N° 127
APRIL • 2019

CEPAL REVIEW

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

UNITED NATIONS

ECLAC

70 ECLAC FOR SUSTAINABLE DEVELOPMENT WITH EQUALITY

ISSN 0251-2920

CEPAL

REVIEW

ECONOMIC
COMMISSION FOR
LATIN AMERICA AND
THE CARIBBEAN

UNITED NATIONS

ECLAC

N° 127
APRIL • 2019

CEPAL

REVIEW

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

UNITED NATIONS

ECLAC

ISSN 0251-2920

The *CEPAL Review* was founded in 1976, along with the corresponding Spanish version, *Revista CEPAL*, and it is published three times a year by the Economic Commission for Latin America and the Caribbean (ECLAC), which has its headquarters in Santiago. The *Review* has full editorial independence and follows the usual academic procedures and criteria, including the review of articles by independent external referees. The purpose of the *Review* is to contribute to the discussion of socioeconomic development issues in the region by offering analytical and policy approaches and articles by economists and other social scientists working both within and outside the United Nations. The Review is distributed to universities, research institutes and other international organizations, as well as to individual subscribers.

To subscribe, please visit the Web page: http://ebiz.turpin-distribution.com/products/197587-cepal-review.aspx

The complete text of the *Review* can also be downloaded free of charge from the ECLAC website (www.cepal.org/en).

This publication, entitled CEPAL Review, is covered in the Social Sciences Citation Index (SSCI), published by Thomson Reuters, and in the Journal of Economic Literature (JEL), published by the American Economic Association

United Nations publication
ISSN: 0251-2920
LC/PUB.2019/6-P
Sales No.: E.19.II.G.9
Distribution: G

Printed at United Nations, Santiago
S.18-01046

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.

Challenges in innovation management for Latin America and the Caribbean: an efficiency analysis

José G. Aguilar-Barceló and Fernanda Higuera-Cota

Abstract

Applying data envelopment analysis (DEA) to data from the 2016 Global Innovation Index (GII) (Cornell University/INSEAD/WIPO, 2016), the paper evaluates the efficiency of 19 Latin American and Caribbean economies in creating innovation-friendly environments. Where the region performs best is on infrastructure and adaptation of information and communication technologies (ICTs), but there are problems with human capital formation, the conduct and impact of research, and institutional aspects. The output of countries such as Chile and Colombia proved lower than expected given their factors, meaning that their strong innovation results are not matched by their efficiency management. Enhancing market functioning (competition, credit and investment) and knowledge absorption capacities is among the main challenges for the region.

Keywords

Innovations, evaluation, statistical data, human resources, technological change, competitiveness, statistical methodology, Latin America and the Caribbean

JEL classification

O32, D24, F63

Authors

José G. Aguilar-Barceló is a full-time professor and researcher with the Faculty of Economics and International Relations of the Autonomous University of Baja California (Mexico). Email: gaba@uabc.edu.mx.

Fernanda Higuera-Cota is a professor with the Faculty of Accounting and Administration of the Autonomous University of Baja California (Mexico). Email: higuera.maria@uabc.edu.mx.

I. Introduction

In the past, countries' socioeconomic development and growth were considered to depend mainly on their capital and labour endowments, while other less tangible resources, such as levels of information and training, were treated as external factors influencing market behaviour only indirectly. Over time, however, the idea that knowledge management is a determinant of productivity in both modern and traditional economies has increasingly taken hold (Cañibano, 2005). According to this new holistic conception, more and more jobs need to centre on the development of innovative ideas that can be applied to products, services and processes.

Support for innovation, understood as the ability to generate, obtain, adapt and use new knowledge to achieve sustainable competitive advantages that accumulate over time (OECD/Eurostat, 2005), is provided for in the development plans of all first world countries where innovation policy has been strengthened as a key element in industrial policy.[1] Although Latin America and the Caribbean has a long tradition of science and technology development policies and has increasingly invested in innovation (Bárcena, 2008), the region is not finding it easy to reverse its deficit in this area by strengthening innovation policy.[2] Among other explanations, this is because the countries making up the region face challenges typical of emerging economies, such as failures of coordination between firms, high levels of corruption and informality, a shortage of skilled human capital and the limited ability of governments to act (Navarro and Olivari, 2016), which reduces the effectiveness of public policy implementation.

