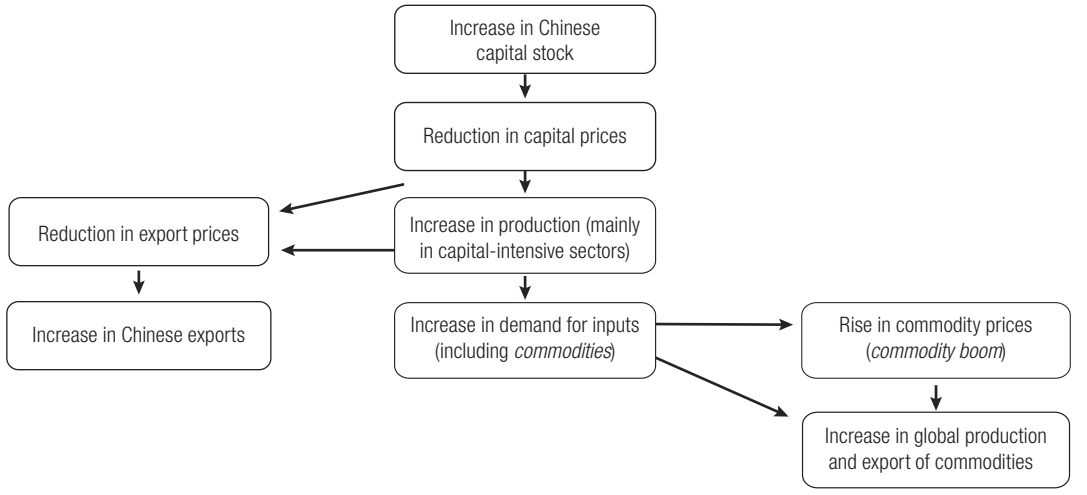
The strategy involves simulating the growth of the Chinese economy through an expansion of capital investment (increase in total capital stock). China's capital stock grew by an average of 9.6% per year between 1981 and 2014; so the empirical strategy is to simulate an increase of approximately 10%

in China's capital stock and trace the effects of such growth on the sectoral production, exports and imports, and well-being of selected Latin American countries, and of China itself.

The parameter used for the shock is qo ("Capital", "China") = 10%, such that the increase in the stock of capital is proportional to the amount of capital used in each sector.

Diagram 2 displays the main causal relations in the GTAP model, following the change in China's capital stock. As can be seen, following the positive shock to the Chinese capital stock, the price of capital decreases in this economy, which stimulates production, especially in capital-intensive sectors. The increase in production lowers product prices; and, since the Chinese economy is highly export-oriented, its exports to the rest of the world increase. At the same time, China's output growth draws in additional imports from the rest of the world, including Latin America, from which it mainly imports commodities.

Diagram 2
Causal relations of the GTAP model following the change in China's capital stock



Source: Prepared by the authors.

IV. Results

Table 2 shows the effects of Chinese growth on sectoral production in selected Latin American countries, and in China and the rest of the world.

Table 2 reports a decrease in the production of industrial sectors in the high, medium and low- tech segments, both in Latin American countries and in the rest of the world. The decrease in production in Latin American countries is more accentuated in the high-tech sector. The only increases in industrial production are recorded in the medium-high, medium-low and low-tech sectors in Costa Rica and in the medium-low-tech sector in Paraguay.

The production of services also increased in the countries analysed; and commodity production grew across the board, except in the Bolivarian Republic of Venezuela (-0.04%), Colombia (-0.11%) and Ecuador (-0.01%).

In China, the increase in the capital stock fuelled output expansion in all sectors, but mainly in the high- and medium-high-tech industrial segments.

Table 2
Latin American (selected countries), China and the rest of the world: variation in production by sector, 2011
(Percentages)

Countries	High-tech industries	Medium-high tech industries	Medium-low-tech industries	Low-tech industries	Services	Primary products
Argentina	-1.14	-0.68	-0.5	-0.62	0.12	0.06
Bolivia (Plurinational State of)	-1.53	-0.98	-0.51	-0.23	0.04	0.04
Brazil	-0.77	-0.55	-0.55	-0.46	0.12	0.04
Chile	-2.16	-0.83	-0.74	-0.71	0.14	0.52
China	7.27	5.58	5.23	3.49	3.26	2.57
Colombia	-1.67	-0.82	-0.7	-0.34	0.16	-0.11
Costa Rica	-0.99	0.24	0.45	0.01	0.07	0.52
Ecuador	-1.28	-0.73	-0.3	-0.5	0.12	-0.01
Mexico	-1.37	0	-0.07	-0.08	0.09	0.38
Panama	-1.32	-0.59	-0.21	-0.56	0.08	0.08
Paraguay	-1.87	-0.74	0.04	-0.39	0.06	0.01
Peru	-0.55	-0.42	-0.77	-0.23	0.2	0.33
Uruguay	-1.88	-0.95	-0.38	-1.01	0.19	0.15
Venezuela (Bolivarian Republic of)	-1.36	-0.33	-0.63	-0.09	0.14	-0.04
Rest of Latin America	-1.33	-0.28	-0.06	-0.31	0.05	0.27
Rest of the world	-1.19	-0.29	-0.31	-0.23	0.09	0.29

Source: Prepared by the authors, on the basis of results.

In terms of the effects on exports and imports, table 3 shows that Latin American exports declined in the industrial and service sectors after the shock caused by the increase in the Chinese capital stock. The exceptions were Costa Rica, where exports increased in the medium-high and medium-low-tech industrial sectors and in the services sector; and Mexico, where low-tech industrial and service exports grew.

Table 3
Latin American (selected countries), China and the rest of the world: variation in exports by sector, 2011
(Percentages)

Countries	High tech industries	Medium-high tech industries	Medium-low tech industries	Low tech industries	Services	Primary products
Argentina	-3.59	-1.53	-1.59	-2.14	-1.33	1.07
Bolivia (Plurinational State of)	-4.41	-1.91	-1.53	-1	-1	0.52
Brazil	-5.27	-2.5	-2.25	-2.91	-1.75	0.73
Chile	-3.34	-1.47	-0.93	-1.58	-0.35	1.61
China	11.16	9.91	6.42	4.64	5.73	-7.55
Colombia	-4.7	-1.93	-1.83	-2.07	-1.44	-0.03
Costa Rica	-1.24	0.32	0.92	-0.07	0.63	1.1
Ecuador	-3.91	-1.46	-1.14	-1.88	-0.57	0.12
Mexico	-1.57	-0.05	0.01	-0.36	0.31	1.06
Panama	-1.26	-0.6	-0.16	-0.1	-0.32	2.13
Paraguay	-3.21	-0.79	-0.91	-1.63	-0.94	-0.03
Peru	-3.58	-1.37	-1.45	-1.45	-0.79	1.42
Uruguay	-4.18	-1.21	-1.36	-2.06	-1.03	0.71
Venezuela (Bolivarian Republic of)	-4.95	-1.96	-1.24	-2.4	-1.06	0.18
Rest of Latin America	-2.4	-0.5	-0.23	-0.69	-0.02	1.08
Rest of the world	-1.92	-0.45	-0.44	-0.61	0.13	1.03

Source: Prepared by the authors, on the basis of results.

Over the years, Mexico's production structure has diversified, while Costa Rica is noted for the manufacture of computer chips and other components, especially after Intel set up production facilities in the country and began exporting to Lenovo, HP and Dell —firms that have assembly lines in China (Medeiros and Cintra, 2015; Castillo and Martins, 2016). Exports of services from the rest of the world also grew following the increase in China's capital stock.

Except in the cases of Colombia and Paraguay, commodity exports also reported growth, signalling a re-primarization process in Latin America's export structure. In contrast to the Latin American countries, China's industrial exports increased, particularly in the high- and medium-tech sectors, whereas its commodity exports declined.

Table 4 shows the variation in imports. In Latin America generally, imports grew in the industrial sectors, especially in the high-tech segment; but in Costa Rica and Mexico, they decreased. The region's imports in the primary goods sector generally shrank, although Brazil, Mexico and Peru were exceptions.

Table 4
Latin America (selected countries), China and the rest of the world: variation in imports by sector, 2011
(Percentages)

Countries	High tech industries	Medium-high tech industries	Medium-low tech industries	Low tech industries	Services	Primary products
Argentina	1.45	0.3	0.41	-0.02	0.61	-0.03
Bolivia (Plurinational State of)	0.67	0.39	0.07	0.05	0.64	-0.4
Brazil	3.3	1.05	1.45	0.73	1.1	0.29
Chile	0.89	0.52	0.89	0.45	0.64	-0.05
China	-0.58	-0.16	0.84	1.84	0.1	7.15
Colombia	1.77	0.58	0.78	0.76	0.95	-0.23
Costa Rica	-0.67	0.06	-0.15	-0.21	-0.19	-0.12
Ecuador	1.32	0.36	0.45	0.3	0.74	-0.22
Mexico	0.13	-0.04	-0.05	-0.2	-0.07	0.02
Panama	0.27	0.14	0.67	0.03	0.38	-0.68
Paraguay	0.39	0.19	0.27	0.07	0.76	-0.5
Peru	1.7	0.8	0.71	0.66	0.72	0.27
Uruguay	1.42	0.1	0.38	0.29	1.03	-0.22
Venezuela (Bolivarian Republic of)	1.55	0.65	0.55	0.91	0.89	-0.09
Rest of Latin America	0.54	0.18	0.03	-0.04	0.12	-0.22
Rest of the world	0.84	0.19	0.32	-0.02	0.14	-0.18

Source: Prepared by the authors, on the basis of results.

In China, the imports of high- and medium-high-tech sectors decreased while those of less technology-intensive industrial sectors, services and primary products all increased, particularly commodity imports (+7.15%).

The variation in well-being is calculated on the basis of the equivalent variation. This represents the change in wealth that would have the same well-being impact as the variation in prices (Mas-Colell, Whinston and Green, 1995). The well-being decomposition effect expresses the effects of shocks in the economy's different well-being contributions, measured in monetary units.

According to Burfisher (2011), the well-being decomposition effect can be divided into six components, as follows: (i) an allocative efficiency effect: this shows the excess burden of each tax; (ii) an endowment effect: changes in the quantities of factors of production (such as capital) that alter an economy's production capacity of; (iii) a technology effect: changes in the productivity of factors or intermediate products, which modify an economy's effective endowments and its productive capacity; (iv) an effect on the terms of trade of the goods produced: changes in the rest of the world and in the

economy in the prices of exported goods and services (valued FOB) and imported goods and services (valued CIF); (v) a saving-investment effect: changes in the price of investment goods relative to the price of saving in the global bank; (vi) a preferences effect: changes in the share of private consumption, government and savings in national expenditure.

Following the 10% positive shock to the Chinese capital stock, the net change in well-being stems from a combination of the allocative efficiency, endowment, terms of trade and investment-saving effects, as shown in table 5. Overall well-being improved for all countries except Costa Rica.

Table 5
Latin America (selected countries), China and the rest of the world: decomposition of well-being, 2011
(Millions of dollars)

Countries	Allocative efficiency effect	Endowment effect	Terms of trade effect	Investment-saving effect	Total
Argentina	214.21	0	363.3	-72.49	505.02
Bolivia (Plurinational State of)	4.03	0	16.37	0.32	20.72
Brazil	899.01	0	1 713.98	-102.13	2 510.86
Chile	61.3	0	433.64	-56.27	438.68
China	18 262.22	153 011.13	-29 373.98	3 376.33	145 275.69
Colombia	61.73	0	258.72	-13.66	306.79
Costa Rica	-0.06	0	-8.57	-3.76	-12.39
Ecuador	42.76	0	78.94	1.56	123.27
Mexico	252.03	0	281.33	-96.88	436.48
Panama	18.38	0	81.72	35.51	135.62
Paraguay	15.63	0	27.38	5.34	48.36
Peru	-15.68	0	217.18	-36.09	165.41
Uruguay	43.01	0	51.86	2.31	97.19
Venezuela (Bolivarian Republic of)	90.15	0	363.12	-129.14	324.13
Rest of Latin America	18.17	0	38.81	8.87	65.84
Rest of the world	2 563.68	0	25 224.98	-2 892.45	24 896.21

Source: Prepared by the authors, on the basis of results.

Only China suffered the factor endowment effect owing to its increased capital stock. The well-being decomposition effects point to a positive allocation effect in the regions analysed, except in the cases of Costa Rica and Peru.

The terms of trade effect measures the economy's purchasing power and is calculated as the ratio between the price of a country's exported goods and the price of its imported goods. Thus, given the increase in China's production of industrial goods and the increase in its demand for primary products (commodity price boom), Latin American countries gained from trade through improved terms of trade. In contrast, the terms of trade deteriorated in China and Costa Rica. The latter may have experienced a "competitive" effect with Chinese production.

The effect of the investment-saving (I-S) ratio varies from country to country and depends on whether the country is a net demander or supplier of savings.

In general, the largest well-being gains accrue to China, the country that experienced the 10% shock in the capital stock. Brazil, whose main trading partner is precisely China, also recorded a significant well-being gain (Government of Brazil, 2019).

V. Conclusions

The aim of this paper was to use the CGE model of the Global Trade Analysis Project, to empirically analyse the effects of China's growth on a selected group of Latin American countries and on China itself. Chinese growth was simulated on the basis of a 10% expansion of its capital stock, in line with the trend observed in recent decades.

Most Latin American countries are exporters of commodities and low-tech products to China. In contrast, Chinese exports to the region consist of products associated with the high- and medium-tech industrial sectors, as well as low-tech and low-cost manufactures.

The effects of the simulated Chinese growth on the Latin American countries analysed lead to a reduction in industrial output and an increase in the production of primary products and services.

Nonetheless, there are some exceptions, such as Costa Rica, which experienced increases in production and exports in industrial sectors —other than high-tech— and a reduction in industrial imports. The withdrawal of Intel from Costa Rica in 2014 may have impacted Costa Rica's trade relations. Mexico also diverges from the general Latin American pattern, with imports in the medium- and low-tech industrial sectors declining. The export structure of the Mexican economy has improved in recent years; and, while it both competes and trades with China, it maintains more intensive trade relations with the United States.

The overall picture in Latin America is worrying. Although the partnership between China and the region increased the overall well-being of these economies in the 2000s (thanks to the commodity price boom), signs of deindustrialization can be discerned in the Latin American countries. These include the declining share of industrial production and the increasing output of both services and the commodity export sector.

In contrast, China's industrial production and the technological intensity of its products are increasing. China is no longer merely an exporter of cheap manufactured products, but is now competing in higher technology sectors. It could even hinder the progress of Latin American production in these sectors.

This begs the following question: are trade relations between Latin America and China mutually beneficial or are they fostering dependency? Latin America has abundant natural resources, but its countries' reliance on the production of these resources makes them vulnerable on the international stage —in other words, they are susceptible to what happens in periods of commodity boom and bust. The rise of China and its consequent increase in demand for commodities highlights the degree of specialization present in Latin America's production and export structure, and its fragility in the face of competition in the industrial sectors.

If Latin American countries wish to forge an economic success story, they must rethink their trade relations with China, while also addressing address their domestic shortcomings. Investment in quality human capital and infrastructure, and the pursuit of technical progress through a planned industrial policy involving all sectors of society, including both market and State, are necessary conditions for Latin America to break the shackles of its historical dependency on the international scenario.

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The inclusion of poor youth in the Brazilian labour market and the impact of the Bolsa Família programme

Gilson de Oliveira and Augusta Pelinski Raiher

Abstract

This article analyses the labour market inclusion of young Brazilians, especially poor ones, by measuring the impact of the Bolsa Família programme on the process. Using data from the 2015 National Household Survey (PNAD), an exploratory analysis was conducted and the propensity score matching technique applied. Young people were found to have particular difficulty in entering the labour market, while poor young people were even more excluded, suffering high rates of unemployment and informality and receiving the lowest wages. The study also found that the Bolsa Família programme had no effect on the inclusion of young beneficiaries in the formal labour market, while there was a negative impact on participants' incomes. However, no "sloth effect" was observed.

Keywords

Youth, poverty, youth employment, income, labour market, informal sector, full employment, programmes of action, econometric models, Brazil

JEL classification

J08, I38

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I. Introduction

Bolsa Família is a federal cash transfer programme in Brazil whose objective is to ensure that people with per capita incomes of up to 170 reais per month can meet their basic needs.[1] The programme's aim is the social inclusion of families living in extreme poverty with a view to improving social indicators and breaking the intergenerational cycle of poverty reproduction (Campello, 2013).

The 2003 interim measure instituting the programme became law in January 2014. It was originally intended to unify and expand some of the country's existing cash distribution programmes, such as Bolsa Escola, Bolsa Alimentação, Auxílio-Gás and the National Food Access Programme (Brazil, Government of, 2014, 2004a and 2004b). In August 2017, the Bolsa Família programme served 13,495,513 families, transferring a total of 2,425,517,419 reais (MDS, 2017).

To be eligible for the Bolsa Família programme, a family must include expectant mothers or children or adolescents between the ages of 0 and 17. In addition, families entering the programme must keep their children and adolescents in school and comply with all basic health-care requirements. These conditions are designed to increase school attendance and improve implementation of the health agenda, thus affecting the quality of human capital formation among beneficiaries and facilitating their subsequent entry into the labour market.

While the empirical literature suggests that cash transfers have a positive impact on socioeconomic indicators, especially when it comes to poverty reduction, as pointed out by Jannuzzi and Pinto (2013) and Campello (2013), among others, some studies point to a negative relationship in the occupational choice between formal and informal jobs (e.g. Castro, 2010). The greatest challenge for the programme, then, is to ensure that beneficiaries comply with its conditions and enter the labour market, thus ceasing to depend on State financial assistance.

Indeed, the report by the Ministry of Social Development (MDS, 2012) found a decrease of 8.8 hours per week in formal working and an increase of 8.7 hours per week in informal working among programme beneficiaries aged 18 to 65. This employment shift reflects a substitution effect in choices between employment with and without a formal contract (Barbosa and Corseuil, 2013).

Costa and Oliveira (2014) used microdata from the 2010 Brazilian Institute of Geography and Statistics (IBGE) sample census to investigate the existence of a "sloth effect" among beneficiaries of the Bolsa Família programme. Overall, they found that the programme had a negative impact on the working hours of beneficiary households. They also found a negative effect on earnings, suggesting that beneficiary households tended to receive less income from work than households not covered by the programme.

It should be noted that this and other empirical evidence relates the Bolsa Família programme to the labour market in general, encompassing the active population as a whole rather than concentrating on the groups directly affected by the programme (i.e. without specifically examining the groups subject to its conditions). Accordingly, the present paper contributes to the literature on the subject by measuring the impact of the Bolsa Família programme on the labour market inclusion of young people, especially the young poor.[2] It does this by comparing two groups: young people who benefited from the programme and those who did not receive these resources but were also poor. This impact is investigated in three dimensions: formal labour market participation, earnings and hours worked.

[1] Note that this figure is for 2015.

[2] Because the Bolsa Família programme started in 2003, many of the young people of 2014 and 2015 (especially those benefiting from it) received its entitlements for a period and thus were subject to its conditions. For this reason, the years furthest from 2003 (i.e. 2014 and 2015) were chosen for the analysis in order to test the effect of the Bolsa Família programme on the part of the population that may have received its entitlements previously and been subject to its conditions.

It is particularly important to analyse the influence on these dimensions of the additional income provided by the Bolsa Família programme in an effort to ascertain whether, given the programme's conditions, it succeeded in enhancing the autonomy of this segment of the population, i.e. whether the young people in the programme actually were able to participate more actively in the labour market and break the vicious circle of intergenerational poverty. The working hypothesis is that the programme's conditions facilitate the entry of young beneficiaries into the formal labour market, leading to higher earnings and an increase in hours worked.

The way young people participate in the labour market is seen as one of the obstacles to economic development in Brazil. This participation is conditioned by certain factors, such as education level and work experience, which constrain individual opportunities and the country's development process (Andrade, 2008; Cunha, Araújo and Lima, 2011; among others).

According to National Household Survey (PNAD) data (IBGE, 2015), the employment rate was 16% lower for economically active young people than for the country's general population, while their unemployment rate was 2.6 times as high. These data show how difficult it is for young people to enter the Brazilian labour market.

Furthermore, only 56% of employed young people worked in the formal sector. The level of formality in an economy is important for the dynamics of development, most particularly because formality is associated with higher wages and guarantees access to employment rights (Oliveira and Piccinini, 2011). Thus, informality is a problem in the Brazilian labour market, and young people are affected by it.

The earnings of young people working informally in 2015 were indeed lower than the wages of those in formal employment. The difference is even greater, however, when these earnings are compared with those of all informal workers in Brazil (32% less). The same situation was observed for young people in formal employment, as they earned 46% less than the national average wage. Thus, not only was there inequality between the formal and informal sectors, but young people also tended to be paid less in each sector considered separately. This was due both to lack of experience and to the fact that this segment of the population does the least-skilled and lowest-paid jobs, owing to the lack of human capital formation and the scarcity of such jobs in the country.

All these indicators confirm the vulnerability of young people in the Brazilian labour market, which is particularly acute in the case of the poor. In 2015, 15% of economically active young people were poor, and the unemployment rate of this group was 2.7 times as high as that of the non-poor young. In other words, unemployment, high as it was among youth generally, was even higher among the most vulnerable young people. Moreover, in addition to being less employable, these worked mainly in the informal sector (78%), which meant they were very differently placed from the non-poor, only 20% of whom worked informally. This confirms how insecure young people's jobs are, especially in the case of those with the lowest incomes, and corroborates the results arrived at by Corseuil and Franca (2015), who found that groups in a difficult social situation faced greater barriers to entry in the Brazilian labour market.