According to the Inter-American Development Bank (IDB), in 2016 the economies of Latin America and the Caribbean presented a large deficit in the incorporation of knowledge and technology into their production processes. This is why it is so important to analyse and understand the market failures that have resulted in investment in innovation being inadequate and its implementation unsystematic and intermittent, leaving it well below socially desirable levels. An added challenge is to find ways of measuring the efficiency of policies aimed at generating innovative environments and quantifying them in terms of economic returns.

The Organization for Economic Cooperation and Development (OECD) points out that reliably estimating innovation capacity is essential for the proper design of public policies and stresses that current measurements do not fully reflect the role it plays in today's economy (OECD, 2012). Against this backdrop, the present study focuses on analysing the way input endowments are used to create innovation-friendly environments in the countries of Latin America and the Caribbean, by measuring returns. It presents an alternative view of innovation management in the context of its most important aggregate indicators, as the individual results are linked to create regional benchmarks. The hypothesis to be contrasted is that in the countries of Latin America and the Caribbean it is not always true that a higher level of innovation inputs denotes a sounder economy with greater development potential, translating into more and better innovation outputs, with the result that an invaluable opportunity to reduce the gap with developed countries is being missed.

The aim here is to measure efficiency in innovation management through the statistical analysis of a number of observable variables obtained from the 2016 Global Innovation Index. This index provides an annual ranking of the world's major economies in terms of innovation performance and its impact on development. The economies included in the index represent 92.8% of the world population and 97.9% of world GDP.

The article is organized into six sections, including this introduction. Section II describes the theoretical framework used to outline the international innovation and efficiency landscape and presents

[1] Innovation policy can be understood as an amalgam of science and technology policy and industrial policy (OECD/Eurostat, 2005).

[2] According to Bárcena (2008), public spending on research and development (R&D) grew by about 40% in the region between 1990 and 2003.

the main challenges for developing countries in creating and capitalizing on innovation environments. Section III explains the variables and how they work, while section IV describes the methodology used. Section V interprets and discusses the results from the statistical analysis. Lastly, section VI sets out the main conclusions and future lines of work.

II. The theoretical framework

1. Clarification of some basic innovation and efficiency concepts

According to the European Commission (1995), innovation is the use of knowledge to turn an idea into a new or improved product, service or manufacturing or distribution procedure. It is therefore clear that innovation is particularly relevant to the development and competitiveness of emerging economies. OECD (2012) describes how innovation can make the difference in addressing the challenges faced by these economies, such as disease eradication, poverty alleviation and public insecurity, or technology transfer and adaptation to modernize production.

Different explanations have been proposed over the last century with a view to better understanding innovation, especially when conceived as a process. The main ones include the technology-push model, which encompasses the innovation process, originating in science and technology, right through to the commercialization of an economically viable good or process (Rothwell, 1994). Emphasis on the role of the market as a source of innovative ideas and a determinant of the course of R&D led later to the design of the demand-pull model. For Saren (1984), who adopts another perspective, the innovation process, from the time an idea becomes an innovation input until this input becomes a product, occurs in stages in terms of the functioning of the departments of a firm.

Another way of explaining innovation is the chain-linked model, in which different paths, based on information and knowledge, connect the three major areas in the technological innovation process (research, knowledge and the central chain of the technological innovation process), with success requiring interaction between technological capabilities and market needs (Kline and Rosenberg, 1986). Lastly, the triple helix model of Etzkowitz and Leydesdorff (2000) is the most complete of those described, as it deals with the role of the firm, the State-government and the academic sector as a whole.[3] The triple helix is considered to be a spiral model of innovation because it captures different relationships at multiple points in the knowledge capitalization process.

According to Restrepo and Villegas (2007), any production process involves the use of resources to turn inputs into outputs so as to meet certain needs. This results in a number of terms used in the resource management and administration debate that serve to establish parameters for the formulation and implementation of public policies, such as productivity, effectiveness and efficiency. Productivity can be defined as the relationship between the amount of goods produced and resources used (Carro and González, 2015). It is a tool for assessing the yield of the factors forming a society, country, organization or individual. Effectiveness is the virtue of achieving the expected results, which does not necessarily mean maximizing the productive capacity of inputs. In contrast to this concept, efficiency does imply the maximization of profit or the minimization of costs, which means obtaining more outputs with a minimum of inputs, or, in other words, ensuring that the means employed are correctly distributed in relation to the ends (Quindós, Rubiera and Vicente, 2003).[4]

[3] Quadruple helix innovation models, which add society to the triple helix components, have begun to be implemented.

[4] Restrepo and Villegas (2007) argue that the terms "productivity" and "efficiency" have traditionally been used interchangeably to measure the performance of production processes.

2. Creating innovation environments and assessing their economic returns

According to this resources and capabilities approach, an innovation system must be made up of the different public and private actors, bringing together the best technical, commercial and financial capabilities and inputs in order to foster a favourable environment. The government will always be one of these actors. Its role as implementer of a potentially efficient innovation policy goes beyond the design of regulations in this area and oversight of their implementation. It should also act as a facilitator in coordinating and operationalizing innovation initiatives and commit itself to building a receptive and creative population (World Bank, 2010).

For Guimón (2004), R&D plays a key role in the performance of a country's different industrial sectors, including the more traditional ones (such as agriculture). The author emphasizes that not only must new knowledge be pursued, but it is also necessary to create environments and develop capabilities that allow it to be absorbed. That is where the role of governments is crucial.

The World Intellectual Property Organization (WIPO) (Cornell University/INSEAD/WIPO, 2016) argues that a government can intervene in two ways to correct the problem of low private investment in R&D: explicitly, by investing in sectors considered crucial for economic development, or implicitly, by structuring policies that facilitate the creation of innovation-friendly environments. Likewise, OECD (2012) stresses that innovation is not only about generating high-technology products or increasing learning capabilities, but also involves seeking ways to maximize the use of technologies such as ICTs, as these are vital for disseminating knowledge and overcoming technological barriers.

Given limited resources, there is no single process for determining which elements to consider in order to correctly assess the economic returns on innovation. Use is generally made of output indicators, also known as "innovation outputs", and to a lesser extent of indicators associated with the factors conducive to innovation. For Atilano, Mercado and Casanova (2015), research outputs are the parameters that serve to establish a baseline for evaluating the process itself, via comparison with the expected results.

For the COTEC Foundation (2001), innovation requires investments in tangible and intangible assets that can increase economic growth in two ways: via a change in production structures (an increase in the innovation effort and recomposition of technology spending) and via an intensive multiplier effect in specific areas that may present a technological deficit or represent a strategic opportunity. From this it may be inferred that numerous indicators can be used to measure the economic returns on innovation, whose composition shows differences of degree and class.[5]

3. Innovation challenges for developing countries

Bogliacino and others (2009) argue that innovation is pushed by industrialization and pulled by growth of markets. For innovation to have its greatest social impact, however, research efforts must be directed towards finding solutions to the problems of the neediest populations and increasing their well-being, a task that must undoubtedly involve both private and public entities (World Bank, 2010).

Innovation involves different processes depending on whether a country is developed or developing (Bogliacino and others, 2009). Strategies to encourage innovation in high-income economies often include creating the conditions for factor mobility in markets, trade openness and investment.[6] This

[5] From the perspective of the Global Competitiveness Index, the measurement of innovation is related to the technological capabilities of firms, public investment in innovation, the quality of scientific research institutions and collaboration between firms and universities (Schwab, 2016).

[6] Factor mobility in markets means the adaptability of factors of production, especially labour.

could also apply to developing economies provided that procedures are adapted to local conditions and needs (Navarro and Olivari, 2016). However, emerging economies should emphasize knowledge management as a strategy for bridging the gap with the developed world.

In the case of developed countries, a strong R&D capacity and science and technology infrastructure are needed to acquire and, above all, develop the knowledge and skills required to operate at the technological frontier, while for developing countries technological change occurs through the acquisition of machinery and the imitation of products and processes previously developed in advanced economies.

III. Analysis of variables and indicators

1. The composition of the Global Innovation Index

The Global Innovation Index provides an annual ranking of 128 countries by their degree of innovation and the performance of their national innovation systems in the global economic context. The index aims to capture the multidimensional facets of innovation and to provide tools that can help adapt policies to promote productivity growth through the creation of an environment in which both the drivers of innovation and their outputs are constantly assessed.

This index comprises 21 indicators grouped into 7 pillars: 15 input indicators (conducive to innovation) and 6 output indicators (resulting from innovation) (see table 1).[7] It then presents four basic measures of innovation: (i) the input subindex, which averages out the scores of the five input pillars; (ii) the output subindex, which averages out the scores of the two output pillars; (iii) the overall index, which averages out the input and output subindices; and (iv) the efficiency ratio, which is the ratio between the output subindex and the input subindex.