Brazil's labour market is therefore a heterogeneous one in which young people are particularly vulnerable, especially those living in poverty, who have a lower employment rate, earn lower wages and are significantly more likely to be unemployed or work informally.

These data are the justification for this study, whose purpose is to analyse the impact of the Bolsa Família programme on the inclusion of poor youth in the Brazilian labour market. To this end, the article is divided into four sections, including this introduction. The second section presents the methodology, while the third analyses the market for the labour of poor young Brazilians and the impact of the Bolsa Família programme. The fourth and last section presents some final considerations.

II. Methodology

The data used in this research were taken from the 2014 and 2015 PNAD, with the objective of estimating the impact of the Bolsa Família programme on the market for the labour of young urban Brazilians.[3] Only young people declaring themselves to be economically active were considered in estimating the econometric models, and sample expansion was used in all analyses.

One of the challenges for those studying the impact of the Bolsa Família programme is to identify programme participants, since annual sample surveys generally do not include a specific variable classifying respondents as beneficiaries or otherwise. This makes it necessary to use a method suitable for determining how likely young urban Brazilians are to be participating in the Bolsa Família programme.

Some identification procedures are used in the literature. For example, Dropa (2016) estimated the impact of the Bolsa Família programme on the decisions of children and adolescents to work, using two criteria to identify beneficiaries: (i) a reported per capita income of up to 300 reais and (ii) certain values declared for the "other income" variable.[4] The present study used the same criteria as that author and added the following characteristics to make up the analysis group: economically active young people aged from 15 to 24 and living in urban areas. Young people with no reported per capita income or with inconsistent values were eliminated to minimize bias.

The characteristics of poor youth (taking per capita income of up to 300 reais as a cut-off line) were analysed in relation to other economically active young Brazilians. Setting out from the classification of young people (aged 15 to 24) into those who participated in the Bolsa Família programme and those who did not, the propensity score matching method was used to assess the impact of the programme in terms of the successful inclusion of young people in the formal labour market, the generation of earnings, and hours worked. In total, the sample size for 2014 was 3,810 young people, with 2,101 in the control group and 1,709 in the treatment group. In 2015, the total sample was 3,899 young people, with 1,691 in the treatment group and 2,208 in the control group. The sample consisted of 2,011,122 young people in 2014 and 2,088,975 in 2015.

The econometric method used is presented below. It is important to note that propensity score matching is considered one of the best methods for evaluating public policies, precisely because it compares people in terms of selection probability given their characteristics. This method aims to find a comparison group to set against the treatment group, basing this on a sample of people who do not participate in the programme or policy (control group). The observable characteristics of the treatment group are taken as a basis, and it is compared with the control group, which consists of people with similar characteristics. An average is taken not simply between groups, but between people with the same (or similar) characteristics, i.e. the control group usually has the greatest possible similarity to the group affected by the policy in terms of the observed variables relevant to the treatment. Essentially, this methodology serves to identify non-beneficiary young people with observable characteristics similar to those of young beneficiaries, setting out from selected control groups.

1. The econometric model: propensity score matching

An efficient way of evaluating the effect of a public policy on a given variable is to observe it when the unit of analysis i (in this case, young people) benefits from a given policy as opposed to when it does

[3] Only urban youth are considered in the study because of the high levels of informality in rural areas, as inferred in the study by Costa and Oliveira (2014).

[4] PNAD variable V1273 captures reported values for interest on savings accounts and other financial investments, dividends, social programmes and other income. Setting out from the assumption that the poor did not have financial investments or receive significant amounts of interest from saving accounts or dividends, this research took declared values of between 30 and 350 reais to be resources transferred by the Bolsa Família programme.

not (Heinrich, Maffioli and Vázquez, 2010). The difference obtained in the variable of interest is the impact of the public policy, i.e.:

$$\delta_i = \Upsilon_{1i} - \Upsilon_{0i} \tag{1}$$

Where: δ_i is the effect of the public policy, in this case the Bolsa Família programme, on the variable of interest (formal employment, earnings, hours worked) for the unit of analysis (the young) i; Υ_{1i} is the value of the variable of interest after the young person i has participated in the programme; and Υ_{0i} denotes the value of the variable of interest if the young person i did not participate in the programme.

The aim is not to individualize the impact of public policies but to measure their average effect on the group under analysis. For this purpose, the parameter known as the average treatment effect (ATE), described by (2), is used.

$$ATE = E(\delta) = E(\Upsilon_1 - \Upsilon_0) \tag{2}$$

Where: E is the expected value; Υ_1 is the value of the variable of interest after the participation of young people in the programme; and Υ_0 denotes the value of the variable of interest in the event that young people do not participate in the programme.

The difficulty in measuring (2) is that this and other effects are not necessarily observable. Thus, assuming that the difference between the means is given by the mean of the differences, ATE can be represented by (3).

$$ATE = E(\Upsilon_1 \mid T = 1) - E(\Upsilon_0 \mid T = 1) \tag{3}$$

$E(\Upsilon_0 \mid T=1)$ represents the mean result that would have been obtained for those treated in the absence of treatment, which is unobserved. Consequently, this value is substituted by $E(\Upsilon_0 \mid T=0)$, measuring the value of the variable of interest, Υ_0, for the non-beneficiary group, which is observed. This can be used to calculate:

$$\Delta = E(\Upsilon_1 \mid T = 1) - E(\Upsilon_0 \mid T = 0) \tag{4}$$

Taking (4) and adding and subtracting the term $E(\Upsilon_0 \mid T=1)$ will yield the difference between Δ and ATE (5):

$$\Delta = E(\Upsilon_1 \mid T = 1) - E(\Upsilon_0 \mid T = 1) + E(\Upsilon_0 \mid T = 1) - E(\Upsilon_0 \mid T = 0) \tag{5a}$$

$$\Delta = ATE + E(\Upsilon_0 \mid T = 1) - E(\Upsilon_0 \mid T = 0) \tag{5b}$$

$$\Delta = ATE + SB \tag{5c}$$

Where: SB is the difference between the Y variable for the group of programme beneficiaries and the group of non-beneficiaries. If SB is zero, ATE can be measured by the difference between the means of the Y variable; however, this is unlikely to be the case, so an appropriate methodology must be used to ensure that the SB term is equal to zero.

One of the methods used to minimize selection bias, especially when the selection of participants in a given programme is not random, is propensity score matching. For this there must be two groups, a treatment group and a control group. The first consists of the people (in the case of this research, young people) who received resources from the programme and the second of those who did not.

The difficulty in measuring the effects of the Bolsa Família programme across these two groups is to distinguish the characteristics of each (age, race, education, etc.), which may be determining the difference in the variable of interest. Cavalcanti and others (2016) argue that the ideal way to evaluate the impact of any public policy would be to compare the same group in two contexts: participation and non-participation in a programme. As this is not possible, however, the alternative is to create a statistically identical group, so that the only differential is whether or not they participate in a specific public policy.

The propensity score matching method allows this comparison to be made by finding similarities within the groups of young people benefiting (treatment group, T=1) and not benefiting (control group, T=0) from the Bolsa Família programme. This propensity is generated from the observable characteristics of the young people, which affect the likelihood of their participation in the programme. Thus, the participation or non-participation of young people in the programme becomes random (Heinrich, Maffioli and Vázquez, 2010). In this research, the characteristics (called control variables) used for matching were: living in the South or South-East region; living with a partner; being head of household; age; number of children; race; gender; number of people in the family; level of education; per capita household income; being employed. These variables were identified on the basis of studies on the topic that use propensity score matching and analyse the labour market, such as Nascimento and Kassouf (2016), Tavares (2010) and Vasconcelos and others (2017).

The search for similar observations when different characteristics are listed may come up against the problem of multidimensionality, i.e. young person i may have some characteristics similar to those of young person j and others similar to those of young person m. In this case, the difficulty would be to establish whom i should be compared to. As Rosenbaum and Rubin (1983) point out, propensity score matching minimizes this problem by calculating the probability that the young person will receive the treatment in the light of his or her observable characteristics (covariates). In the present research, the logit model (6) was used to measure this probability, with matching based on the assumption of conditional independence. As a consequence of this assumption, the difference between the means of the covariates in the treatment group and the control group cannot be statistically different from zero.

$$P\left(T_i = 1 \mid X_i\right) = \frac{1}{1 + e^{-x_i'\beta}} \tag{6}$$

Where: $P(T_i = 1|X_i)$ denotes the probability of the young person participating in the programme, considering his or her covariates.

Next, propensity score matching is used to match young people with equal or similar scores and then assess whether the treatment group secured statistically higher levels of formal employment, hours worked and earnings than the control group.[5] The main limitation of propensity score matching is that if "treated" status is influenced by unobservable characteristics, the conditional independence assumption is not met and the effects estimated may be biased (Oliveira, 2016). Also, when only one particular year is analysed, there may be one-off factors that affect the treatment or control group, skewing the results. For this reason, we opted to repeat the method for another year, applying the analysis to both 2014 and 2015. Annexes A1 and A2 show the correlation between the covariates. In no case did the value exceed 0.80, which, according to Oliveira (2016), is the maximum correlation if the propensity score matching results are not to be distorted.

[5] Matching was carried out using the nearest neighbour algorithm.

III. Brazilian youth and the labour market: empirical evidence

1. The market for the labour of poor youth and the impact of the Bolsa Família programme

Statistics show how vulnerable economically active young Brazilians are, particularly when they are poor. To break the vicious circle of poverty in Brazil, specific actions are needed to interrupt the process, focusing on this most vulnerable group.

The Bolsa Família programme is one of the policies implemented in the 2000s with the aim of reducing or eliminating vulnerability in the Brazilian population. In theory, its conditions are meant to be conducive to greater inclusion of the population in the labour market, for example by requiring that children and adolescents attend school. The medium-run expectation is that human capital formation in this group will break the intergenerational transmission of poverty via greater labour market inclusion and income autonomy.

Accordingly, the propensity score matching method was used to assess the effectiveness of the Bolsa Família programme in terms of the labour market participation of young people benefiting from its conditions.

The first step in the correct application of the method was to divide the set of poor Brazilian youth into a treatment group (those who participated in the Bolsa Família programme) and a control group (those who did not participate in the programme), ensuring that the characteristics of both groups were the same (see table 1).

Table 1
Brazil: difference of means between the covariates of poor youth before matching, 2014 and 2015

	2014 mean			2015 mean		
	Untreated	Treated	t test – p-value	Untreated	Treated	t test – p-value
South or South-East dummy	0.33	0.20	8.9*	0.33	0.21	7.91*
Partner dummy	0.36	0.22	9.39*	0.31	0.25	4.31*
Number of people	3.96	4.62	11.89*	4.05	4.62	9.72*
Children	0.23	0.29	2.11*	0.26	0.32	2.66*
Household head dummy	0.30	0.16	9.91*	0.25	0.18	5.67*
Gender dummy	0.57	0.55	1.58	0.55	0.56	0.51
Age	20.00	19.52*	5.48*	20.02	19.72	3.64*
Race dummy	0.28	0.20	5.60*	0.27	0.22	1.98*
Household per capita income	214.15	192.89	9.15*	210.34	184.56	10.57*
Occupation	0.61	0.57	1.43	0.50	0.52	0.61
Education	9.31	9.05	2.78*	9.71	9.23	5.14*

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).
Note: South or South-East dummy: 1 for South or South-East, 0 otherwise; gender dummy: 1 for male, 0 otherwise; household head dummy: 1 for household head, 0 otherwise; race dummy: 1 for white, 0 otherwise; partner dummy: 1 if has partner (married or cohabiting), 0 otherwise.

To accommodate this principle, a test of difference of means was used to compare the characteristics (selected covariates) of the young people who participated in the programme (treatment) with the characteristics of the young people who did not participate (control). The results

showed that all covariates except gender and occupation presented significant differences between means, indicating that the two groups' characteristics were different. The results were maintained in both 2014 and 2015, with fairly close values, which confers robustness on the analyses that were then performed.

It is important to note that the characteristics of the treatment group and the control group should be similar after matching, so that the test of difference between means for each covariate should not be significant. If it were, it would not be possible to carry out the analysis of the impact of the Bolsa Família programme on the labour market, essentially because the results could derive from other characteristics of the young people and not from the influence of the programme. Table 2 therefore compares the treatment and control groups after matching, again performing the test of difference between means.

Table 2
Brazil: difference of means between the covariates of poor youth after matching, 2014 and 2015

	2014 mean			2015 mean		
	Untreated	Treated	t test – p-value	Untreated	Treated	t test – p-value
South or South-East dummy	0.20	0.21	0.25	0.22	0.20	1.40
Partner dummy	0.22	0.20	1.42	0.25	9.27	1.34
Number of people	4.62	4.56	0.99	4.61	4.56	0.79
Children	0.29	0.29	0.16	0.32	0.33	0.29
Household head dummy	0.16	0.18	1.41	0.18	0.18	0.27
Gender dummy	-	-	-	-	-	-
Age	19.54	19.59	0.78	19.72	19.75	1.20
Race dummy	0.21	0.20	0.77	0.23	0.22	0.70
Household per capita income	192.89	190.53	0.92	184.56	185.94	0.53
Occupation	-	-	-	-	-	-
Education	9.05	8.8	1.90	9.23	9.18	0.61

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).
Note: South or South-East dummy: 1 for South or South-East, 0 otherwise; gender dummy: 1 for male, 0 otherwise; household head dummy: 1 for household head, 0 otherwise; race dummy: 1 for white, 0 otherwise; partner dummy: 1 if has partner (married or cohabiting), 0 otherwise.

As a corollary, the differences between the means of the treatment and control group variables were not statistically significant in either 2014 or 2015, allowing the two groups to be compared.

The results of the logit model that calculates the probability of participating in the Bolsa Família programme for the years 2014 and 2015 are shown in table 3. This probability is used to match observations, so that for each treated observation one (or more than one) "match" is found in the control group with the same estimated probability of participation in the programme. The observations compared differ only in that one receives the benefit and the other does not, i.e. they are identical in all other respects. Virtually all covariates affect the probability of participation in the Bolsa Família programme.

Following the matching of the treatment and control groups, propensity score matching was applied to determine the impact of the Bolsa Família programme on the market for the labour of poor youth. Table 4 shows the result for inclusion in the formal market, which was not statistically significant in either year. In other words, young people who received benefits from the Bolsa Família programme were not necessarily more likely to enter the formal labour market than other poor youth.

Table 3
Brazil: results of the logit model that estimates the probability of participation in the Bolsa Família programme, 2014 and 2015

Variable	2014 coefficient	2015 coefficient
South or South-East dummy	-0.64*	-0.63*
Partner dummy	-0.36*	-0.14**
Number of people	0.17*	0.15*
Children	0.13*	0.19*
Household head dummy	-0.47*	-0.32*
Age	-0.01	-0.2
Race dummy	-0.26*	0.34*
Household per capita income	-0.004*	-0.004*
Education	-0.02*	-0.04*
Pseudo R	0.37	0.28

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).
Note: *significant at 5%; **significant at 10%.

Table 4
Brazil: average effect of the Bolsa Família programme on the formal labour market inclusion (1 if in the labour market and 0 otherwise) of poor youth participating in the programme, 2014 and 2015

Result variable	Mean effect	Standard error	Z
Formal labour market 2014	-0.02	0.01	-1.31
Formal labour market 2015	0.004	0.01	0.35

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).

Barbosa and Corseuil (2013) obtained similar results. When they analysed beneficiaries as a group, they found that being a beneficiary of the Bolsa Família programme did not lead to greater participation in the formal labour market. One hypothesis is that the eligibility requirement of the programme limiting it to families with per capita incomes of up to 170 reais leads people (in this case young people) to enter the informal market so as to avoid declaring their income and thus remain in the programme.

In the case of earnings (see table 5), there was an inverse effect, with the Bolsa Família programme having a negative impact on income from work. Specifically, the average earnings of young programme beneficiaries were 24.22 reais lower in 2014 and 14.55 reais lower in 2015.

Table 5
Brazil: average impact of the Bolsa Família programme on the earnings of poor youth participating in the programme, 2014 and 2015

Result variable	Mean effect	Standard error	Z
Earnings 2014	-24.22	10.56	-2.29*
Earnings 2015	-14.55	9.48	-1.90**

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).
Note: *significant at 5%; **significant at 10%.

One of the explanations for this result derives from the greater prevalence of informal working among the poor youth participating in the programme, who consequently earn less. It should be noted that, among the poor, both Bolsa Família participants and non-participants had high unemployment rates and low employment rates. However, formality and earnings were higher among young people who did not benefit from the programme.

Costa and Ulyssea (2016) found similar results. When analysing the impact of the Bolsa Família programme on the average earnings of participants and non-participants, they also found the programme to have a negative effect on the earnings of beneficiaries.

Lastly, hours worked in the labour market were analysed, without any statistical difference being found in this variable for either 2015 or 2014 (see table 6). This contradicts some research, such as that of Costa and Ulyssea (2016), who pointed to a "sloth effect" for those receiving benefits from the Bolsa Família programme. Thus, no such effect was captured in the case of economically active youth.

The fact that there was no statistically significant difference in hours worked between Bolsa Família beneficiaries and other poor youth, then, and that even so the former tended to earn less, strengthens the argument that informality is a decisive factor in the earnings discrepancy suffered by young workers in the Bolsa Família programme.

Table 6
Brazil: average impact of the Bolsa Família programme on the hours worked by poor youth participating in the programme, 2014 and 2015

Result variable	Mean effect	Standard error	Z
Hours worked 2014	0.42	0.74	0.57
Hours worked 2015	0.89	0.81	1.10

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).

Thus, it cannot be inferred that the Bolsa Família programme is important for the inclusion of young people in the labour market. On the contrary, the programme's requirements could, in part, be making beneficiaries more likely to work informally in order to remain in it.

IV. Final considerations

This article has analysed the situation of urban youth in the Brazilian labour market and assessed the effect of the Bolsa Família programme on formal employment, earnings and hours worked.

As a corollary, it has found that young people particularly struggle to participate in the labour market, as they have higher rates of unemployment and informality and receive lower wages than the rest of the population. Lack of professional experience has been identified in the literature as one of the main determinants of the exclusion of young people from the labour market, intensified by the economic crisis experienced during this period.

Within the group of young people, however, the poor were even more severely excluded. Thus, if young people generally are marginalized, the poorer among them are even more isolated from the world of work, with alarming rates of informality and unemployment and the lowest wages.

This situation justifies the implementation of direct actions to break this negative cycle and promote the well-being of the entire population. Given its conditions, which apply particularly to beneficiaries' children, the Bolsa Família programme should tend to contribute to this change in the medium term. Accordingly, we sought to ascertain whether the programme was having an impact on the market for the labour of poor young Brazilians.

The results did not corroborate this hypothesis, as they did not identify a statistically significant impact of the Bolsa Família programme in terms of increased hours worked or inclusion in the formal labour market. Especially in the latter case, the programme eligibility requirement of a limited per capita income may be the reason why young beneficiaries remain in the informal sector, with more flexible jobs that allow them to underreport their income.

With respect to income formation, the impact of the programme was negative and statistically significant. This finding reinforces the hypothesis that participants chose jobs without employment contracts.

Thus, one of the programme's objectives is not being achieved: it is not leading to greater inclusion of young people in the formal labour market, with the higher incomes this entails, with the result that the future autonomy of this section of the population is being curtailed. The income limit of 170 reais per capita for participation in the Bolsa Família programme seems to be a decisive factor in results that run quite counter to the programme's objectives, as it is likely to keep future generations of beneficiaries in the informal economy.

Accordingly, some points of the Bolsa Família programme need to be reformulated, in particular the per capita income limit for inclusion in the programme. Public policies should also be adopted to combat informality and generate new jobs, especially jobs with formal contracts. Programmes providing incentives to hire young people can also reduce vulnerability to unemployment. Alongside this, young people need to be provided with professional skills through technical courses and high-quality school education appropriate to the demands of the labour market.

Lastly, it must be stressed that the main limitation of research to evaluate public policies using PNAD data is the lack of a variable identifying beneficiaries of the Bolsa Família programme. It is therefore imperative to include questions in the questionnaire about participation in the Bolsa Família programme and the duration of benefits, in order to improve the estimated results. It should also be borne in mind that in 2014 and 2015 the Brazilian economy was in a severe recession and the crisis undoubtedly affected the labour market, a factor that was not considered in the estimates made in this research.

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Annex A1

Table A1.1
Correlation between covariates, 2015

	South or South-East	Age	Household head	Race	Partner	Per capita income	Education	Number of people	Children
South or South-East	1								
Age	-0.0527	1							
Household head	-0.0235	0.3056	1						
Race	0.1794	-0.0492	-0.0244	1					
Partner	-0.0887	0.3539	0.3988	-0.0598	1				
Per capita income	0.0329	0.0215	-0.0717	0.0046	0.036	1			
Education	0.0412	0.1559	-0.0443	0.0568	-0.1031	0.0814	1		
Number of people	0.0215	-0.1425	-0.3557	-0.0445	-0.2307	-0.0061	-0.0957	1	
Children	0.0043	0.2629	0.2662	-0.0233	0.1623	-0.122	-0.048	-0.0993	1

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).

Annex A2

Table A2.1
Correlation between covariates, 2014

	South or South-East	Age	Household head	Race	Partner	Per capita income	Education	Number of people	Children
South or South-East	1								
Age	-0.0313	1							
Household head	-0.0061	0.3426	1						
Race	0.1931	-0.0021	0.0108	1					
Partner	-0.0277	0.3872	0.4255	0.0056	1				
Per capita income	0.094	0.0724	-0.0397	0.039	0.0789	1			
Education	0.0268	0.1248	-0.0315	0.0888	-0.0748	0.0959	1		
Number of people	0.0182	-0.1587	-0.3752	-0.0578	-0.263	0.0007	-0.0798	1	
Children	0.0147	0.2815	0.2273	-0.0183	0.1495	-0.0726	-0.0456	-0.0955	1

Source: Prepared by the authors, on the basis of Brazilian National Household Survey (PNAD).

The spatial concentration of high-skilled workers and city productivity: the case of Latin America

Miguel Vargas and Nicolás Garrido[1]

Abstract

The aim of this study is to cast light on the relationship between the spatial concentration of high-skilled workers and the productivity of cities in Latin America. The relationship is not clear at first sight. On the one hand, the segregation of high-skilled workers should create agglomeration economies and give rise to positive spillovers amongst the most advantaged, offsetting productivity losses that result from the existence of ghettos of low-skilled workers. On the other hand, it may well be that these spillovers are not enough to compensate for the loss of productivity in the worse-off groups, so that aggregate productivity is negatively affected. We analysed this segregation for a group of Latin America's largest cities and found a negative and significant relationship between the productivity of cities and the segregation of high-skilled workers. However, we also found evidence of a quadratic relationship between segregation and productivity.

Keywords

Skilled workers, productivity, cities, segregation, geographical distribution, labour productivity, measurement, economic development, Latin America

JEL classification

R32, R11

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I. Introduction

The purpose of this study is to investigate the effects that the segregation of high-skilled workers, understood as residential segregation, has on the productivity of Latin American cities. This relationship is not clear at first sight. On the one hand, the spatial concentration of high-skilled workers yields agglomeration economies and positive spillovers among the most advantaged that could offset productivity losses resulting from the existence of ghettos of the worse-off. On the other hand, these spillovers might not be enough to compensate for those productivity losses, resulting in the city's aggregate productivity being negatively affected.

To achieve this goal, we use census data from Latin American countries to calculate segregation indices for high-skilled groups. Census information was obtained from the University of Minnesota Population Center's Integrated Public Use Microdata Series (IPUMS) for two dates, the first around the year 2000 and the second around the year 2010. We use individual education levels as a proxy for skills. As a productivity measure, we consider cities' labour productivity, deflating this measure by the Big Mac index for comparability. We collect this information for the countries' largest cities, in several cases more than one per country. Our empirical approach uses cities' productivity as the dependent variable and well-off groups' segregation as the explanatory variable, plus a group of controls. We run pooled regressions and a first difference model, the latter to deal with the contamination of results by omitted variables bias. Using two segregation indices and more than one productivity measure for robustness, we found segregation to have a significant and negative effect upon cities' productivity. We also found evidence of a U-shaped relationship between segregation and productivity. According to this finding, a low level of segregation of the high-skilled has a negative impact, but after a certain threshold has been reached this effect changes and becomes positive. Intuition tells us that below that threshold the segregation level is not capable of generating spillovers big enough to offset the productivity losses due to the isolation of the low-skilled group. Moreover, the analysis shows that there is a relationship between productivity, segregation and sectoral specialization. The segregation of high-skilled workers has a negative effect on the productivity of cities where most employment is generated by primary and secondary sectors. The same segregation could have a positive effect on productivity in cities where the bulk of employment is in tertiary sectors.

II. Literature review

A great deal of academic effort has gone into trying to understand the effects that segregation might have on the performance of individuals and cities alike. For a long time, the general view was that segregation had negative consequences only. More recently, a slew of articles have indicated that this phenomenon can affect households in a positive way. Regarding either type of effect, positive or negative, empirical research must deal with a serious problem of identification, and this is particularly true of segregation based on income. The question that has to be answered is: is a household poor because it is segregated, or segregated because it is poor? As a way of dealing with this endogeneity problem, the United States Department of Housing and Urban Development's Moving to Opportunity for Fair Housing (MTO) programme was designed as an experiment, providing randomly selected low-income families living in some of the most disadvantaged urban areas of the United States with the chance, through the provision of housing vouchers, to move to private sector housing in much less distressed communities. After 11 years of empirical research using the MTO data, the Department reached a striking conclusion: segregation had negligible effects on individuals' well-being except in the area of mental health. This finding reopened the discussion on the topic, and new research has been

carried out to look at the effects of segregation on well-being from other angles. For instance, Cuttler and Glaeser (1997), Anas (2002), Conejeros and Vargas (2012) and Corvalan and Vargas (2015) look for macro effects of segregation, while Bjerk (2010) investigates segregation effects on different types of crime, finding evidence that segregation increases violent crime, but not crime in the aggregate. Similarly, Kessler and others (2014) and Ludwig and others (2012 and 2013) investigate the impact of segregation on self-reported life satisfaction and mental health. A significant number of these new papers have found that segregation does have effects, but not necessarily in the areas that the traditional literature has identified. In particular, they indicate that segregation has no consequences for an individual's ability to be economically independent. More recently, Chetty, Hendren and Katz (2016) have found an answer to this puzzle: segregation has irreversible effects, which is why all previous studies using MTO data were not able to find significant consequences. These authors study the consequences for individuals who were very young when their families received vouchers under the MTO programme and find that exposure to a better neighbourhood has no impact on individuals' outcomes if it occurs after the age of 13.

Despite its importance, however, little has been said about segregation of the better-off and its consequences for society as a whole.[2] Probably the most important studies to have addressed this issue are Benabou (1993 and 1996) and Oltmans (2011). According to these, the segregation of high-income groups can have either positive or negative consequences. For instance, if higher levels of income are correlated with greater human capital, then the agglomeration of these groups produces positive spillovers. If these spillovers are enough to compensate for the loss of productivity faced by worse-off households owing to the existence of ghettos of low-skilled workers, aggregate city productivity will be greater because of segregation. However, if these spillovers are not enough to compensate for the productivity losses of the worse-off, then the aggregate effects will be negative. Given the relevance of these studies to the present research, the following subsection will discuss Benabou (1993) and Oltmans (2011) in more detail.

1. Segregation of the high-skilled and the outcomes for cities

Benabou (1993) develops a theoretical model for understanding how the segregation of the high-skilled might affect outcomes for cities. In this model, agents decide the skill level they want to achieve (high, low or none) and their residential location. If agents decide that their skill level is to be zero, they will be out of the labour market. An important assumption of this model is that the labour market embraces the whole city. Meanwhile, education is a local public good. In every neighbourhood, whether high-skilled or low-skilled, the more agents invest in education, the easier it is for them to obtain skills, but it is less easy in low-skilled neighbourhoods than in high-skilled ones. This asymmetry makes high-skilled agents bid for land in neighbourhoods inhabited by high-skilled workers, which will affect the city's economic surplus owing to the mix of abilities and the cost of educating the labour force. In consequence, education costs will grow faster in those communities with a high concentration of low-skilled workers. Hence, in their desire to live among peers, high-skilled workers will transform other communities into unproductive ghettos. A key element of this model is the relationship between local and global interactions, i.e. between educational spillovers, which are local to the neighbourhood level, and neoclassical production complementarities, which work at the city level. The segregation of high-skilled workers results in low-skilled workers' ghettos being left outside the labour market, because in these

[2] Since Piketty and Saez (2003), interest in top income analysis has grown very quickly. Given the high level of inequality in Latin America, this sort of analysis can be of great interest and yield numerous important policy implications for the region (see, for instance, Williamson, 2010).

ghettos education costs will be so high that agents will choose to have no skills at all and will therefore be left outside the labour market. Thus, the more easily high-skilled workers can isolate themselves, the higher unemployment will be. When perfect segregation is attained, the productive sector will collapse because the city's production function needs both inputs: high- and low-skilled workers. Therefore, the segregation of high-skilled workers will harm city productivity, because although the segregated high-skilled workers will more easily obtain better qualifications, segregation will deprive them of the low-skilled workers they need to work with.

Local complementarities operate in different ways. The most obvious is a fiscal externality: if schools are financed by local resources and if they provide an input that supplements individual effort, the return on education will be higher in communities with a high concentration of high-skilled workers because they earn higher wages. This mechanism would work through pure human capital externalities as well. These include peer effects in educational and social networks which decrease the cost of getting a job or provide role models for young people, whom the presence of high-skilled workers in the neighbourhood will teach about the importance of education. Lastly, an alternative explanation is provided by the negative externalities and disruptive influence created by some unemployed and low-skilled workers in the form of crime or drug abuse.

A different possibility is suggested by Oltmans (2011), who seeks to cast light on the causal role that racial segregation may play in urban poverty and inequality. The study is empirical and tests this causal role by examining the historical great migration of African Americans and the pattern of railways within cities. To establish a framework of ideas, she presents a very simple model, some of whose main features will now be discussed. First, there are two cities, one integrated C_I and one segregated C_s, that exist for two generations. The proportion of black inhabitants in each city is β and therefore the proportion of white inhabitants is 1-β. The average human capital for black and white inhabitants is μ_{HB} and μ_{HW}, respectively. From the historical record it is inferred that $\mu_{HB} < \mu_{HW}$. Consider the following human capital production function:

$$E\left[\lambda_2\right] = f\left(\lambda_1\right)\mu_{HI}^{\alpha} \tag{1}$$

Where $E[\lambda_2]$ is the expected value of the human capital of an individual's offspring, λ_1 is the individual's human capital, α_{HI} is the average human capital of the individual's neighbourhood and $\alpha \geq 0$. In C_I, black and white inhabitants are exposed to the same average human capital, $\beta\mu_{HB} + (1-\beta)\mu_{HW}$, while in C_s, white inhabitants are exposed to higher average human capital than black inhabitants, as $\mu_{HB} < \mu_{HW}$. If $\alpha < 1$, then personal human capital and average neighbourhood human capital are substitutes in the production of the next generation's human capital level, so that integration will produce higher human capital than segregation. If a>1, then personal human capital and average neighbourhood human capital are complements, so that segregation will produce higher levels of human capital than integration. The main finding of this work is that segregation increases black poverty and inequality between white and black inhabitants but reduces white poverty and inequality among white inhabitants. This an important study because of the identification strategy used, which makes it possible to isolate the impact of exogenous segregation on an individual's human capital.

Combining the findings of Benabou (1993) and Oltmans (2011) in relation to the segregation of high- and low-skilled workers, we can identify the following line of argument regarding the connection between segregation of high-skilled workers and urban productivity: the segregation of more advantaged individuals generates positive spillovers for them by reducing the costs of acquiring human capital. This process reduces inequality within the most advantaged population but increases inequality between the more advantaged groups and the less advantaged ones. In Oltmans (2011), these groups are white

and black inhabitants, while in Benabou (1993), and in the present article as well, they are high-skilled and low-skilled workers. Benabou (1993) points out that since the city production function needs both types of workers, segregation of high-skilled workers will have a negative effect on a city's production because it will raise the cost of acquiring human capital to the extent that low-skilled workers will prefer not to have any education at all, which in turn will cause the city's production to collapse, as it needs both types of workers. But what would happen if the city did not specialize in sectors that needed high-skilled and low-skilled workers as inputs, e.g. if the city specialized in technology or financial services, and consequently the degree of complementarity between high-skilled and low-skilled workers was very low? In this case, it is not clear that segregation would damage city productivity. Indeed, in the extreme case where a city does not need low-skilled workers at all, segregation of high-skilled workers will have a positive effect on its productivity. The empirical answer to this question will depend mainly on the following factors: first, the extent of specialization in industries that do not need low-skilled workers or the share of high-skilled workers in the city production function and, second, the productivity differences between high-skilled and low-skilled workers. The combination of these factors will tell us whether segregation of high-skilled workers will have a positive or negative impact on the city's productivity and will determine the equilibrium level of high-skilled workers' share of the city's total population.

On the basis of these concepts, we expect, other things being equal, to find the following possible relationship between the productivity of Latin American cities and the segregation of high-skilled workers:

(i) Segregation of high-skilled workers will have a negative effect on productivity in cities specializing in primary and secondary sectors.

(ii) Segregation of high-skilled workers will have a positive effect on productivity in cities specializing in tertiary and quaternary sectors.

Therefore, cities specializing in primary and secondary sectors where high-skilled workers are highly segregated should exhibit a low level of productivity, other things being equal, but cities specializing in the same sectors where high-skilled workers are not very segregated will have a high level of productivity. If a city specializes in tertiary or quaternary sectors, the relationship will be exactly the opposite of the one just described.

III. Methodology

1. A reduced form model

To identify which of the situations prevails in Latin American cities, the effect of segregation on productivity is captured in the following reduced form:

$$y_{i,t} = \alpha + \beta_1 s_{i,t} + X_{i,t}\beta_2 + \mu_{i,t}$$

Where $y_{i,t}$ represents productivity, $s_{i,t}$ is residential segregation and $X_{i,t}$ are control variables for city i during period t.

We calculate residential segregation based on education as a proxy for highly-skilled workers in Latin American cities. Specifically, we calculate segregation of household heads with a university degree. Then we obtain cities' productivity and regress productivity against traditional controls and segregation. Lastly, we use an econometric specification capable of dealing with potential endogeneity issues due to omitted variables bias.

2. Segregation measures

(a) The Duncan Segregation Index

This index can be obtained from the Lorenz curve. It represents the maximum vertical distance between the Lorenz curve and the diagonal line representing complete evenness. When the group under study is small in comparison with the number of geographical subareas (such as census districts), the Duncan Segregation Index is heavily affected by the deviation from evenness and is not sensitive to redistribution between geographical subareas where the proportion of the group under study is smaller than the same group's proportion of the city as a whole. With this index, just moving people belonging to the group under study from the geographical subareas where they are overrepresented to geographical subareas where they are underrepresented can affect the level of residential segregation (Massey and Denton, 1988).

The functional form of the Duncan Segregation Index is:

$$D = \sum_{i=1}^{n} \left[\frac{t_i}{p_i} - \frac{P}{2TP(1-P)} \right] \tag{2}$$

where t_i and p_i are the total population and minority population of areal unit i, and T and P are the population size and minority proportion of the whole city.

(b) The Gini coefficient

As Massey and Denton (1988) explain, another measure of evenness is the Gini coefficient. Like the Duncan Segregation Index, it can be derived from the Lorenz curve and varies between 0.0 and 1.0, with 1.0 indicating maximum segregation. The Gini coefficient corresponds to the mean absolute difference between minority proportions weighted across all pairs of subareas, expressed as a proportion of the maximum weighted mean difference.

$$Gini = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} t_i t_j p_i - p_j}{2T^2 P(1-P)} \tag{3}$$

Where t_i and p_i are the total population and minority population of areal unit i, and T and P are the population size and minority proportion of the whole city.

(c) City productivity

The *Competitive Cities in the Global Economy* report of the OECD Territorial Reviews series (OECD, 2006) shows that most Organisation for Economic Co-operation and Development (OECD) metro regions have higher productivity and growth than the average for the countries they are in. The report says that "...most OECD metro-regions have a higher GDP per capita than their national average (66 out of 78 metro-regions) and higher labour productivity (65 out of 78 metro-regions) and many of them tend to have faster growth rates than their countries" (OECD, 2006). Cities are centres of economic activity. As such, they are the main platforms for business, commerce and trade. This concentration of activity is at the root of the agglomeration economies which have been identified in the economic literature as the main source of productivity gains. The first sources of positive agglomeration effects were described

by Marshall (1920), who argued that having an industry located in one place resulted in labour market pooling, input sharing and knowledge spillovers that fostered the continued growth of that industry. In contrast to Marshallian specialization, Jacobs (1969) stresses the importance of urban diversity for the cross-fertilization of ideas. Strange and Rosenthal (2004) describe three sources of agglomeration economies that go beyond Marshall's and Jacobs' descriptions: the home market effect, consumption and rent-seeking. The home market effect described by Krugman (1980) comes from the interaction between internal scale economies in production and transport costs. This interaction leads to expansion of the home market in a self-reinforcing process of agglomeration. Consumption and rent-seeking are sources of agglomeration economies that work through mechanisms unrelated to productivity. On the empirical side, various studies have tried to measure the impact of agglomeration economies on the productivity of cities. Looking at the manufacturing sector, Fogarty and Garofalo (1978) find the elasticity of productivity to city size to be about 0.05 for a sample of 13 large metropolitan areas from 1957 to 1977. This means that the total factor productivity (TFP) of the manufacturing sector increases by 10% when the size of the city is doubled. Tabuchi (1986), using labour productivity, finds this elasticity to be about 0.02 for Japanese cities in 1980. These studies show the positive relationship between agglomeration economies and productivity in cities.

Whether agglomeration economies derive from city size or industry size is relevant for metropolises in Latin American. Most of the economies in Latin America are dependent on primary commodities which are produced close to small cities. The abundance of nearby natural resources creates conditions favourable to the production of such commodities. In these cities, the industry is large, which means that productivity is high relative to bigger cities. Antofagasta in Chile is a good example of a small city with a large mining industry. Although the copper is produced in rural areas, the sector that supplies services to the mining industry operates mainly in the city, and its productivity is high. Sveikauskas, Gowdy and Funk (1988) show that in these cases city productivity is high because of the large volume of natural resources in the area, suggesting that industry concentration is not enough to obtain high productivity.

Different measures can be used to compute the productivity of an economy. TFP is a legacy of the neoclassical literature (Solow, 1957) and one of the most widely used measures. An economy increases its productivity when it produces more with the same amount of labour and capital. Computing the TFP of a city requires calculation of its stock of capital and the number and characteristics of its workers. Although employee numbers are available, data on capital stock are not for most Latin America cities. In OECD (2006), labour productivity, computed as the ratio between GDP at purchasing power parity (PPP) and employment, is used as the primary measure for the productivity of metro-regions. Sveikauskas (1975) uses labour productivity in a set of manufacturing sectors as a proxy for city productivity. This measure is widely employed in the literature as presented by Eberts and McMillan (1999). Labour productivity has the advantage of being easy to calculate because the information requirements are low.

Following this literature, and in view of the poor availability of information for Latin American cities, labour productivity will be used as a proxy for city productivity. The labour productivity of a city c is computed as:

$$y_c = \frac{Y_c}{L_c} \tag{4}$$

Where Y_C and L_C are, respectively, value added and the total number of workers in city c. City value added is computed as:

$$Y_c = \sum_{i=1}^{n} \frac{l_{i,c}}{L_{i,N}} Y_i^N \tag{5}$$

Where Y_i^N is the value added by sector i in the national economy, l_{ic} is the number of employees working in sector i in city r, and $L_{i,N}$ is the total number of workers in the sector in the national economy. Using this specification to compute productivity involves the assumption that the technology employed to produce at the city and country level is the same in each economic sector. The specificity of the city is captured by the specificity index. This means that agglomeration affects the proposed productivity measure through the self-selection of economic sectors in each city. Cities have more workers in sectors where agglomeration has a greater effect.

IV. Data

1. Segregation data

As mentioned above, we use census samples from the Integrated Public Use Microdata Series (IPUMS). The information has been gathered for metropolitan areas. To obtain consistent and comparable information is a considerable challenge. To achieve this, we have sacrificed accuracy and granularity in some metropolitan areas. For instance, samples for metropolitan areas in Brazil have very detailed information down to the stratum level, but samples from other countries do not have the same level of detail. Consequently, for the calculation of segregation indices, we have used municipalities as the sub-areal unit. We have proceeded in this way in order to maintain consistency between all the indices calculated for each city, which enables us to make comparisons between metropolitan areas and provides a reasonable number of observations for the empirical analysis. We calculate segregation indices for 49 metropolitan areas around the year 2000 and 49 around the year 2010. We calculate 23 indices for each metropolitan area, but in view of the high level of correlation that they exhibit we have used only the Duncan and Gini indices for the analysis here. To calculate segregation, we define high-skilled individuals as household heads with a university degree. The metropolitan areas considered are shown in table 1. The specific metropolitan areas for each country and year are:

Argentina: In the case of Argentina, the cities are Greater Buenos Aires, Córdoba, Mendoza and Rosario. Greater Buenos Aires includes the Autonomous City of Buenos Aires and the Province of Buenos Aires. In the cases of Córdoba, Mendoza and Rosario, the provinces of Córdoba, Mendoza and Santa Fe, respectively, were considered.

Brazil: For Brazil, we collect information on the 10 biggest metropolitan regions: São Paulo, Rio de Janeiro, Salvador, Fortaleza, Belo Horizonte, Curitiba, Porto Alegre, Goiânia, Recife and Belém.

Bolivia (Plurinational State of): Information on the departments of La Paz, Cochabamba and Santa Cruz is collected for the metropolitan areas of the same names.

Chile: Instead of IPUMS data, information from the National Socioeconomic Survey (CASEN) for 2000 and 2009 is used to calculate segregation indices for Greater Santiago, Antofagasta, Viña del Mar-Valparaíso, Concepción and La Serena-Coquimbo in Chile. Greater Santiago consists of 30 municipalities belonging to the Santiago metropolitan area, while the metropolitan areas of Antofagasta, Viña del Mar-Valparaíso, Concepción and La Serena-Coquimbo consist of the provinces of Antofagasta, Valparaíso, Concepción and Elqui, respectively.