Table 1
Composition of the Global Innovation Index (GII), 2016

Type of pillar	Pillar (identifier)	Pillar indicators
Input	Institutions (P1)	Political environment, regulatory environment and business environment.
	Human capital and research (P2)	Education, tertiary education and research and development (R&D).
	Infrastructure (P3)	Information and communication technologies (ICTs), general infrastructure and ecological sustainability.
	Market sophistication (P4)	Credit, investment, and trade, competition and market scale.
	Business sophistication (P5)	Knowledge workers, innovation linkages and knowledge absorption.
Output	Knowledge and technology (P6)	Knowledge creation, knowledge impact and knowledge diffusion.
	Creativity (P7)	Intangible assets, creative goods and services and online creativity.

Source: Prepared by the authors, on the basis of Cornell University/INSEAD/World Intellectual Property Organization (WIPO), *The Global Innovation Index 2016: Winning with Global Innovation*, Geneva, 2016.

The partial conception of the first two measures (the input and output subindices) clearly demonstrates their limitations in determining efficiency. For its part, the overall index treats input and output items in the same way (i.e., does not set them against each other), and although this means the level of the former is internalized, it does not contribute to an understanding of how they are used to obtain the latter, and thence of efficiency. Lastly, the efficiency ratio, while reflecting the differential between input and output items (treating the former as generating the latter), does not put this differential into perspective in terms of the performance of a group of similar countries.[8]

[7] The 21 indicators themselves are derived from 81 variables associated with innovation.

[8] In other words, it does not generate any information not arising from simple cross-sectional or temporal comparisons.

Because it is desirable for efficiency to be measured across similar units, this study is limited geographically to the Latin American and Caribbean countries. It is assumed, then, that the countries in this group share the economic and social problems associated with the development of innovation capacity, regardless of what are sometimes very substantial differences in income and human development levels, the type of political regime or patterns of innovation (Bogliacino and others, 2009).[9] The region is considered to have great unexplored potential for innovation, but also significant and latent short-term risks associated with inequality and social vulnerability.

A glance at the data from the 2016 Global Innovation Index shows that Chile topped Latin America and the Caribbean in the overall index and placed forty-fourth in the global ranking, followed by Costa Rica in both the regional and global tables.[10] Ranking sixty-first in the world, Mexico was the third best placed in the region. Table 2 shows the Latin America and Caribbean countries' scores and positions for the overall index, as well as the income categories, based on per capita GDP. The countries' efficiency ratios and rankings are also presented.

Table 2
Latin America and the Caribbean: innovation, income and efficiency indicators according to the Global Innovation Index (GII), 2016

Country (abbreviation)	Overall index (1)	Rank for overall index (1)	Income category (based on per capita GDP) (2)	Rank for income category (2)	Efficiency ratio (3)	Rank for efficiency ratio (3)
Argentina (AR)	30.24	81(10)	HI	48(2)	0.56	98(12)
Bolivia (Plurinational State of) (BO)	25.24	109(17)	LM	105(18)	0.59	89(9)
Brazil (BR)	33.19	69(7)	UM	66(9)	0.55	100(13)
Chile (CL)	58.41	44(1)	HI	40(4)	0.59	91(10)
Colombia (CO)	34.16	63(5)	UM	63(7)	0.56	96(11)
Costa Rica (CR)	38.40	45(2)	UM	54(5)	0.71	50(1)
Dominican Republic (DR)	30.55	76(9)	UM	70(11)	0.62	82(7)
Ecuador (EC)	27.11	100(14)	UM	82(14)	0.60	87(8)
El Salvador (ES)	26.56	104(16)	LM	101(17)	0.48	113(17)
Guatemala (GT)	27.30	97(13)	LM	97(15)	0.62	79(5)
Honduras (HN)	26.94	101(15)	LM	98(16)	0.53	105(15)
Jamaica (JM)	28.97	89(11)	UM	77(12)	0.53	104(14)
Mexico (MX)	34.56	61(3)	UM	63(6)	0.63	76(3)
Nicaragua (NI)	23.06	116(18)	LM	102(19)	0.41	120(19)
Panama (PA)	33.49	68(6)	UM	65(8)	0.66	61(2)
Paraguay (PY)	28.20	94(12)	UM	81(13)	0.62	77(4)
Peru (PE)	32.51	71(8)	UM	68(10)	0.51	109(16)
Uruguay (UR)	34.28	62(4)	HI	45(1)	0.62	81(6)
Venezuela (Bolivarian Republic of) (VE)	22.32	120(19)	-	49(3)	0.46	114(18)