Colombia: The Colombian cities covered are Medellín, Bogotá and Barranquilla. The department of Antioquia is used as a proxy for the Medellín metropolitan area, the departments of Bogotá and Cundinamarca for the Bogotá metropolitan area and the department of Atlántico for the Barranquilla metropolitan area.

Costa Rica: Information on the province of San José is used as a proxy for the San José metropolitan area.

Dominican Republic: The Santo Domingo metropolitan area comprises the province of Santo Domingo.

Ecuador: The cities included are Guayaquil, Quito, Cuenca and Santo Domingo, and data were collected for the provinces of Guayas, Pichincha, Azuay and Santo Domingo, respectively.

Mexico: The metropolitan area of Valley of Mexico is made up of 76 municipalities (*delegaciones*), 11 belonging to Mexico City, 59 to Mexico State and 1 to Hidalgo State. The other metropolitan areas are Guadalajara, Monterrey, Puebla, Toluca, Tijuana, Ciudad Juárez, Laguna, San Luis de Potosí and León. All meet the definition of a metropolitan area given by the Mexican National Institute of Statistics and Geography.

Panama: The province of Panamá was used as a proxy for the Panama City metropolitan area.

Paraguay: The Asunción metropolitan area is made up of two districts, Capital and Central.

Peru: The Peruvian metropolitan areas considered here are Lima/Callao, Chiclayo, Arequipa and Trujillo, with the provinces of Lima and Callao, Lambayeque, Arequipa and La Libertad, respectively, being used as proxies.

Uruguay: In the case of Uruguay, the information is for the department of Montevideo.

Table 1
Latin America (13 countries): cities included in the sample for the study of segregation

Country	Cities	Country	Cities
Argentina	Greater Buenos Aires	Dominican Republic	Santo Domingo
	Córdoba	Ecuador	Guayaquil
	Mendoza		Quito
	Rosario		Cuenca
Bolivia (Plurinational State of)	La Paz		Santo Domingo
	Cochabamba	Mexico	Mexico City
	Santa Cruz		Guadalajara
Brazil	São Paulo		Monterrey
	Rio de Janeiro		Puebla
	Salvador		Toluca
	Fortaleza		Tijuana
	Belo Horizonte		Juárez
	Curitiba		Laguna
	Porto Alegre		Querétaro
	Goiânia		San Luis de Potosí
	Recife		León
	Belém	Panama	Panama City
Colombia	Medellín	Paraguay	Greater Asunción
	Bogotá	Peru	Lima
	Barranquilla		Chiclayo
Costa Rica	San José		Arequipa
Chile	Greater Santiago		Trujillo
	Antofagasta	Uruguay	Montevideo
	Viña del Mar-Valparaíso La Serena-Coquimbo		Concepción

Source: Prepared by the authors.

Tables 2 and 3 present segregation rankings based on the Duncan and Gini indices, respectively. On both measures, the Chilean capital Santiago was by far the most segregated metropolitan area in 2000 and 2010. In the Duncan Segregation Index rankings, Brazil had 4 cities among the 10 most segregated in 2000 and 2010 (Porto Alegre, Belo Horizonte, Curitiba and Rio de Janeiro). Bolivian cities (Santa Cruz and La Paz) were also among the most segregated. Montevideo is another city which exhibits high levels of segregation on both the Duncan and Gini indices.

Table 2
Latin America (13 countries): segregation rankings of cities based on the Duncan Segregation Index, 2000 and 2010

Ranking in 2000			Ranking in 2010		
Country	City	Duncan index value	Country	City	Duncan index value
Chile	Santiago	0.4758	Chile	Santiago	0.5237
Brazil	Porto Alegre	0.4264	Bolivia (Plurinational State of)	Santa Cruz	0.4092
Bolivia (Plurinational State of)	Santa Cruz	0.4092	Uruguay	Montevideo	0.3869
Uruguay	Montevideo	0.3869	Brazil	Porto Alegre	0.3864
Brazil	Belo Horizonte	0.3845	Bolivia (Plurinational State of)	La Paz	0.3834
Bolivia (Plurinational State of)	La Paz	0.3834	Paraguay	Asunción	0.3825
Paraguay	Asunción	0.3825	Brazil	Belo Horizonte	0.3444
Brazil	Curitiba	0.3496	Brazil	Curitiba	0.3404
Brazil	Rio de Janeiro	0.3346	Brazil	Rio de Janeiro	0.3143
Argentina	Buenos Aires	0.3317	Colombia	Medellín	0.3114
Argentina	Mendoza	0.3222	Argentina	Buenos Aires	0.3108
Colombia	Medellín	0.3114	Argentina	Mendoza	0.3071
Peru	Trujillo	0.2954	Mexico	Toluca	0.3024
Mexico	Toluca	0.2898	Peru	Trujillo	0.2954
Argentina	Córdoba	0.2852	Mexico	Mexico City	0.2927
Ecuador	Cuenca	0.2818	Ecuador	Cuenca	0.2818
Colombia	Barranquilla	0.2787	Colombia	Barranquilla	0.2787
Bolivia (Plurinational State of)	Cochabamba	0.2763	Bolivia (Plurinational State of)	Cochabamba	0.2763
Mexico	Mexico City	0.2715	Brazil	Recife	0.2594
Mexico	Monterrey	0.268	Chile	Concepción	0.2565
Costa Rica	San José	0.2579	Argentina	Córdoba	0.2514
Brazil	Fortaleza	0.2493	Brazil	Fortaleza	0.2408
Dominican Republic	Santo Domingo	0.2362	Mexico	Puebla	0.2383
Argentina	Rosario	0.2294	Mexico	Monterrey	0.2379
Mexico	Laguna	0.224	Costa Rica	San José	0.2326
Chile	Concepción	0.2202	Argentina	Rosario	0.2322
Mexico	Puebla	0.215	Mexico	Guadalajara	0.2261
Brazil	Recife	0.2148	Dominican Republic	Santo Domingo	0.2161
Ecuador	Guayaquil	0.213	Ecuador	Guayaquil	0.213
Brazil	São Paulo	0.2055	Mexico	Querétaro	0.1837
Mexico	Guadalajara	0.186	Brazil	São Paulo	0.1832
Brazil	Belém	0.1805	Colombia	Bogotá	0.1788
Colombia	Bogotá	0.1788	Brazil	Belém	0.1757
Chile	La Serena-Coquimbo	0.172	Peru	Arequipa	0.1705
Peru	Arequipa	0.1705	Chile	Viña del Mar-Valparaíso	0.1606
Peru	Chiclayo	0.1517	Mexico	Laguna	0.1596
Panama	Panama City	0.1494	Brazil	Salvador	0.1543
Ecuador	Quito	0.1489	Peru	Chiclayo	0.1517
Brazil	Salvador	0.1364	Ecuador	Quito	0.1489
Mexico	Querétaro	0.1334	Panama	Panama City	0.1404
Mexico	San Luis Potosí	0.1302	Mexico	Juárez	0.1389
Mexico	León	0.118	Mexico	León	0.1126
Ecuador	Santo Domingo	0.111	Ecuador	Santo Domingo	0.111
Mexico	Juárez	0.0892	Mexico	San Luis Potosí	0.1087
Chile	Viña del Mar-Valparaíso	0.0809	Peru	Lima	0.0754
Peru	Lima	0.0754	Chile	La Serena-Coquimbo	0.07
Mexico	Tijuana	0.0479	Chile	Antofagasta	0.0651
Chile	Antofagasta	0.0366	Brazil	Goiânia	0.0557
Brazil	Goiânia	0.0335	Mexico	Tijuana	0.0225

Source: Prepared by the authors.

Table 3
Latin America (13 countries): segregation rankings of cities based on the Gini coefficient, 2000 and 2010

Ranking in 2000			Ranking in 2010		
Country	City	Gini	Country	City	Gini
Chile	Santiago	0.6323	Chile	Santiago	0.6547
Uruguay	Montevideo	0.5224	Uruguay	Montevideo	0.5224
Bolivia (Plurinational State of)	Santa Cruz	0.4871	Bolivia (Plurinational State of)	Santa Cruz	0.4871
Brazil	Porto Alegre	0.4675	Paraguay	Asunción	0.4642
Paraguay	Asunción	0.4642	Brazil	Porto Alegre	0.4304
Argentina	Mendoza	0.4375	Mexico	Mexico City	0.4144
Argentina	Buenos Aires	0.4335	Argentina	Mendoza	0.4063
Brazil	Belo Horizonte	0.4049	Bolivia (Plurinational State of)	La Paz	0.3877
Bolivia (Plurinational State of)	La Paz	0.3877	Brazil	Belo Horizonte	0.3859
Mexico	Mexico City	0.3807	Colombia	Medellín	0.3678
Colombia	Medellín	0.3678	Mexico	Toluca	0.3646
Mexico	Monterrey	0.3661	Argentina	Buenos Aires	0.3635
Brazil	Rio de Janeiro	0.3659	Brazil	Curitiba	0.3561
Brazil	Curitiba	0.3582	Mexico	Monterrey	0.3497
Costa Rica	San José	0.3576	Brazil	Rio de Janeiro	0.3455
Mexico	Toluca	0.3504	Chile	Concepción	0.3326
Argentina	Córdoba	0.3307	Costa Rica	San José	0.3306
Peru	Trujillo	0.3237	Peru	Trujillo	0.3237
Dominican Republic	Santo Domingo	0.3016	Mexico	Guadalajara	0.3044
Chile	Concepción	0.294	Argentina	Córdoba	0.3021
Colombia	Barranquilla	0.2927	Dominican Republic	Santo Domingo	0.2965
Ecuador	Cuenca	0.2837	Brazil	Recife	0.2963
Bolivia (Plurinational State of)	Cochabamba	0.2836	Colombia	Barranquilla	0.2927
Mexico	Guadalajara	0.267	Mexico	Querétaro	0.2883
Argentina	Rosario	0.2587	Ecuador	Cuenca	0.2837
Brazil	Recife	0.2547	Bolivia (Plur. State of)	Cochabamba	0.2836
Brazil	Fortaleza	0.2516	Argentina	Rosario	0.2677
Ecuador	Guayaquil	0.243	Mexico	Puebla	0.2574
Brazil	São Paulo	0.2374	Brazil	Fortaleza	0.2449
Mexico	Puebla	0.2374	Ecuador	Guayaquil	0.243
Mexico	Laguna	0.237	Brazil	São Paulo	0.21
Chile	La Serena-Coquimbo	0.1948	Chile	Viña del Mar-Valparaíso	0.2088
Brazil	Belém	0.1862	Colombia	Bogotá	0.1862
Colombia	Bogotá	0.1862	Brazil	Belém	0.1843
Peru	Arequipa	0.173	Mexico	Laguna	0.179
Panama	Panama City	0.1573	Peru	Arequipa	0.173
Peru	Chiclayo	0.1518	Brazil	Salvador	0.1584
Ecuador	Quito	0.1501	Peru	Chiclayo	0.1518
Brazil	Salvador	0.1417	Panama	Panama City	0.1512
Mexico	Querétaro	0.1412	Ecuador	Quito	0.1501
Mexico	San Luis Potosí	0.1302	Mexico	Juárez	0.1389
Ecuador	Santo Domingo	0.126	Ecuador	Santo Domingo	0.126
Mexico	León	0.1207	Mexico	León	0.1154
Chile	Viña del Mar-Valparaíso	0.1148	Mexico	San Luis Potosí	0.1087
Mexico	Juárez	0.0892	Chile	La Serena-Coquimbo	0.0924
Peru	Lima	0.079	Peru	Lima	0.079
Mexico	Tijuana	0.0485	Chile	Antofagasta	0.0654
Chile	Antofagasta	0.0368	Brazil	Goiânia	0.0561
Brazil	Goiânia	0.0335	Mexico	Tijuana	0.0227

Source: Prepared by the authors.

Among the least segregated cities are Antofagasta and Valparaíso in Chile, Goiânia in Brazil, Tijuana and León in Mexico, Lima in Peru and Santo Domingo in Ecuador. We have also calculated the segregation of household heads without any qualifications. Table 4 shows descriptive statistics for both types of segregation. As can be appreciated, segregation is greater in the case of high-skilled workers and is relatively constant in both cases.

Table 4
Latin America (13 countries):[a] descriptive statistics for segregation by skill groups, 2000 and 2010

Variable	Mean	Standard deviation	Minimum	Maximum
Duncan Segregation Index high-skilled, full sample	0.2310194	0.1066767	0.0225	0.5237
Duncan Segregation Index high-skilled, 2000	0.2314388	0.1083908	0.0355	0.4758
Duncan Segregation Index high-skilled, 2010	0.2306	0.1060564	0.0225	0.5237
Duncan Segregation Index low-skilled, full sample	0.1791367	0.0849578	0.0151	0.3958
Duncan Segregation Index low-skilled, 2000	0.1799375	0.0827937	0.0359	0.3888
Duncan Segregation Index low-skilled, 2010	0.1779898	0.0886876	0.0151	0.3958

Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

If these results are compared with those of cities in more developed countries, it transpires that segregation values are not much different. For instance, table 5 presents the evolution of high-income and low-income segregation in the United States between 1970 and 2009. Segregation levels are very similar to those in Latin American cities, although not quite as high. It can be observed that segregation of the better-off is systematically higher in Latin American cities as well. However, mean values have increased in the United States while holding more or less steady in Latin America.

Table 5
United States: average segregation by income groups, 1970–2009

	1970	1980	1990	2000	2007	2008	2009
Segregation of poverty	0.112	0.124	0.153	0.146	0.158	0.163	0.163
Segregation of affluence	0.173	0.156	0.189	0.185	0.195	0.202	0.200

Source: Prepared by the authors.

2. Productivity data

Data-gathering for this project involved three main challenges. First, the information had to be collected from countries that have different models for constructing their statistical information. Second, there is no agreement between countries on what defines a city. Third, there are large differences in data availability between Latin American countries. In order to reduce the sources of variability, most of the data used to compute the indices of segregation and employment were collected from IPUMS-International. This is an effort by the Minnesota Population Center at the University of Minnesota to inventory, preserve, harmonize and disseminate census microdata from around the world. The information on the sectoral value added of each country was obtained from OECD input-output tables (OECD, 2021). Lastly, when harmonized data were lacking, information from the national institutes of statistics and central banks of each country was used. Two criteria were applied to select the metropolises to be included in the regressions, namely the importance of the city within a country and the availability of data for the city. The importance of a city was mainly measured by its population relative to the national population. Following these criteria, 49 cities in 13 countries are presented. In many cases, lack of information from the countries means that the information cannot be computed for specific years (table A1.1 itemizes data availability for each city around the initial and final year). When the demographic information does not match the value added information, the demographic data are updated in accordance with the

population growth rate reported by each country during the period. In order to compare the productivity of city c at time t with that of another city in a different country or in the period ($t + 1$), all productivity figures were converted using the Big Mac index. In addition, productivity converted to PPP dollars and updated using the dollar inflation rate was used to compare productivity across countries. Table 6 provides abbreviated city rankings by productivity per worker at PPP in 2000 and 2010. It can be seen that the positions of the most productive cities changed considerably over the 10-year period. However, the ranking is more static where the bottom-ranked five cities are concerned (table A1.2 in annex A1 gives full city rankings based on the Big Mac index).

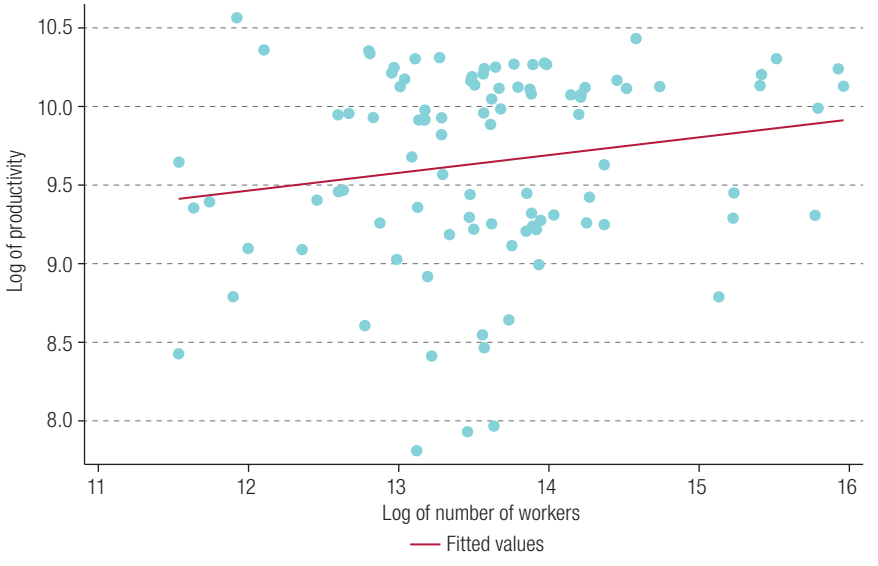
Table 6
Latin America (6 countries): rankings of cities by productivity, 2000 and 2010

Ranking in 2000	Ranking in 2010	Country	City
18	1	Chile	Antofagasta
19	2	Chile	Santiago
23	3	Chile	La Serena-Coquimbo
20	4	Chile	Viña del Mar-Valparaíso
21	5	Chile	Concepción
13	6	Uruguay	Montevideo
1	7	Argentina	Buenos Aires
2	8	Argentina	Mendoza
45	45	Paraguay	Asunción
42	46	Ecuador	Santo Domingo
47	47	Bolivia (Plurinational State of)	La Paz
48	48	Bolivia (Plurinational State of)	Santa Cruz
49	49	Bolivia (Plurinational State of)	Cochabamba

Source: Prepared by the authors.

Figure 1 is a scatter chart plotting the number of workers in each city against the city's productivity. The line shows that there is a positive relationship, suggesting the presence of economies of agglomeration. In the upper-left corner are two small cities with high productivity. These are Antofagasta and La Serena-Coquimbo in Chile, where the mining sector is influential.

Figure 1
Latin America (13 countries):[a] agglomeration economies in selected cities, 2000 and 2010



Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

V. Empirical analysis and results

The first empirical exercise that we perform is a pooled regression. The reason is that while collecting consistent and comparable information for 49 cities in Latin America is a challenging task, for the purposes of empirical analysis this is still only a small sample. Using information for 2000 and 2010 in a pooled regression increases the sample to 98 observations, which is a more suitable number for econometric analysis. The additional controls used for this regression are the proportion of high-skilled workers in the metropolitan area, the per capita GDP in PPP of the country concerned, a year dummy and city population. The dependent variables used are productivity deflated by the Big Mac index and productivity in PPP terms, as explained earlier. Descriptive statistics for these variables are shown in table 7. As can be appreciated, the mean of all these variables increased during the period 2000–2010. It can also be observed that the continent is quite heterogenous and unequal.

Table 7
Latin America (13 countries):[a] descriptive statistics of variables for empirical analysis of segregation in selected cities, 2000 and 2010

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
2000					
Big Mac index	49	6 260.575	2 894.455	1 090.809	11 166.74
Productivity	49	13 592.87	6 724.517	2 465.228	26 984.03
Per capita GDP	49	8 574.673	2 445.306	3 497	13 188
Proportion of high-skilled workers	49	0.1024776	0.0324008	0.0318	0.1661
Population	49	1 187 125	1 565 015	102 183	7 210 874
2010					
Big Mac index	49	6 627.128	3 221.966	1 208.268	11 618.85
Productivity	49	22 534.07	8 384.848	4 502.31	38 739.53
Per capita GDP	49	13 292.18	3 637.439	5 289	1 8249
Proportion of high-skilled workers	49	0.1244531	0.0436779	0.0318	0.2298
Number of workers	49	1 441 099	1 820 342	112 930	8 545 510

Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Intuition says that these correlations should all be positive: the most productive cities should have higher average income per worker and income per capita and should attract more people to work there, drawing in a more educated labour force. Figure 2 presents scatter plots showing the unconditional relationship between these variables and productivity (log of the Big Mac index). As expected, all these variables have a positive effect on productivity. The clearest impact is from per capita GDP and income per worker, but the proportion of high-skilled workers can be seen to have a similar effect. The relationship between productivity and the number of workers in a city is weaker, albeit still positive. Of course, these are just correlations, and it should be borne in mind that there is a major issue with endogeneity between the variables.

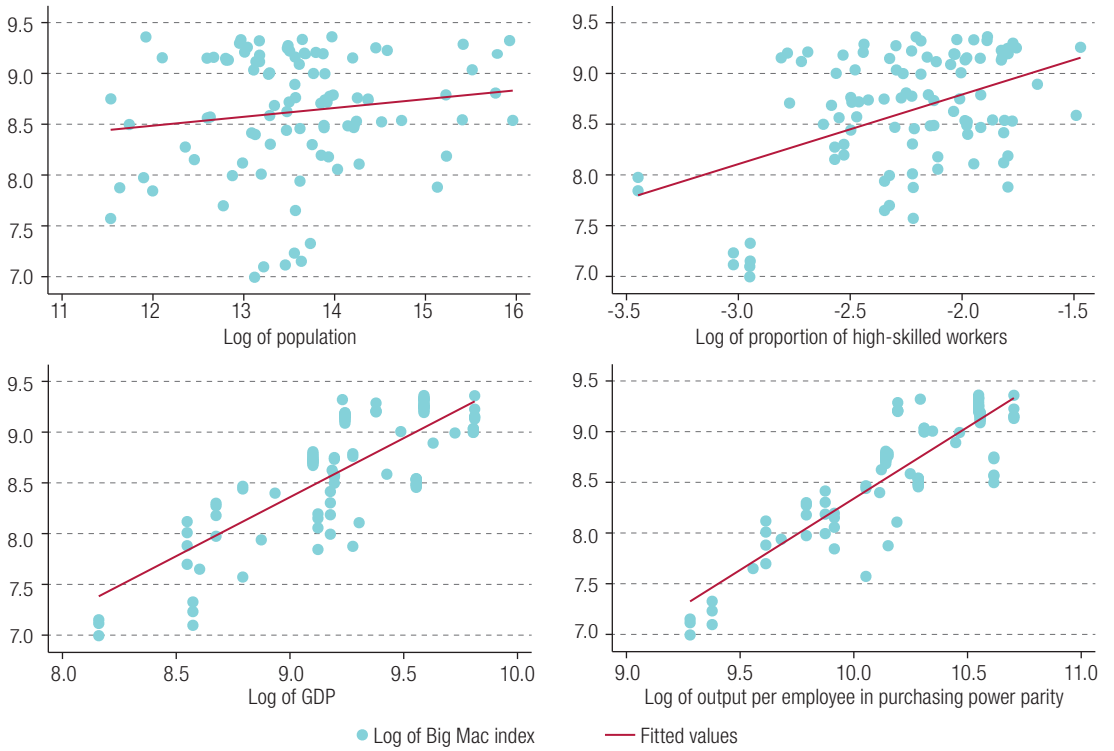
For robustness we have conducted four regressions using as the dependent variables productivity measured in PPP terms and deflated by the Big Mac index and segregation as measured by the Duncan and Gini indices. Standard errors are clustered by country. Table 8 shows the results of these four pooled regressions.[3] Segregation is not significant in any of them, but the sign of the relevant parameters is always negative. However, this regression is most certainly affected by an omitted variable bias problem. As Oltmans (2011, p. 3) explains: "…some unmeasured economic, political, or other attribute may lead certain cities to have both more segregation and more negative characteristics than other cities. For example, cities such as Detroit are highly segregated and their residents have poor economic outcomes, but other characteristics, such as political corruption or the legacy of a manufacturing economy, may

[3] We have performed multicollinearity tests for this set of regressions and those that will be presented below, namely the variance inflation factor (VIF), square root of the VIF, tolerance and R-squared tests. Results are presented in table A1.4. In none of the cases analysed is there any evidence of multicollinearity.

be a cause of both. Failure to entirely capture such attributes will cause omitted variable bias in OLS estimates of the relationship between segregation and population characteristics."

Figure 2

Latin America (13 countries):[a] unconditional relationship between productivity and population, high-skilled workers, total GDP and per capita income in selected cities, 2000 and 2010



Source: Prepared by the authors.

[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Table 8

Latin America (13 countries):[a] pooled regressions from empirical analysis of segregation in selected cities, 2000 and 2010

	(1)	(2)	(3)	(4)
	Log of productivity	Log of productivity	Log of Big Mac index	Log of Big Mac index
Duncan Segregation Index	-0.100		-0.240	
	(0.186)		(0.254)	
Proportion of high-skilled workers	1.519*	1.548*	1.620**	1.677**
	(0.560)	(0.550)	(0.441)	(0.433)
Log of GDP	1.481***	1.486***	1.554***	1.564***
	(0.0616)	(0.0620)	(0.0551)	(0.0568)
Log of number of workers	0.0190	0.0166	0.0231	0.0191
	(0.0443)	(0.0444)	(0.0590)	(0.0592)
Year dummy	-0.141	-0.143	-0.673	-0.677
	(0.0899)	(0.0890)	(0.0761)	(0.0748)
Gini coefficient		-0.0296		-0.110
		(0.150)		(0.212)
Constant	-4.363***	-4.388***	-5.823***	-5.887***
	(0.751)	(0.785)	(0.832)	(0.905)
N	98	98	98	98
R-squared	0.895	0.895	0.837	0.836

Source: Prepared by the authors.

Note: Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001.

[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Given the characteristics of our sample, we have opted for a first difference approach which allows us to address the omitted variable problem because it uses repeated observations over time to remove time-invariant omitted variables. As Wooldridge (2001) explains, if we have an omitted variable in the following set of equations:

$$y_{it} = x_{it}\beta + c_i + u_{it}, \quad t = 1, ..., T \tag{6}$$

$$y_{i,t-1} = x_{i,t-1}\beta + c_i + u_{it}, \quad t = 1, ..., T \tag{7}$$

Then by differencing the two equations we get:

$$\Delta y_{it} = \Delta x_{it}\beta + \Delta u_{it}, \quad t = 2, ..., T \tag{8}$$

Which removes the omitted variable c_i. As first differences and fixed effects estimators are numerically equivalent when T=2, we have used a panel data fixed effects model to implement the first differences regressions. As before, standard errors are clustered by country. The results are displayed in table 9.

Table 9
Latin America (13 countries):[a] first differences from empirical analysis of segregation in selected cities, 2000 and 2010

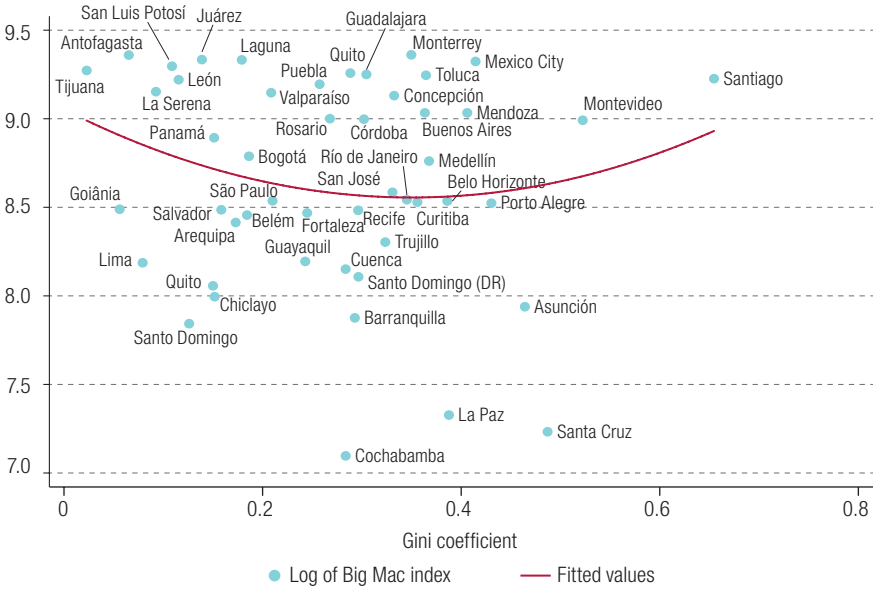
	(1)	(2)	(3)	(4)
	Log of productivity	Log of productivity	Log of Big Mac index	Log of Big Mac index
Duncan Segregation Index	-0.422		1.594*	
	(0.865)		(0.721)	
Proportion of high-skilled workers	1.310	1.335	-1.977	-2.194
	(1.865)	(1.997)	(2.109)	(2.092)
Log of GDP	1.716**	1.711**	1.061	1.074
	(0.553)	(0.543)	(0.700)	(0.716)
Log of number of workers	0.277	0.291	0.0269	-0.0287
	(0.508)	(0.499)	(0.455)	(0.462)
Year dummy	-0.295	-0.295	-0.375	-0.368
	(0.340)	(0.333)	(0.374)	(0.384)
Gini coefficient		-0.362		1.663*
		(1.052)		(0.753)
Constant	-9.866	-10.01	-1.487	-0.911
	(11.65)	(11.52)	(12.15)	(12.38)
N	98	98	98	98
R-squared	0.860	0.860	0.307	0.323

Source: Prepared by the authors.
Note: Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Segregation is still not significant, except in the case where productivity is measured using the Big Mac index and segregation using the Gini index. Something striking on this occasion is that the sign for segregation is positive. This could be the result of the omitted variable bias being corrected by the first difference regression. Nevertheless, we explore the hypothesis of a potential non-linear relationship between productivity and segregation. Figure 3 presents the scatter plot between the log of productivity (Big Mac index) and the Gini index and a quadratic fitted curve.

As can be observed, there seems to be a non-linear relationship between productivity and segregation. Consequently, we should include a segregation quadratic term in the regression. Since the line is U-shaped, we should expect a negative sign for the linear term and a positive one for the quadratic. Table 10 shows the results of this new group of first difference regressions, including the quadratic segregation term.

Figure 3
Latin America (13 countries):[a] Non-linear relationship between productivity and segregation, 2000 and 2010



Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Table 10
Latin America (13 countries):[a] first differences with quadratic segregation of variables in empirical analysis of segregation in selected cities, 2000 and 2010

	(1)	(2)	(3)	(4)
	Log of productivity	Log of productivity	Log of Big Mac index	Log of Big Mac index
Duncan Segregation Index	1.142		-2.883*	
	(1.389)		(1.290)	
Duncan Segregation Index 2	-4.040		11.56**	
	(4.466)		(2.938)	
Proportion of high-skilled workers	1.280	1.345	-1.892	-2.054
	(1.719)	(1.998)	(1.994)	(2.079)
Log of GDP	1.743*	1.707**	0.985	1.018
	(0.582)	(0.550)	(0.585)	(0.618)
Log of number of workers	0.283	0.286	0.0104	-0.106
	(0.513)	(0.499)	(0.434)	(0.422)
Year dummy	-0.309	-0.292	-0.334	-0.320
	(0.354)	(0.334)	(0.318)	(0.328)
Gini coefficient		-0.746		-3.631***
		(2.319)		(0.480)
Gini coefficient 2		0.852		11.74***
		(6.604)		(1.567)
Constant	-10.28	-9.874	-0.305	0.984
	(11.99)	(11.61)	(10.97)	(11.10)
N	98	98	98	98
R-squared	0.861	0.860	0.378	0.412

Source: Prepared by the authors.
Note: Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

As expected, the signs are negative in the linear term and positive in the quadratic one in three of the four regressions, ratifying what can be seen in the figure 3 scatter plot. Of the regressions, regression 4 in table 10 is the one that exhibits the best fit. This regression uses the Gini and quadratic Gini as the segregation variable and the logarithm of the Big Mac index as the productivity measure. To learn whether this procedure has been successful in removing the omitted variables problem, we used the Shapiro-Wilk test to ascertain whether the errors of this regression exhibited a normal distribution. In the case of regression 4 in table 10, the hypothesis that the errors have a normal distribution cannot be rejected.

This finding can be explained by the following argument. According to Benabou (1993), the consequences of segregation for cities' outcomes depend on the interplay between local and global complementarities. Local complementarities concern educational spillovers that individuals experience in their neighbourhoods, while global complementarities concern the way the high-skilled and low-skilled labour forces complement each other in the production function. If segregation precludes the correct functioning of global complementarities because it shuts low-skilled workers out of the labour market, then segregation will have a negative effect on a city's productivity and in the long run the economy will collapse. However, if global complementarities are not very significant, e.g. because the city specializes in a production sector such as the financial sector where these complementarities are less important, then the city's output will not suffer from segregation but, on the contrary, will be improved by it.

The left side of the scatter plot in figure 3 shows metropolitan areas such as Tijuana, León, Antofagasta and La Serena. These cities exhibit low levels of segregation and are highly productive. The main production sectors in these cities are manufacturing and mining, which are clearly sectors that need both high-skilled and low-skilled workers, so that in this case a high level of segregation would have a negative impact on cities' outcomes, i.e. for the overall economy, global complementarities are more important than local ones. At the other extreme, Santiago and Montevideo are highly segregated and highly productive. These cities specialize in the tertiary sector. In the case of Santiago, for instance, almost 80% of the economy is accounted for by this sector and 30% by financial services. Consequently, global complementarities between high-skilled and low-skilled workers are less important in these cities, and local spillovers predominate.

The worst situation is that found in Bolivian cities: they specialize in economic sectors which take advantage of global complementarities, such as agriculture, but exhibit high levels of segregation (above the mean). In this case, therefore, segregation has a negative effect on productivity, as can be inferred from figure 3.

To provide a clearer picture, figure 4 presents the correlation between productivity and the Gini coefficient. The left panel shows this correlation when cities specialize in primary and secondary sectors.[4] As can be appreciated, the correlation in this case is negative. The right panel shows the correlation when cities specialize in tertiary sectors.[5] By contrast with the previous case, the correlation between productivity and high-skilled workers' segregation is positive.

Additionally, we run two regressions incorporating both the scenarios explained in the previous paragraph. Table 11 shows the results of these regressions. In the first case, the correlation is negative and significant at 10%, while in the second case, the correlation is positive but not statistically significant, perhaps because of the small size of the sample (just 53 observations).

[4] The share of a city's primary sector is computed as the proportion of workers employed in agriculture, fishing, forestry, mining and energy supply in the city. The share of the secondary sector is computed as the proportion of workers in manufacturing and construction.

[5] The share of the tertiary sector is computed as the proportion of all the city's workers employed in transportation, communications, financial services, insurance, education, business services, public administration, health services and social work. Note that wholesale and retail trade, hotels and restaurants were left out of this definition.

Figure 4
Latin America (13 countries):[a] correlation of productivity and segregation in selected cities, by sectors of specialization, 2000 and 2010

Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Table 11
Latin America (13 countries):[a] sectoral productivity and segregation, 2000 and 2010

Variable	Primary and secondary sectors	Tertiary sector
	Log of Big Mac index	Log of Big Mac index
Gini coefficient	-0.408*	0.22
	(0.239)	(0.21)
Proportion of high-skilled workers	2.109**	1.21
	(0.806)	(0.98)
Log of GDP	1.551***	1.62***
	(0.0894)	(0.15)
Log of population	0.0479	0.0075
	(0.0348)	(0.03)
Year dummy	-0.646***	-0.748***
	(0.0655)	(0.101)
Constant	-6.102***	-6.3***
	(0.866)	(1.52)
Observations	75	53
R-squared	0.87	0.7

Source: Prepared by the authors.
Note: Standard errors are in parentheses. *p < 0.01, **p < 0.05, ***p < 0.1.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

This analysis seems to validate the argument that the segregation of high-skilled workers has a negative effect on productivity when cities specialize in the primary and secondary sectors but a positive effect when cities specialize in the tertiary sector.

VI. Conclusions

The aim of this study has been to cast light on the relationship between Latin American cities and the residential segregation of high-skilled workers. It is important to research this issue because, as the literature has pointed out, spatial isolation of the better-off can be expected to produce momentous

effects for the economy as whole. To achieve our goal, we collected census sample information from the Minnesota Population Center website (IPUMS) in order to calculate measures of productivity and segregation indices for cities. Gathering this data was a challenging task owing to differences between countries in the quality, detail and other characteristics of data. We were finally able to obtain consistent and comparable information for 49 cities around 2000 and the same groups of cities around 2010.

Our definition of a city is as close to a functional city as possible. Consequently, we work with metropolitan areas as defined by each country's office of statistics. High-skilled workers are defined as household heads with a university degree. We use the Duncan and Gini segregation indices. We calculated productivity per worker and deflated it by the Big Mac index as a productivity measure, then conducted pooled and first difference regressions using productivity as the dependent variable and segregation plus other controls as independent variables. We found evidence of a non-linear relationship between productivity and segregation of high-skilled workers. Specifically, this relationship presents as a U-shaped curve.

The potential explanation of this relationship is that the consequences of segregation for cities' outcomes depend on the interplay between local and global complementarities. Local complementarities concern educational spillovers that individuals experience in their neighbourhoods, while global complementarities are related to the way high-skilled and low-skilled workers complement each other in the production function. If segregation precludes the correct functioning of global complementarities because it leaves low-skilled workers outside the labour market, then segregation will have a negative effect on a city's productivity and in the long run the economy will collapse. Notwithstanding, if global complementarities are not very significant, for instance because the city specializes in a production sector such as the financial sector where these complementarities are less important, then the city's output will not suffer from segregation.

As an example of this relationship, we can observe what happens in cities such as Tijuana, Antofagasta, Santiago and Santa Cruz de la Sierra. The first two cities have high levels of productivity but low levels of segregation. This can be explained in the light of global and local complementarities. As the two cities specialize in manufacturing and mining, respectively, global complementarity between high-skilled and low-skilled workers can be expected to be strong and more important than local complementarities in education. Since segregation leaves low-skilled workers outside the labour market, and these are important in the production function, segregation in this case will harm productivity.

In the case of Santiago, we observe high productivity and high segregation. This too can be explained by the city's specialization. Because a substantial part of Santiago's economic activity is in the area of financial services, where complementarities between high-skilled and low-skilled workers are less obvious, local complementarities in education turn to be more important, and hence segregation has a positive impact on productivity.

Santa Cruz de la Sierra in the Plurinational State of Bolivia presents the worst combination: it is a city whose main specialization is in agriculture, a sector where production complementarities between high-skilled and low-skilled workers are important, yet it exhibits a high level of segregation, which harms productivity in this case.

The effect of segregation on cities' productivity thus depends on the interaction of production complementarities between high-skilled and low-skilled workers and educational complementarities at the local level, as Benabou (1993) points out, which in turn is strongly connected to the city's specialization. If the city's main production sector requires global complementarities between these two types of workers, as in manufacturing, mining and agriculture, then residential isolation of the high-skilled, which precludes them, will harm productivity. If the city's productive specialization does not require complementarities, however, segregation will not harm productivity but will improve local spillovers in education, which will ultimately enhance the city's outcomes.

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Annex A1

The tables in this annex supplement those presented in the main body of the text.

Table A1.1
Latin America (13 countries):[a] sources of productivity data used in the study of segregation in selected cities

City	Employment data	Value added data	City	Employment data	Value added data
Santiago	2000 CASEN	2000 OECD	San Luis de Potosí	2010 IPUMS	2010 OECD
Santiago	2009 CASEN	2010 OECD	León	2000 IPUMS	2000 OECD
Antofagasta	2000 CASEN	2000 OECD	León	2010 IPUMS	2010 OECD
Antofagasta	2009 CASEN	2010 OECD	Buenos Aires	2001 IPUMS	2000 OECD
Viña del Mar-Valparaíso	2000 CASEN	2000 OECD	Buenos Aires	2010 IPUMS	2010 OECD
Viña del Mar-Valparaíso	2009 CASEN	2010 OECD	Córdoba	2001 IPUMS	2000 OECD
Concepción	2000 CASEN	2000 OECD	Córdoba	2010 IPUMS	2010 OECD
Concepción	2009 CASEN	2010 OECD	Rosario	2001 IPUMS	2000 OECD
La Serena	2000 CASEN	2000 OECD	Rosario	2010 IPUMS	2010 OECD
La Serena	2009 CASEN	2010 OECD	Mendoza	2001 IPUMS	2000 OECD
São Paulo	2000 IPUMS	2000 OECD	Mendoza	2010 IPUMS	2010 OECD
São Paulo	2010 IPUMS	2010 OECD	Medellín	2005 IPUMS	2000 OECD
Rio de Janeiro	2000 IPUMS	2000 OECD	Medellín	2005 IPUMS	2010 OECD
Rio de Janeiro	2010 IPUMS	2010 OECD	Bogotá	2005 IPUMS	2000 OECD
Salvador	2000 IPUMS	2000 OECD	Bogotá	2005 IPUMS	2010 OECD
Salvador	2010 IPUMS	2010 OECD	Barranquilla	2005 IPUMS	2000 OECD
Fortaleza	2000 IPUMS	2000 OECD	Barranquilla	2005 IPUMS	2010 OECD
Fortaleza	2010 IPUMS	2010 OECD	San José	2000 census	2010 OECD
Belo Horizonte	2000 IPUMS	2000 OECD	San José	2011 census	2010 OECD
Belo Horizonte	2010 IPUMS	2010 OECD	La Paz	2001 IPUMS	2000 INE
Curitiba	2000 IPUMS	2000 OECD	La Paz	2012 IPUMS	2010 INE
Curitiba	2010 IPUMS	2010 OECD	Cochabamba	2001 IPUMS	2000 INE
Porto Alegre	2000 IPUMS	2000 OECD	Cochabamba	2012 IPUMS	2010 INE
Porto Alegre	2010 IPUMS	2010 OECD	Santa Cruz	2001 IPUMS	2000 INE
Goiânia	2000 IPUMS	2000 OECD	Santa Cruz	2012 IPUMS	2010 INE
Goiânia	2010 IPUMS	2010 OECD	Lima	2007 census	2000 INEI
Recife	2000 IPUMS	2000 OECD	Lima	2007 census	2010 INEI
Recife	2010 IPUMS	2010 OECD	Chiclayo	2007 census	2000 INEI
Belém	2000 IPUMS	2000 OECD	Chiclayo	2007 census	2010 INEI
Belém	2010 IPUMS	2010 OECD	Arequipa	2007 census	2000 INEI
Mexico City	2000 IPUMS	2000 OECD	Arequipa	2007 census	2010 INEI
Mexico City	2010 IPUMS	2010 OECD	Trujillo	2007 census	2000 INEI
Guadalajara	2000 IPUMS	2000 OECD	Trujillo	2007 census	2010 INEI
Guadalajara	2010 IPUMS	2010 OECD	Asunción	2002 census	2005 Central Bank
Monterrey	2000 IPUMS	2000 OECD	Asunción	2002 census	2010 Central Bank
Monterrey	2010 IPUMS	2010 OECD	Panama City	2000 IPUMS	2007 INEC
Puebla	2000 IPUMS	2000 OECD	Panama City	2010 IPUMS	2010 INEC
Puebla	2010 IPUMS	2010 OECD	Montevideo	2006 census	2000 INE
Toluca	2000 IPUMS	2000 OECD	Montevideo	2011 census	2010 INE
Toluca	2010 IPUMS	2010 OECD	Guayaquil	2001 IPUMS	2000 Central Bank
Tijuana	2000 IPUMS	2000 OECD	Guayaquil	2001 IPUMS	2010 Central Bank
Tijuana	2010 IPUMS	2010 OECD	Quito	2001 IPUMS	2000 Central Bank