Source: Prepared by the authors, on the basis of Cornell University/INSEAD/World Intellectual Property Organization (WIPO), *The Global Innovation Index 2016: Winning with Global Innovation*, Geneva, 2016.
Note: LM: lower-middle income; UM: upper-middle income; HI: high income. In columns 3, 5 and 7, the first value is the country's global ranking and the second (in brackets) its position relative to the other countries of Latin America and the Caribbean.

Overall, the correlation between the income classification and the efficiency ratio is 29.84%, while the correlation between income and the overall index is 68.81% (see table 2). This suggests that there is a very strong association between the population's income level and the level of inputs for innovation (which weigh heavily in the overall index). The relationship between the efficiency with which

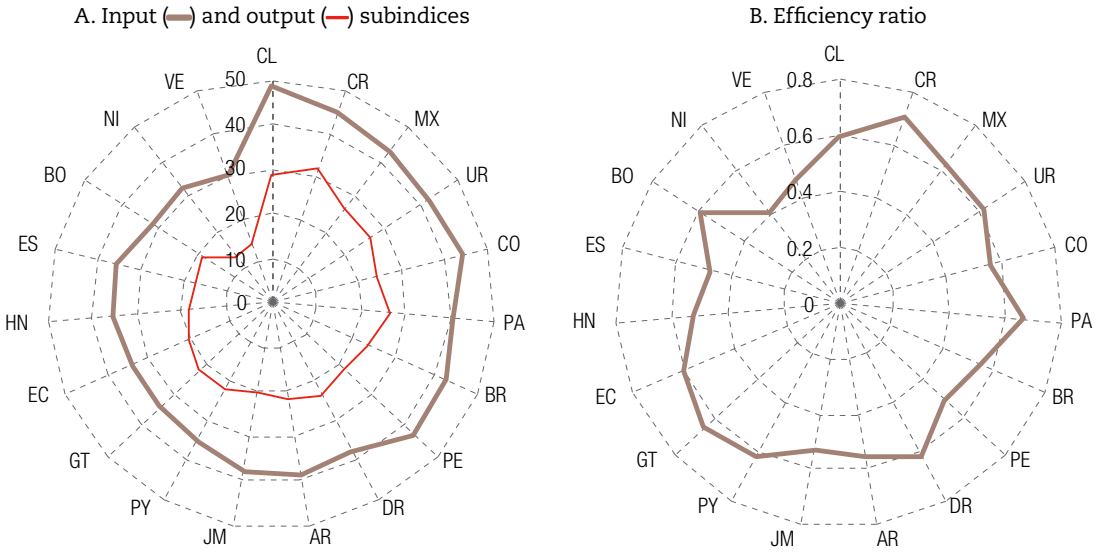
[9] This treatment of the information is justified at the end of section IV.

[10] Switzerland ranked first in the world, followed by Sweden and the United Kingdom.

these inputs are used and the level of wealth in the economy is not as strong, however. For example, economies such as the Bolivarian Republic of Venezuela, Ecuador, Guatemala, Panama, Paraguay and the Plurinational State of Bolivia ranked higher on input use (efficiency ratio) than in the overall index, both globally and regionally.

Figure 1 shows a set of radial shapes representing different measures of the Global Innovation Index associated with the creation of innovation-friendly environments. According to these data, not only is the average innovation output score much lower than the input score, but there is a notable lack of parallelism between the spirals forming the two scores in terms of countries.[11]

Figure 1
Latin America and the Caribbean: radial representations of different measures in the Global Innovation Index (GII)



Source: Prepared by the authors, on the basis of Cornell University/INSEAD/World Intellectual Property Organization (WIPO), *The Global Innovation Index 2016: Winning with Global Innovation*, Geneva, 2016.
Note: The countries are presented in descending order of their positions in the overall index, with Chile (CL) in first place. The nomenclature used in this chart is explained in table 2.