Table A1.1 (concluded)

City	Employment data	Value added data	City	Employment data	Value added data
Juárez	2000 IPUMS	2000 OECD	Quito	2001 IPUMS	2010 Central Bank
Juárez	2010 IPUMS	2010 OECD	Cuenca	2001 IPUMS	2000 Central Bank
Laguna	2000 IPUMS	2000 OECD	Cuenca	2001 IPUMS	2010 Central Bank
Laguna	2010 IPUMS	2010 OECD	Santo Domingo, Dominican Republic	2002 IPUMS	2000 Central Bank
Querétaro	2000 IPUMS	2000 OECD	Santo Domingo, Dominican Republic	2010 IPUMS	2010 Central Bank
Querétaro	2010 IPUMS	2010 OECD	Santo Domingo, Ecuador	2001 IPUMS	2007 Central Bank
San Luis de Potosí	2000 IPUMS	2000 OECD	Santo Domingo, Ecuador	2010 IPUMS	2010 Central Bank

Source: Prepared by the authors.
Note: CASEN: National Socioeconomic Survey; IPUMS: Integrated Public Use Microdata Series; OECD: Organisation for Economic Co-operation and Development; INE: National Institute of Statistics; INEI: National Institute of Statistics and Informatics; INEC: National Institute of Statistics and Census.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Table A1.2
Latin America (13 countries): rankings of cities on the Big Mac index, 2000 and 2010

Ranking in 2000			Ranking in 2010		
Country	City	Big Macs	Country	City	Big Macs
Uruguay	Montevideo	11166.73965	Mexico	Monterrey	11618.84563
Argentina	Buenos Aires	10793.61334	Chile	Antofagasta	11598.66157
Argentina	Mendoza	9996.449794	Mexico	Juárez	11318.6198
Argentina	Córdoba	9961.192768	Mexico	Laguna	11291.11744
Argentina	Rosario	9891.552209	Mexico	Mexico City	11193.25867
Mexico	Mexico City	9811.814948	Mexico	San Luis Potosí	10902.27451
Mexico	Monterrey	9770.052587	Mexico	Tijuana	10651.70953
Mexico	Tijuana	9697.043644	Mexico	Querétaro	10485.91086
Mexico	Juárez	9519.388056	Mexico	Guadalajara	10406.90449
Mexico	San Luis Potosí	9492.556654	Mexico	Toluca	10364.67466
Mexico	Guadalajara	9436.970204	Chile	Santiago	10161.11197
Mexico	Querétaro	9413.488672	Mexico	León	10101.04737
Mexico	Laguna	9248.405271	Mexico	Puebla	9836.425835
Mexico	León	9104.119414	Chile	La Serena-Coquimbo	9451.650954
Mexico	Toluca	9101.691903	Chile	Viña del Mar-Valparaíso	9391.068743
Mexico	Puebla	8851.451708	Chile	Concepción	9232.065182
Panama	Panama City	8145.913908	Argentina	Buenos Aires	8384.960162
Brazil	São Paulo	6679.847307	Argentina	Mendoza	8381.844495
Brazil	Rio de Janeiro	6558.941986	Argentina	Rosario	8099.204496
Brazil	Curitiba	6468.572587	Argentina	Córdoba	8080.177341
Brazil	Porto Alegre	6367.987802	Uruguay	Montevideo	8036.850976
Chile	Antofagasta	6308.845286	Panama	Panama City	7273.621014
Brazil	Belo Horizonte	6296.322268	Colombia	Bogotá	6552.569326
Brazil	Recife	6241.733271	Colombia	Medellín	6384.023835
Chile	Santiago	6206.434154	Costa Rica	San José	5353.213481
Brazil	Goiânia	6115.139454	Brazil	Rio de Janeiro	5124.571709
Brazil	Salvador	6103.46939	Brazil	São Paulo	5104.384167
Brazil	Fortaleza	6039.005177	Brazil	Belo Horizonte	5092.924787
Brazil	Belém	5909.315539	Brazil	Curitiba	5060.667619
Dominican Republic	Santo Domingo	5566.000039	Brazil	Porto Alegre	5032.341579
Chile	Viña del Mar-Valparaíso	5278.257951	Brazil	Goiânia	4857.10337
Chile	Concepción	5229.744615	Brazil	Salvador	4847.332604
Chile	La Serena-Coquimbo	4901.780204	Brazil	Recife	4829.722434
Colombia	Bogotá	4752.925471	Brazil	Fortaleza	4757.989157

Table A1.2 (concluded)

Ranking in 2000			Ranking in 2010		
Country	City	Big Macs	Country	City	Big Macs
Colombia	Medellín	4629.978149	Brazil	Belém	4703.405616
Costa Rica	San José	4442.018337	Peru	Arequipa	4513.754623
Ecuador	Guayaquil	4022.255526	Peru	Trujillo	4038.392012
Ecuador	Cuenca	3921.051866	Ecuador	Guayaquil	3620.84656
Ecuador	Quito	3563.973573	Peru	Lima	3590.05369
Peru	Arequipa	3356.775861	Ecuador	Cuenca	3469.083125
Peru	Trujillo	3009.165406	Dominican Republic	Santo Domingo	3319.768189
Ecuador	Santo Domingo	2905.272975	Ecuador	Quito	3155.191171
Peru	Lima	2646.185677	Peru	Chiclayo	2964.603405
Peru	Chiclayo	2203.590951	Paraguay	Asunción	2802.714553
Paraguay	Asunción	2099.929668	Colombia	Barranquilla	2630.747011
Colombia	Barranquilla	1943.781739	Ecuador	Santo Domingo	2550.215107
Bolivia (Plurinational State of)	La Paz	1276.043587	Bolivia (Plurinational State of)	La Paz	1520.774422
Bolivia (Plurinational State of)	Santa Cruz	1230.582007	Bolivia (Plurinational State of)	Santa Cruz	1382.599926
Bolivia (Plurinational State of)	Cochabamba	1090.808814	Bolivia (Plurinational State of)	Cochabamba	1208.268208

Source: Prepared by the authors.

Table A1.3
Latin America (13 countries): full productivity rankings of selected cities, 2000 and 2010

Ranking in 2000			Ranking in 2010		
Country	City	Output per employee *(purchasing power parity dollars)*	Country	City	Output per employee *(purchasing power parity dollars)*
Argentina	Buenos Aires	26984.03336	Chile	Antofagasta	38739.52966
Argentina	Mendoza	24991.12449	Chile	Santiago	33938.11398
Argentina	Córdoba	24902.98192	Chile	La Serena-Coquimbo	31568.51419
Argentina	Rosario	24728.88052	Chile	Viña del Mar-Valparaíso	31366.1696
Mexico	Mexico City	21782.22918	Chile	Concepción	30835.09771
Mexico	Monterrey	21689.51674	Uruguay	Montevideo	30057.82265
Mexico	Tijuana	21527.43689	Argentina	Buenos Aires	29850.45817
Mexico	Juárez	21133.04148	Argentina	Mendoza	29839.3664
Mexico	San Luis Potosí	21073.47577	Mexico	Monterrey	29047.11407
Mexico	Guadalajara	20950.07385	Argentina	Rosario	28833.168
Mexico	Querétaro	20897.94485	Colombia	Bogotá	28765.77934
Mexico	Laguna	20531.4597	Argentina	Córdoba	28765.43133
Uruguay	Montevideo	20323.46616	Mexico	Juárez	28296.54951
Mexico	León	20211.1451	Mexico	Laguna	28227.7936
Mexico	Toluca	20205.75603	Colombia	Medellín	28025.86464
Mexico	Puebla	19650.22279	Mexico	Mexico City	27983.14667
Panama	Panama City	18409.76543	Mexico	San Luis Potosí	27255.68628
Chile	Antofagasta	15456.67095	Panama	Panama City	27103.3303
Chile	Santiago	15205.76368	Mexico	Tijuana	26629.27383
Chile	Viña del Mar-Valparaíso	12931.73198	Mexico	Querétaro	26214.77716
Chile	Concepción	12812.87431	Mexico	Guadalajara	26017.26123
Dominican Republic	Santo Domingo	12579.16009	Mexico	Toluca	25911.68664
Chile	La Serena-Coquimbo	12009.3615	Mexico	León	25252.61842
Costa Rica	San José	11593.66786	Brazil	Rio de Janeiro	25161.64709
Colombia	Bogotá	11169.37486	Brazil	São Paulo	25062.52626
Brazil	São Paulo	11021.74806	Brazil	Belo Horizonte	25006.2607
Colombia	Medellín	10880.44865	Brazil	Curitiba	24847.87801
Brazil	Rio de Janeiro	10822.25428	Brazil	Porto Alegre	24708.79715

Table A1.3 (concluded)

Ranking in 2000			Ranking in 2010		
Country	City	Output per employee *(purchasing power parity dollars)*	Country	City	Output per employee *(purchasing power parity dollars)*
Brazil	Curitiba	10673.14477	Mexico	Puebla	24591.06459
Brazil	Porto Alegre	10507.17987	Brazil	Goiânia	23848.37755
Brazil	Belo Horizonte	10388.93174	Brazil	Salvador	23800.40308
Brazil	Recife	10298.8599	Brazil	Recife	23713.93715
Brazil	Goiânia	10089.9801	Brazil	Fortaleza	23361.72676
Brazil	Salvador	10070.72449	Brazil	Belém	23093.72157
Brazil	Fortaleza	9964.358542	Costa Rica	San José	20502.80763
Brazil	Belém	9750.37064	Peru	Arequipa	15978.69137
Ecuador	Guayaquil	9090.29749	Peru	Trujillo	14295.90772
Ecuador	Cuenca	8861.577217	Peru	Lima	12708.79006
Peru	Arequipa	8324.804135	Ecuador	Guayaquil	12672.96296
Ecuador	Quito	8054.580276	Dominican Republic	Santo Domingo	12370.28622
Peru	Trujillo	7462.730208	Ecuador	Cuenca	12141.79094
Ecuador	Santo Domingo	6565.916924	Colombia	Barranquilla	11548.97938
Peru	Lima	6562.540479	Ecuador	Quito	11043.1691
Peru	Chiclayo	5464.905558	Peru	Chiclayo	10494.69605
Paraguay	Asunción	4745.841049	Paraguay	Asunción	10443.6151
Colombia	Barranquilla	4567.887087	Ecuador	Santo Domingo	8925.752875
Bolivia (Plurinational State of)	La Paz	2883.858507	Bolivia (Plurinational State of)	La Paz	5666.785691
Bolivia (Plurinational State of)	Santa Cruz	2781.115335	Bolivia (Plurinational State of)	Santa Cruz	5151.912973
Bolivia (Plurinational State of)	Cochabamba	2465.227921	Bolivia (Plurinational State of)	Cochabamba	4502.30941

Source: Prepared by the authors.

Table A1.4
Latin America (13 countries):[a] collinearity diagnostics in the study of segregation in selected cities, 2000 and 2010

Variable	Variance inflation factor	Variance inflation factor	Square root tolerance	R-squared
Duncan Segregation Index	1.17	1.08	0.8582	0.1418
Proportion of high-skilled workers	1.3	1.14	0.7707	0.2293
Log of gross domestic product	1.67	1.29	0.6005	0.3995
Log of population	1.21	1.1	0.8248	0.1752
Year dummy	1.48	1.21	0.6777	0.3223
Gini coefficient	1.12	1.06	0.8914	0.1086
Proportion of high-skilled workers	1.28	1.13	0.779	0.221
Log of gross domestic product	1.63	1.28	0.6141	0.3859
Log of population	1.2	1.1	0.8316	0.1684
Year dummy	1.46	1.21	0.6832	0.3168

Source: Prepared by the authors.
[a] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, Plurinational State of Bolivia, Uruguay.

Tax exemption in Brazil in 2009: why vehicles and not agriculture? An interregional general equilibrium analysis

Leonardo Coviello Regazzini, Carlos José Caetano Bacha and Joaquim Bento de Souza Ferreira Filho

Abstract

Tax exemption has been used systematically in Brazil to stimulate the economy. In 2009, in an attempt to stem the economic slowdown, the Brazilian government adopted a countercyclical economic policy that included lowering taxes on vehicle prices. Why was this sector chosen rather than another? This article seeks to analyse the effects of this policy on the Brazilian economy in 2009, using as a counterfactual a tax exemption policy targeted on the agriculture sector. Based on an interregional computable general equilibrium model (TERM-BR), the two policies are simulated and compared. The results show that lowering taxes on agricultural products can be considered superior to an equivalent tax reduction for vehicles, in terms of the effects on employment, income, household consumption, GDP and, especially, the distribution of economic activity across the regions of Brazil and the income distribution.

Keywords

Fiscal policy, taxation, tax exemption, automobile industry, agriculture, economic development, regional development, income distribution, macroeconomics, econometric models, Brazil

JEL classification

C68, H25, R58

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I. Introduction

In recent decades particularly, the Brazilian government has adopted temporary tax and contribution reduction policies aimed at protecting its economy from the fallout of international economic crises (especially in terms of the level of production and, as a result, employment and prices). Most of these policies have covered only a few sectors of domestic industry, including automobiles and the "white goods" industry (refrigerators, washing machines and household appliances in general).

The use of tax exemption (also referred to as tax reduction or tax relief) as a mechanism to protect the economy is grounded in economic theory. Since the mid-1930s, economists have believed that expansionary fiscal policies —such as cuts in taxes and contributions or increases in public spending— can have significant short-term effects on the main macroeconomic variables (such as employment, income and inflation). This is because policies of this type would directly influence aggregate demand.

Tax exemption —specifically eliminating or lowering the rates of taxes and indirect contributions that affect the sale of goods and services— has a direct impact on the main macroeconomic variables, since it causes the price received by the seller to rise (and, therefore, improves business profitability), or lowers the price paid by the consumer. The equilibrium level of production also rises, which boosts employment and real wage levels.

In terms of its direct effects on the economy (not forgetting that government functions have to be funded), any tax exemption policy is therefore welcome. However, as the design of the national tax system can have significant effects on other important indicators (such as employment, inflation, the external accounts, fiscal revenues, the income distribution and regional balance), some tax exemption policies may not only be more effective than others in promoting lower prices and higher employment but may also have more positive effects on other economic indicators.

As was discovered years later, the choice of the automotive sector for tax relief in Brazil in 2009 was not a purely economic decision. In economic terms, one might think that reducing taxes and contributions on agricultural products would have more positive effects on the regional income distribution and inequality than the same policies targeting the automotive industry. The reasons would be the following: (i) the agriculture sector employs less-skilled labour; (ii) agricultural products represent a larger share in the consumption basket of lower-income families; (iii) agricultural production is of major importance in all states of the federation, especially the poorest ones; and (iv) agricultural and agribusiness products have become more important in Brazil's trade balance.

A study that can identify the differential impact on the national economy of a tax reduction policy benefiting the automotive industry, as adopted from the late 2000s until the early 2010s, compared to one that favours agriculture, could be highly valuable in the analysis of the fiscal policies adopted by the Brazilian government in recent years. It could also inform the formulation of future tax policies.

Accordingly, the aim of this article is to compare the economic and social effects of tax exemption policies targeting the automotive industry in 2009 with those that could have targeted the agriculture sector in the same year. These effects include traditional macroeconomic variables (production, employment, wages and price levels), as well as other equally important elements, such as the income distribution and the concentration of economic activity between regions. The aim is, therefore, to evaluate a past experience (of choosing sectors to be stimulated through tax reduction) which may be considered again in the future, especially given the need to revive the economy after the crisis caused by the coronavirus disease (COVID-19) pandemic.

This comparative analysis uses an applied interregional computable general equilibrium (CGE) model, with 2009 as the base year —the year in which the tax exemption policy was implemented in depth in Brazil. The model makes it possible to analyse the effects of policies (such as taxation) on

other variables, such as the income distribution (through their impacts on consumer price indices at each income level), and regional balance, in other words the share of the various federative units in Brazilian GDP.

Even when they target certain sectors only, the effects of changes in tax policy can propagate throughout the economy; so any analysis of their impacts must consider the economy as a whole. A CGE model makes it possible to do this.

II. Literature review

There are various studies in the literature that seek to analyse the effects that changes in tax policy have had on the Brazilian economy. Many of them, including those by Varsano and others (2001), Siqueira, Nogueira and Souza (2001), and Kume (2004), use a partial equilibrium approach and seek to measure only the direct impact of the tax changes.

Given their characteristics, general equilibrium models have been used widely to analyse the impact of tax policy changes. Shoven and Whalley (1972 and 1973) were the first to visualize this possibility; and following the first applied study using this methodology (Whalley, 1977), the methodology began to disseminate. In the belief that equity is a desirable feature of an "ideal" tax system, Adelman and Robinson (1978) seek mechanisms to analyse factors such as the effects of changes in tax policy on the income distribution in developing countries. Dervis, De Melo and Robinson (1982) apply this methodology to developing countries whose economies have specific characteristics. Ballard and others (1985) develop a general equilibrium model to analyse taxation in the United States (known as the Ballard, Fullerton, Shoven and Whalley (BFSW) model). This work has been supported by a succession of taxation studies that have appeared since. For example, Shoven and Whalley (1992) discuss how general equilibrium models can be used to structure public policies; Berck, Golan and Smith (1996) used a general equilibrium model to study the economy of California; and Fehr (2000), Baylor and Beauséjour (2004) and Ahmed, Ahmed and Abbas (2010) used general equilibrium models to study the economies of Germany, Canada and Pakistan, respectively.

In the case of Brazil, major studies have used general equilibrium models to analyse fiscal and tax policy. Pioneering papers include Sousa (1985, 1987 and 1993) and Sousa and Hidalgo (1988), who estimated the impacts of changes in tariff protection on a set of macroeconomic variables (including output, prices and others). Subsequently, Araújo and Cavalcanti (1999) and Lledo (2005) investigated the economic effects of tax reform measures implemented between the late 1990s and the early 2000 decade. Araújo and Ferreira (1999) use a dynamic general equilibrium model, with an infinite lifetime agent, to compare the efficiency of the measures in the long run. Lledo (2005), in contrast, uses an overlapping generations general equilibrium model to analyse the effects of the measures on the distribution of income across generations. Fochezatto (2003) also evaluates the effects of tax reform, but in a more general context, analysing its effects on growth and the income distribution.

In Brazil, five different taxes and contributions are levied on the sale of goods and services and affect their prices. These are: (i) the Goods and Services Sales Tax (ICMS); (ii) the Industrialized Products Tax (IPI); (iii) the Social Integration Programme/Civil Servant Asset Formation Programme (PIS/PASEP) (iv) the Social Security Funding Contribution (COFINS); and (v) the Tax on Services (ISS). These five levies are equivalent to value added tax (VAT) in other countries. There is also a contribution levied specifically on agricultural activity: the Rural Workers Assistance Fund (FUNRURAL). These six charges are referred to as commercial taxes and contributions, and Bacha (2016) describes how they operate in Brazil.

Silva, Tourinho and Alves (2004) analyse the effects of the transformation of COFINS into VAT and the incidence of PIS/PASEP and COFINS (both approved in 2003) on imports. These authors also studied the effects of the abolition, in 2007, of the Provisional Contribution on Financial Movements (CPMF).[1] Salami and Fochezatto (2009) analyse changes in tax revenue through an overlapping generations model for long-term analysis. Similarly, Paes (2012) uses a general equilibrium model incorporating the external sector to analyse the effects of the abolition of the industrial employer's contribution on exports, among other variables.

The studies referenced above use models that consider the Brazilian economy as a single region, which does not make it possible to analyse the regional-balance effects of shocks derived from tax changes. Regional analyses for Brazil first appear in the works of Fochezatto (2002), Domingues and Haddad (2003), Porsse (2005), Paes and Bugarin (2006), and Palermo, Porsse and Portugal (2010).

Other studies, including those by Ponciano and Campos (2003), Santos (2006), De Souza, Petterini and Miro (2010) and Paes (2012), specifically analyse taxation by sector, including the automotive industry and the agriculture sector, but considered separately. The present article makes two contributions in relation to these studies: (i) a comparative evaluation of the effects of similar tax exemption policies applied to two sectors (the automotive industry compared to the agriculture sector); and (ii) an analysis of the regional effects of lowering taxes on the two sectors, and in particular on income inequality between the regions of Brazil.