The Bolivarian Republic of Venezuela and the Plurinational State of Bolivia, even allowing for the fact that they are at the bottom of the overall index for Latin America and the Caribbean, have input subindex scores below what would be expected in a downward-trending spiral. In Brazil, Chile, Colombia, El Salvador and Peru, on the other hand, the level of outputs does not match the endowment of inputs (see figure 1.A), so that none of these countries manages better than tenth place in the efficiency ratio (see table 2).

In addition, a marked variability was found in the positions of the economies, measured as the difference between the position they occupy for an indicator and their position in the overall index. Notably, 22.44% of the positions of the Latin American and Caribbean countries for the different input indicators were worse than that of the hundredth-placed economy in the world and 17.21% were better than that of the fiftieth economy. When innovation outputs are reviewed, however, it is observed that 28.91% of the results were below the hundredth economy in the world and only 8.77% were in the top 50. This shows that the relative position of indicators worsens in Latin America and the Caribbean when outputs are looked at instead of inputs.

[11] It may be mentioned that the difference in scores is not as marked in some other regions of the world.

2. The relationship between inputs and outputs in the countries of Latin America and the Caribbean[12]

On the face of it, a positive relationship would be expected between the scores of the input and output indicators for the group of countries treated, and this is generally borne out.[13] The evidence shows a positive "one to one" correlation between the three indicators of the institutional pillar and the six output indicators.[14] The countries with the strongest presence at the efficient frontiers are Brazil (middle), Costa Rica (upper-middle) and Chile (high), all these being above the income average for Latin America and the Caribbean.[15]

There is also a positive (although in some cases incipient) correlation between the levels of human capital and research inputs and each of the outputs, except in the case of tertiary education and R&D and the generation of intangible assets, when it is negative. This is a cause for concern, as it shows that investment in higher education and research in Latin America and the Caribbean is not resulting in adequate development of the region's intellectual capital or in the creation of value from its trademarks, designs or patents.[16] The countries that usually form the frontier in these relationships are, once again, Brazil (lower-middle), Costa Rica (upper-middle) and Chile (high). Brazil is an outlier in that it has the worst tertiary education indicator in the region and one of the highest levels of knowledge creation and impact. By contrast with Latin America and the Caribbean, in Europe there is a positive relationship between tertiary education and intangible assets. The foregoing shows that high levels of inputs will not be sufficient to reduce the economic and social gaps between Latin America and the Caribbean and other regions of the world.

At the same time, there is a positive correlation between all elements of the infrastructure pillar and each of the outputs. The countries with the greatest presence at the efficient frontier are Guatemala (lower-middle), Costa Rica (upper-middle), Colombia (high) and Chile (high). In the area of ICTs, Costa Rica is a singular case, appearing below the trend line for four of the outputs, although for the rest it forms part of the efficient frontier. Also striking is the way Panama, with the best infrastructure indicator in Latin America and the Caribbean, performs only modestly because of its low output levels. Guatemala is in the opposite situation, since it has the worst infrastructure indicator but manages to position itself at the efficient frontiers, even without outstanding output levels.

The indicators of the market sophistication pillar are those that show the fewest positive relationships when transposed with outputs (55.56% positive correlations). Thus, investment is the input that has the least impact on the development of innovation in Latin America and the Caribbean, although the contribution of credit to knowledge creation and diffusion, and to online creativity, is also unclear.[17] The countries that usually form the frontier are Costa Rica (upper-middle), Chile (high) and Colombia (high). Mexico is below the trend line for three of the six outputs when it comes to trade, competition and market scale, an indicator for which it ranks first in Latin America and the Caribbean. Peru and the Plurinational State of Bolivia, meanwhile, have the highest levels for the credit factor, but are far below the levels of output needed to form part of the efficient frontier.

[12] It should be borne in mind that the output and input figures are for the same time period.

[13] There is actually a correlation of 40.92% between the level of inputs and the efficiency ratio, partially bearing out this conjecture.

[14] The construction of the efficient frontiers referred to in this subsection also needs to be understood in these terms.

[15] The lower part of the efficient frontier is excluded from the analysis because it is associated with incipient input values.