III. Methodology

Computable general equilibrium models are representations of real economies that connect producers and consumers —among other agents— with their respective markets. They consist of a set of equations that simulate the relations that exist between the various agents in the economy and, unlike input-output models, require both the demand and the supply side to be specified. By considering the transactions made between the various economic agents and by modelling their behaviour, CGE models are able to capture both the direct and the indirect effects arising from economic shocks such as tax breaks for eligible sectors. Accordingly, CGE models are used to simulate exogenous events, including government policies. The ability to observe both direct and indirect effects, as well as induced effects, is essential for analysing the impact of a cost-of-living shock on families of different income levels, for example.

To analyse the effects of different tax relief policies on the Brazilian economy, this paper performs simulations using an applied bottom-up interregional general equilibrium model, known as The Enormous Regional Model (TERM) adapted to the Brazilian economy (TERM-BR). This model is based on the TERM developed for the Australian economy (Horridge, Madden and Wittwer, 2005), which was adapted by Ferreira and Horridge (2006) to analyse the Brazilian economy. It is a Johansen-type model, of the Australian school, which uses linearized non-linear equations, so that the solutions are presented in the form of percentage variations. The modelling thus allows for a comparative-static analysis.

The "Australian school" of CGE modelling originated in the 1970s when the ORANI model was developed (Dixon and others, 1997). Over the years, the growing demand for regionalized information led the authors to develop regionally disaggregated models, designed with a top-down approach. The top-down models have since been refined by a second generation of "bottom-up" models, so called because they are structured from the base upwards, that is with behavioural equations and parameters defined for regional agents. Each region is thus represented as a complete national economy, which is related to others (trade flows between regions, as well as origins and destinations, are added to the model); and national results are obtained by aggregating the provincial results.

[1] This was a flat charge on every bank withdrawal.

These models require a much larger amount of data and may run into computational constraints when there are many sectors and regions (Horridge, Madden and Wittwer, 2005). The TERM model has been developed to address this problem, with a more compact data structure based on several simplifying assumptions. The main assumption is that all products are regionally pooled, irrespective of the user (or region) acquiring them. In other words, instead of each user in each region purchasing a given product 'c' from nearby regions, the model assumes that all users in a given region 'd' purchase product 'c' from all producing regions, in proportion to each producing region's share in the purchases of all users in region 'd'. For example, the share Minas Gerais share in all autoparts purchased by the São Paulo automotive industry is assumed equal to the Minas Gerais share of autoparts purchased by São Paulo families.[2]

Based on the above, this article performs an analysis through TERM-BR. This model is an adaptation of TERM developed in 2005 for the analysis of the Brazilian economy, and which has previously been used for similar purposes by Santos (2006). To make the model suitable for the purposes of this study, the following need adjustment: the level of aggregation (that is, the number of elements in the main sets); the way the model describes taxes; the regional shares in sectoral production; and, of course, the data used, which come from different periods.

The models used make it possible to capture endogenous variations in the tax base, resulting from changes in tax or contribution rates, in addition to the effects of such variations. It is thus possible to observe not only the direct (first order) effects on tax collection caused by the change in tax rates, but also the indirect (second order) effects associated with the change in the tax base resulting from this change.

Apart from making it possible to identify the second order effects, the change in the tax base is fundamental for the entire estimation of the model's results, since this forms the basis for updating all of the model's matrices. This, in turn, makes it possible to identify the effects of tax rate changes not only on tax revenues, but also on all the other economic variables observed.

The specification used in this study encompasses 15 products; two origins (domestic or imported); two types of margin (trade and transport); 10 occupation levels (classified according to the wage categories of the Household Budget Survey (POF); 15 sectors and four final demanders (totalling 19 users); 27 regions of origin (26 states and the Federal District); 27 regions of destination and 27 margin-producing regions.

Detailed descriptions of the model's supply and demand structures, as well as the process of building its databank, can be found in Santos (2006), Fachinello (2008), Moraes (2010) and Santos (2013). The latter also provides a detailed description of the database updating process used in this study.

1. Closure of the CGE model

In applied general equilibrium models, consistency requires opposing macroeconomic aggregates to be in equilibrium. This means that the equilibrium conditions between saving and investment, government spending and revenues, and capital inflows and outflows must be respected. The way in which an applied general equilibrium model determines these equilibrium conditions is called "closure". When macroeconomic aggregates behave very differently in the short and long runs, the short and long run closures of the model also have different characteristics.

Kehoe and others (1988) argue that changes in indirect tax rates usually produce their effects after a relatively long period. Long-term analyses therefore afford a clearer view of the policy effects on economic variables, once equilibrium has been established after all transitory effects and all direct and

[2] São Paulo and Minas Gerais are Brazil's two leading provincial economies.

indirect impacts have been manifested and played out (Silva, Tourinho and Alves, 2004). However, the tax reduction policies adopted by the federal government in Brazil, which are analysed in this paper, were not permanent, but circumstantial. They were not even backed by law, but were established by decree and could be revoked —as, in fact, happened, when the need for short-term fiscal adjustment gave rise to new circumstances. It is therefore understood that tax relief policies have been adopted in Brazil for their potential short-term effects, but without considering a horizon of ten years or more. Accordingly, this article observes the effects of these exemption policies based on short-term closure characterized by the following factors.

- The stock of fixed capital is constant at all levels (sectors and regions).
- Each production sector's investment varies according to its income.
- Population and real wages are fixed at all levels (exogenous variables). Increases in labour demand are met through reductions in the unemployment rate (endogenous variable).
- Government expenditures are held fixed in real terms. In other words, it is assumed that the tax breaks are financed by reducing the primary surplus or increasing public debt, but not by cutting government expenditures.
- Real family consumption is an endogenous variable, at all levels.
- The trade balance outturn is an endogenous variable. In the short run, trade deficits can be financed through foreign savings, and surpluses can be converted into reserves.
- Technology shock variables are exogenously determined.
- The nominal exchange rate serves as the model's *numéraire*. The consumer price index (CPI) is determined within the model (endogenous variable).

2. Effects on regional inequality

To analyse the effects of simulated tax exemption policies on income inequality among Brazilian states, this study uses Theil's L index. The Theil-L index is highly suitable for analysing regional inequality and has been used in several published studies (see, for example, Ferreira and Diniz (1995), Azzoni (1997 and 2001), Ferreira (1998), Esteban (2000), Beblo and Knaus (2001), and Cavalcante (2003)).

Mathematically, Theil's index can be expressed as follows:

$$J = \sum_e \left(\frac{N_e}{N}\right) ln\left[\frac{N_e}{N} \Big/ \frac{P_e}{P}\right] = \sum_e n_e ln j_e \qquad (1)$$

Where:

N_e = Income of state e;

N = National income;

P_e = Population of state e;

P = National population;

J_e = State e share in national income relative to its share of national population.

The Theil index can be used to measure the level of inequality between the country's different states (and not just between the largest and the smallest, as is the case with the per capita income ratio, another frequently used indicator). The observed value of the Theil index can vary between zero and log N (Conceição and Galbraith, 1998).

3. Effects on income distribution

Income distribution and welfare effects can be analysed in different ways in CGE models. This paper does so by observing the behaviour of consumer price indices for different income groups and labour demand at different wage levels.

The indices are constructed from values observed in the model and are of the Laspeyres type (the same methodology as used to calculate the main price indices in Brazil). The variation in the cost of each consumer price basket is fundamentally associated with the variation in prices in the economy, which the model itself should identify from the simulated shocks. There are 10 income levels, based on the Family Budget Survey (POF) classification. The price indices were constructed on the basis of the share of each good in the consumption basket of each income bracket in each state, using data from the 2008/2009 POF (IBGE, 2009).

The results generated by the model make it possible to observe the behaviour of labour demand at different wage levels in each of the simulations. This approach has been used by various authors, including Ferreira and Horridge (2005), Santos (2006), Fachinello (2008), Moraes (2010), and Santos (2013). A greater increase in the demand for labour at lower income levels, than at higher ones, is expected to reduce unemployment relatively more among the less skilled economically active population in the short run. In the long run, however, the wage gap between higher and lower skilled workers will narrow.

4. The simulations

To analyse the effects of potential tax relief policies targeting the agriculture sector, compared to those that have actually been deployed in the automotive industry, simulations were performed of a reduction in taxes and contributions in each sector. A tax reduction totalling R$ 3.634 billion was assumed in both cases, to make the comparison possible. The amount in question was the estimated annual cost of the tax relief actually granted to the automotive industry by the Brazilian government in 2009, to combat the recessionary fallout from the real estate crisis in the United States (IPEA, 2011).

The tax exemption for vehicles is simulated by reducing the amount of industrial product tax (IPI) collected by the automotive industry (mirroring what actually happened in 2009); and in the case of agricultural products, the taxes selected are PIS, COFINS and FUNRURAL, since agricultural products are exempt from IPI, and the tax with the greatest impact on the sector (ICMS) is not under federal jurisdiction. So, a reduction in PIS, COFINS and FUNRURAL is the alternative policy that could have been applied to agricultural activity.

The effects of two alternative tax relief scenarios are thus compared. The first scenario is the actual reduction of R$ 3.634 billion in IPI on products sold by the domestic automotive industry. The second scenario is a potential reduction, also of R$ 3.634 billion, in the amount of PIS, COFINS and FUNRURAL levied on crop and livestock products sold in Brazil. In both cases, the reduction is distributed proportionally, both across all products sold and among all regions in which the sectors in question are present.

IV. Results

1. Impacts on the macroeconomic aggregates

Table 1 reports the main results of the simulations in terms of macroeconomic aggregates. All of them refer to the short-term simulations described above, which aim to analyse the effects of shocks over a period of approximately one to two years.

Table 1
Variations in the main macroeconomic aggregates in response to tax relief for the agriculture sector and the automotive industry
(Percentages)

	Tax relief for the agriculture sector	Tax relief for the automotive industry
Real GDP	0.184	0.179
Real household consumption	0.349	0.269
Real private investment	0.244	0.328
Real government expenditure	0.000	0.000
Exports (volume)	-0.390	-0.072
Imports (volume)	0.422	0.503
Aggregate employment	0.332	0.280
Real average wage	0.000	0.000
Capital stock	0.000	0.000
GDP deflator	0.312	0.186
Consumer price index	0.303	0.184
Population	0.000	0.000
Nominal household consumption	0.653	0.453
Nominal GDP	0.497	0.366

Source: Prepared by the authors, on the basis of the model simulation results.

First, the effect of lowering taxes on agricultural products boosts real GDP (growth of 0.184%, which is slightly more than the effect of an equivalent tax break for vehicles (+ 0.179%). An analysis of the behaviour of the components of GDP shows that the main factor responsible for this advantage is household consumption, where the effect of the tax break for the agriculture sector (an increase in consumption of 0.349%) is significantly greater than the effect of the same tax relief granted to the automotive industry (+ 0.269%). This difference stems mainly from the labour intensity of agricultural activity (and, consequently, the sectoral wage bill), which is much higher than in the automotive industry. An increase in agricultural output therefore has a greater effect on income and, hence, on household consumption.

The opposite is true in the case of private investment (increases of 0.244% and 0.328% resulting from tax reductions for the agriculture sector and the automotive industry, respectively). However, this component has a much smaller share in GDP, so the effects on consumption predominate.

The tax cuts, and the resultant economic uptick, have an impact on Brazilian exports and imports. The reallocation of factors of production to meet growing domestic demand reduces exports in both scenarios. Since the tax reduction in the agriculture sector produces a greater economic stimulus, and the goods produced by this sector represent a large share of domestic demand, this scenario caused a steeper reduction in exports (a drop of 0.390%), while the export effects of the tax break for the automotive industry are more modest (a reduction of 0.072%).

In terms of the effect on imports, table 1 shows that reducing the tax on vehicles has a greater effect on Brazilian imports than the tax break for agricultural products (increases of 0.503% and 0.422%, respectively). Figure 1 identifies the sectors for which imports vary by most in each case. In both cases, the only sectors that report a reduction in imports are those in which taxes are lowered, since this makes the products in question more competitive with imported substitutes. For all other sectors, there is a slight increase in imports, as a result of the uptick in economic activity and income generated by the tax reduction.

Figure 1
Variation in imports in response to tax relief for the agriculture sector and the automotive industry, by sector
(Percentages)

Source: Prepared by the authors, on the basis of the model simulation results.

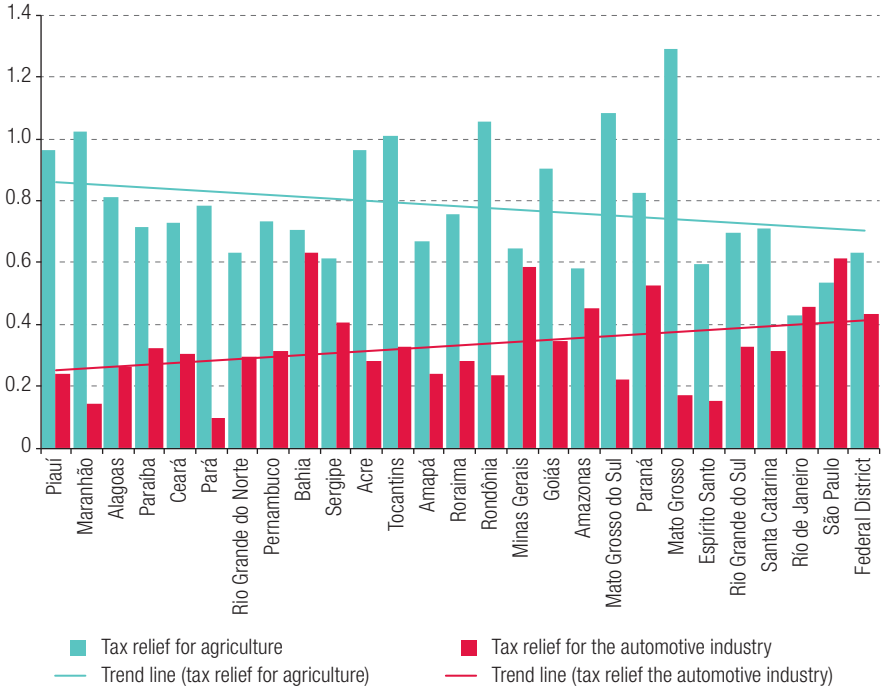
In general, the tax exemption generates higher imports in all sectors of the economy, except for those actually receiving the relief, where imports drop sharply. In the case of agriculture, sectoral imports decrease by 5.08%, whereas in the automotive industry vehicle imports fall by 9.56%. In the latter case, there was also an increase of 4.69% in imports of autoparts, owing to the increased output of the domestic automotive industry and, consequently, in the demand for parts.

Lastly, as agriculture is the more labour-intensive sector, lowering taxes in that sector boosts employment by more than the tax break for the automotive industry (+0.332% compared to +0.280%, respectively). This includes direct, indirect and induced employment —in other words, jobs created in all sectors of the economy as a result of the shocks, and not just in the sectors receiving the relief.

2. Regional impacts

Figure 2 reports the variation in total real factor remuneration for each Brazilian state under the two simulations. To analyse the impact of the shocks on the regional concentration of economic activity in Brazil, the states were ranked in ascending order by per capita income during the period in question. A trend line was drawn for each scenario to facilitate interpretation of the figure.

Figure 2
Variation in real total factor remuneration, in Brazilian states ranked in ascending order by per capita GDP
(Percentages)



Source: Prepared by the authors, on the basis of the model simulation results.

Although the effects generated by the two simulated shocks differ only slightly in terms of the behaviour of macroeconomic aggregates, this is not the case when the impacts are considered from a regional perspective. As agricultural activity is more spatially dispersed than the automotive industry, the tax relief for agriculture affects all Brazilian states. As many of these states have low levels of economic activity, the percentage variations are quite large (see, for example, the states of Mato Grosso, Rondônia, Tocantins and Maranhão).

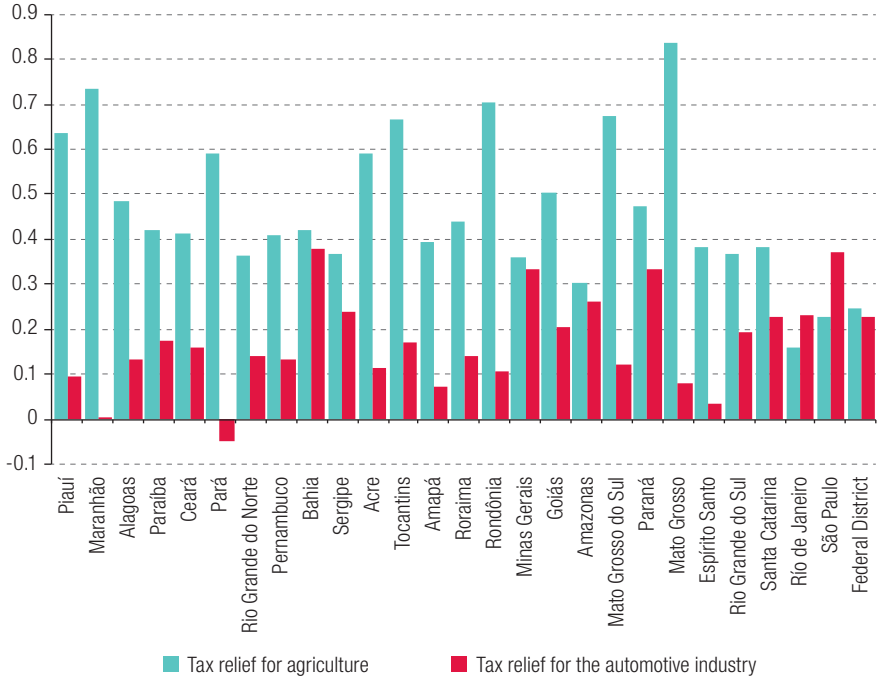
The trend lines show that, while the tax reduction for the agriculture sector produces stronger effects on total factor remuneration in the poorest states, the opposite occurs in the case of vehicles. In the automotive industry, the effects of the tax relief are concentrated in the few states where this economic sector is present. As these are the states with the largest economies (except for Bahia), the effects in terms of percentage variations are smaller.

The percentage variation in factor remuneration in the states is mirrored by the behaviour of labour demand, as shown in figure 3. Reducing taxes on agricultural products stimulates labour demand the most in the states of Mato Grosso and Maranhão (the latter has the second lowest per capita income in Brazil), whereas cutting the tax on vehicles increases labour demand by most in Bahia and São Paulo (the richest state in Brazil), followed by Minas Gerais and Paraná.

The wage bill also displays similar behaviour since it is directly associated with employment (especially considering the wage rigidity imposed by the closure of the CGE model) (see figure 4).

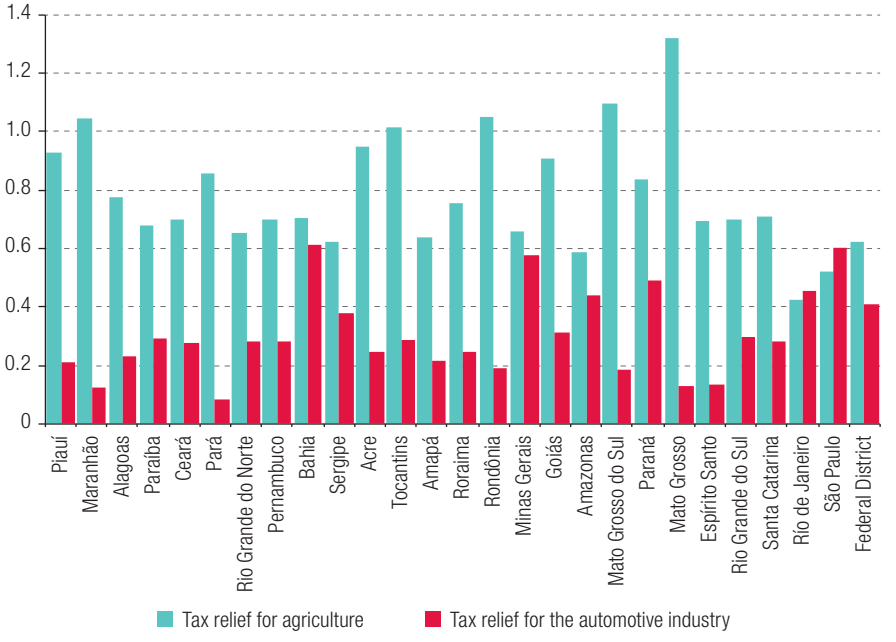
As wages account for the largest share of household income in Brazil, aggregate wage growth fuels an increase in household consumption (see figure 5).

Figure 3
Variation in the demand for labour, in Brazilian states ranked in ascending order by per capita GDP
(Percentages)



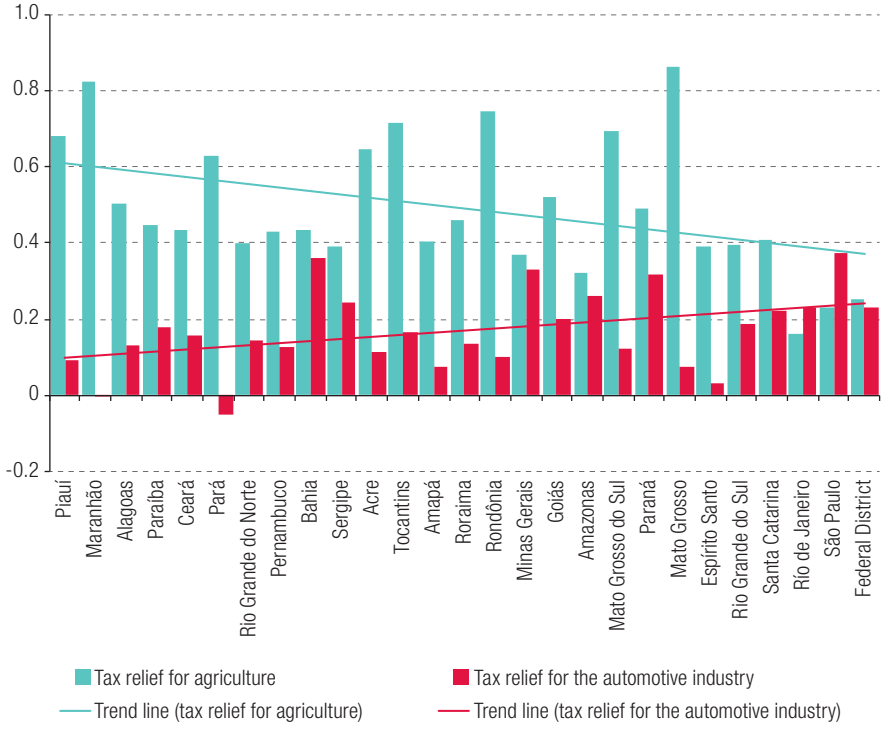
Source: Prepared by the authors, on the basis of the model simulation results.

Figure 4
Variation in the wage bill, in Brazilian states ranked in ascending order by per capita GDP
(Percentages)



Source: Prepared by the authors, on the basis of the model simulation results.

Figure 5
Variation in real household consumption, in Brazilian states ranked by per capita GDP in ascending order
(Percentages)

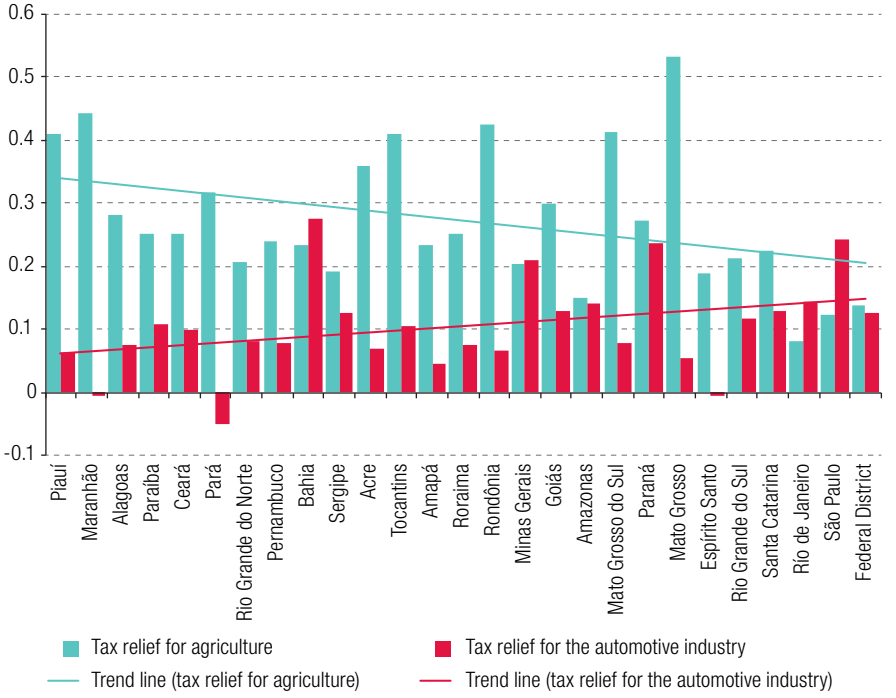


Source: Prepared by the authors, on the basis of the model simulation results.

Lastly, figure 6 reports the results of the two tax relief simulations in terms of real GDP in each Brazilian state. The magnitude of the GDP variations in each state under each scenario, together with the trend lines, show that the two policies have very different effects on the concentration of economic activity. Lowering taxes on agricultural production generates larger increases in GDP in the states with lower per capita income, thereby helping to reduce per capita income differences between states. In contrast, the tax break for the automotive industry leads to greater variations in GDP in the states with higher per capita income, thereby aggravating further the regional concentration of economic activity in Brazil.

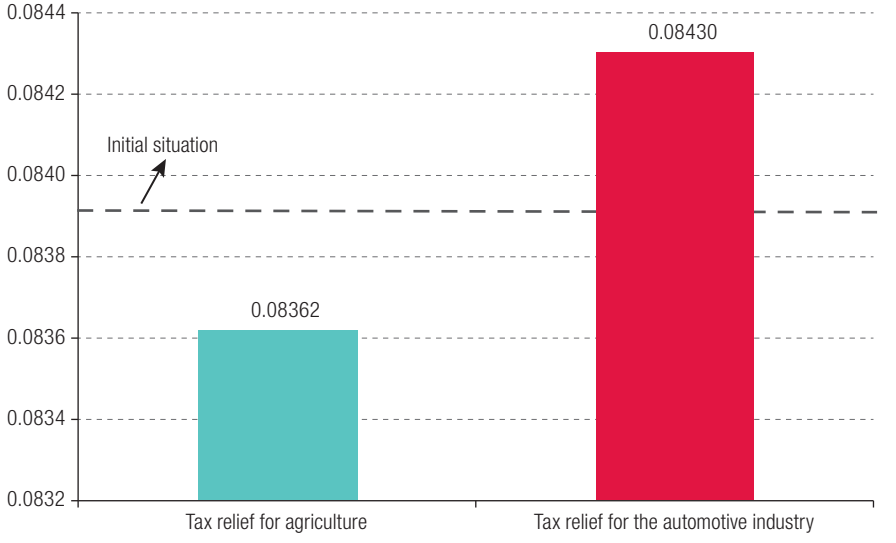
The results obtained by calculating the Theil index, which measures the degree of inequality in the distribution of per capita income between the Brazilian states, confirm the effects noted above (see figure 7).

Figure 6
Variation in real GDP measured through aggregate demand, in Brazilian states ranked in ascending order by per capita GDP
(Percentages)



Source: Prepared by the authors, on the basis of the model simulation results.

Figure 7
Distribution of per capita income among Brazilian states, in the initial situation and after the simulated tax relief scenarios
(Teil index)



Source: Prepared by the authors, on the basis of the model simulation results.

It can be seen that, while tax relief targeted on the agriculture sector produces very positive effects in terms of reducing the concentration of income among Brazilian states, the tax reduction on vehicles has the opposite effect by increasing regional inequality in the country still further. The first scenario results in a 0.43% reduction in the Theil index, while the second produces a 0.39% increase. This reflects the way in which the production activities of the two sectors are distributed across the different Brazilian states. While agriculture is a major player in all states, especially the poorest ones, the automotive industry is concentrated in just a few states, most of which are among the country's wealthiest.

3. Distributive impacts

While higher-wage workers absorb a larger share of the aggregate wages paid by the automotive industry, the opposite is case in agriculture: lower-paid workers receive a larger share of total wage bill in this sector. Thus, a tax break for agricultural products would be expected to generate a relatively larger increase in the demand for labour in the less-skilled and lower-wage job categories. The effect of the tax exemption on the income distribution can be captured by considering the behaviour of labour demand at each of the ten different wage levels. A steeper increase in the demand for lower-paid labour reduces unemployment by more at those levels and creates a long-term trend of significant real wage hikes in the corresponding wage categories. This narrows the gap between the wages of agricultural workers and helps reduce inequality in the individual distribution of income (at least in respect of wages, which generate the largest share of national income). In the long run, lowering taxes on agricultural products can be expected to have a greater positive impact on the income distribution than cutting the tax on vehicle prices. The model used in this paper reveals the impacts of labour demand shocks at each wage level.

The model also makes it possible to analyse the effects of these shocks (the tax exemption on prices) on income inequality, acting through the variation in the cost of living for different groups of people classified according to their income level. Each group has its own average standard of consumption, which is reflected in different average consumption baskets. The model makes it possible to observe and compare how the cost of each of these ten consumption baskets behaves under the two simulated tax break scenarios. This affords a better understanding of which policy generates more positive (or less negative) effects on the cost of living of the poorest families, and which of them produces more positive cost of living effects among the richest families. Since a large proportion of agricultural production consists of food, and food is relatively more important in the consumption basket of the poorest families, lowering tax on agricultural products is likely have more positive effects on the cost of living of families at lower income levels.

It should be noted that the variable used (the cost of a consumption basket) is not the same as agents' income. However, since the importance of income patterns in analysis of economic change fundamentally lies in the possible consumption that a given basket offers to families, then the cost of the goods and services that families consume may not be higher than the amount of their income.

As was the case in the regional analysis, the differences between the effects of the two simulated policies are also significant in distributional terms. Figure 8 displays the impacts on labour demand at the different wage levels.

Figure 8
Variation in labour demand, by wage class
(Percentages)

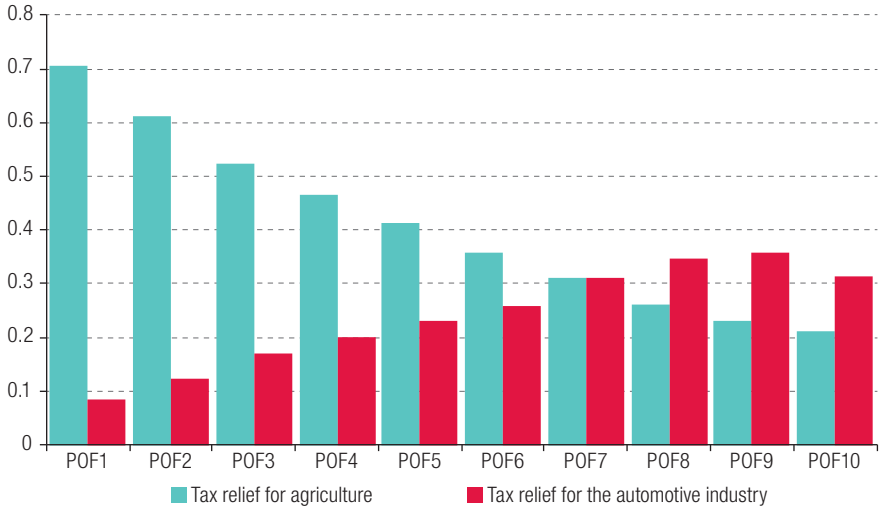
Source: Prepared by the authors, on the basis of the model simulation results.
Note: OCC = Wage classes obtained from the Household Budget Survey.

In eight of the ten defined wage classes, the demand for labour increases by more when a tax break is given to agricultural products than when it is applied to vehicles. The exceptions are the two highest wage brackets, where the demand for labour increases by more when tax relief is provided for the automotive industry than when it is applied to agricultural products. Nonetheless, the difference in this case is very small (growth of 0.290% versus 0.270% at the highest wage level, respectively). In contrast, at the lowest wage levels, the additional labour demand generated by lowering taxes on agricultural product prices is much greater than that resulting from tax relief for the automotive sector (growth of 0.893% compared to 0.088% in the lowest wage group, and 0.850% compared to 0.089%, respectively, in the second lowest group). In other words, tax relief on agricultural activity boosts labour demand by more, especially among the lower paid —that is, the poorest families.

These results are very important because it is precisely at the lowest wage levels that the poorest workers are found. The increase in the demand for labour in these groups, therefore, plays an important role in boosting the incomes of the poorest families and improving the pattern of income inequality across the country. Estimating the magnitude of these effects through the statistical measures used to analyse income inequality, such as the Gini coefficient, could be the subject of future research.

Figure 9 shows the behaviour of real household consumption in ten different income groups. It is reasonable to assume that the scenario that produces stronger effects on labour demand at the lowest wage levels will also have stronger effects on income and, consequently, on consumption by lower-income families.

Figure 9
Real household consumption, by income level
(Percentages)

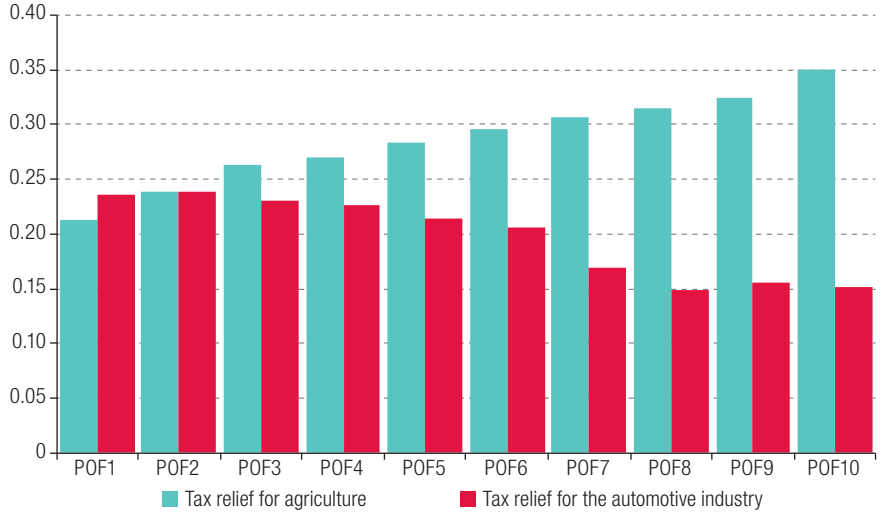


Source: Prepared by the authors, on the basis of the model simulation results.
Note: POF = Family Budget Survey.

In fact, in addition to a significantly greater increase in real household consumption nationwide, reducing the tax on agricultural product prices has more positive effects for lower-income families. In contrast, the effects of lowering the tax on vehicles are more concentrated in those with higher average incomes.

Lastly, figure 10 shows how the cost of living, measured through the consumer price index (CPI), varies for ten different income groups. As explained above, the CPI impact of the tax relief tends to be greater for the agriculture sector than for vehicles, because the first shock generates a larger increase in aggregate demand. Thus, the CPI variation benefits most income groups. The exceptions, however, are precisely those at the lower income levels. At the two lowest income levels (POF1 and POF2), cutting taxes on agricultural products is preferable to reducing the tax on vehicles, from the cost of living standpoint. This is because food has a much larger share in the standard consumption basket of the poorest households.

Figure 10
Variation in the consumer price index (CPI), by income group
(Percentages)



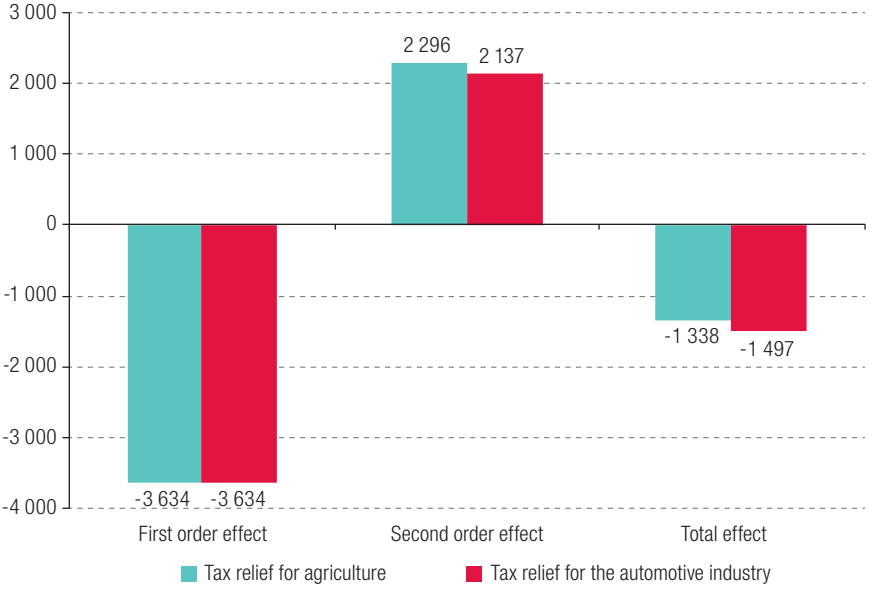
Source: Prepared by the authors, on the basis of the model simulation results.
Note: POF = Family Budget Survey.

4. Budgetary impacts

Although the simulations specify an amount by which taxes and contributions collected by the government are reduced, this does not mean that total government revenue will decrease by the exact same amount. This is because, as noted above, a tax cut in one sector triggers changes throughout the economy, many of which can generate either an increase or a reduction in tax revenue. The change in tax revenue resulting directly from a reduction or increase in taxes is a "first-order effect", whereas the subsequent indirect changes in tax revenue are "second-order effects".

The characteristics of a CGE model mean that it is fully capable of estimating the total (first- and second-order) effects of changes in government tax policy. The effects of the simulations described in this paper are shown in figure 11.

Figure 11
Effects of the policies on tax revenue
(Millions of reais at current prices)



Source: Prepared by the authors, on the basis of the model simulation results.

A tax exemption for agricultural products is capable of neutralizing a slightly larger portion of the initial drop in tax revenue through second-order effects, since it generates a slightly stronger economic recovery than in the case of tax relief for vehicles. Under the tax reduction for agriculture, total tax revenue is ultimately reduced by R$ 1.338 billion. In comparison, the tax cut for the automotive industry produces positive second-order effects amounting to R$ 2.137 billion, which results in a net reduction of R$ 1.497 billion in the government's overall tax revenue.

V. Final considerations

Given the need for economic recovery following the crisis caused by the COVID-19 pandemic, Brazil may decide to adopt a new tax relief policy in the future. If so, a key question is which sector should benefit from the lower taxes. Considering that the agriculture sector and other parts of Brazilian agribusiness have trended countercyclically in years of recession or low economic growth, such as in 2020, this paper

has sought to analyse the effects on the main macroeconomic variables of the Brazilian government's 2009 policy of cutting taxes on vehicles to combat the recessionary effects of the crisis in the United States housing market. This comparative study considers the hypothetical alternative of a tax break of equal value for the domestic agriculture sector. For this purpose, a static interregional CGE model (TERM-BR) was used to simulate both shocks and trace their effects on a wide range of macroeconomic variables. The model was calibrated for 2009, the year in which the policy under review was implemented; and it was aggregated as needed to achieve the aims of this study.

The analysis showed that lowering taxes on agricultural products would be superior to the same reduction applied to vehicles, in terms of its effects on the main variables analysed, especially when considered at the regional level. Given its wide spatial distribution, with the incentive provided by tax relief, the agriculture sector could generate much stronger effects in the poorer states of the Brazilian federation. In contrast, the effects of the incentives granted to the automotive sector are concentrated in the richer states. Whereas the vehicle tax relief would have led to an increase in the regional concentration of per capita income in Brazil (raising the Theil index of regional income distribution from 0.0840 to 0.0843), an equivalent tax break for agricultural products would lead to a decrease in regional income concentration (lowering the Theil index from 0.0840 to 0.0836) (see figure 7).

As it uses skilled labour more intensively, the automotive industry, benefiting from the tax cut, increases labour demand at the higher wage levels, whereas the equivalent tax relief for the agriculture sector increases the demand for labour by more at the lower levels. While lowering taxes for the automotive industry causes increases in the demand for labour of 0.08% at the lowest wage levels and 0.29% at the highest, the same tax relief for the agriculture sector would generate increases of 0.89% and 0.27%, respectively.

Moreover, since agricultural products account for the largest share of the consumption basket among the poorest families, lowering taxes on these products would result in a smaller increase in the cost of living for these families than the tax relief on vehicles (CPI increases of 0.21% and 0.23%, respectively). For the highest-income families, on the other hand, the tax reduction for vehicles generated more modest increases in the cost of living than the tax cut for agricultural products (0.15% and 0.35%, respectively).

The general conclusion of this study is that the federal government should have granted tax relief to agricultural products instead of vehicles in 2009. Furthermore, other things being equal, future tax relief policies should prioritize agriculture ahead of the automotive sector, since tax breaks for the former produce much better economic results than cutting taxes for the latter.

Lastly, it is worth noting that this article does not offer any political economy arguments to justify prioritizing the automotive sector to the detriment of agriculture.

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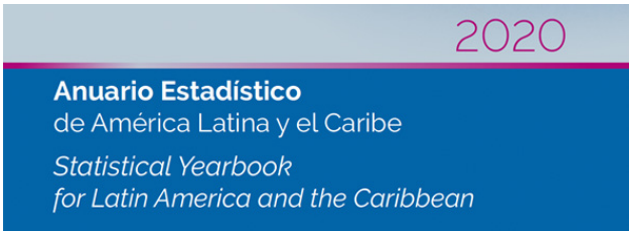

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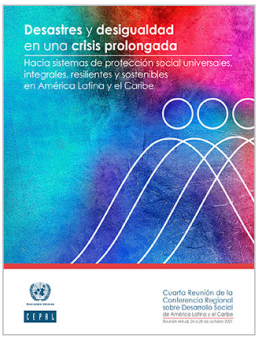

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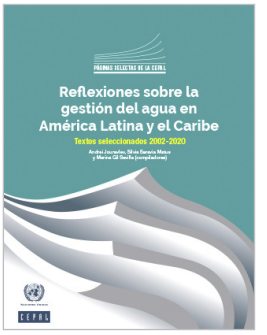

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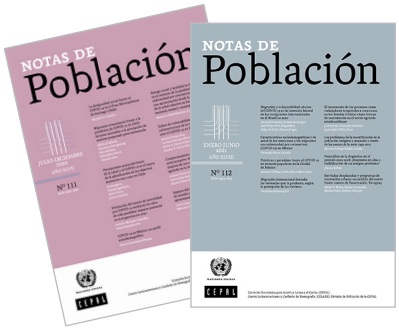

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