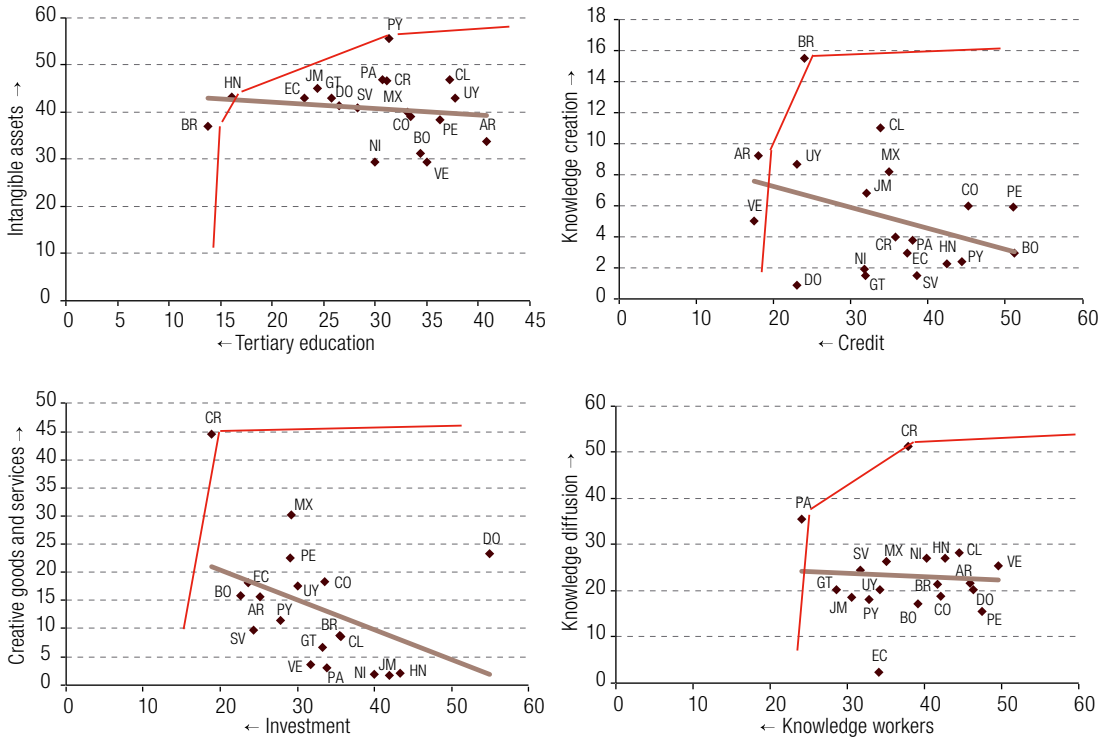
[16] In Europe, there is a positive relationship between these inputs and intangible assets. Even North Africa and Asia show a modestly positive correlation between these indicators (although in this case the relationships with most of the other outputs are not positive).

[17] In contrast to the situation in Latin America and the Caribbean, in Europe there is a positive relationship between the investment input and outputs, with the exception of knowledge impact.

As regards business sophistication, although knowledge absorption is positively associated with all outputs, in the case of knowledge workers and innovation links this sign is observed with only three of them. This behaviour could prove peculiar to Latin America and the Caribbean in relation to that pillar if it is shown that the absorption of knowledge (understood as an input) is being used as a development option because of the weakness of other inputs for this purpose. The countries that usually form the border are Chile (high), Costa Rica (high) and Uruguay (high).

Lastly, it is important to note that the negative relationships between the entry and exit indicators give rise to doubts as to whether the former really cause the latter. Around 25% of the individual relationships between these pillars showed a negative trend for Latin America and the Caribbean (see figure 2).

Figure 2
Some relationships between inputs and outputs with a negative trend



Source: Prepared by the authors, on the basis of Cornell University/INSEAD/World Intellectual Property Organization (WIPO), *The Global Innovation Index 2016: Winning with Global Innovation,* Geneva, 2016.
Note: The dashed lines represent a hypothetical efficient frontier between the variables depicted, premised on "more outputs with less inputs". The unbroken lines show the trend of the data.

IV. Methodology

Measuring efficiency means evaluating the performance of multiple indicators for an organization in search of an optimum (Álvarez, 2001). Setting out from this premise, one approach to ascertaining the level of efficiency would be to compare what the decision-making unit does with what it ought to have done to maximize its profit. However, it is unlikely that full information will be available on the context in which the decision-making units operate and, therefore, on what the maximum potential profit of each is. The best way of remedying this lack of information is to make a comparison between the decision-making unit concerned and the best-performing units with similar characteristics to the unit in question.

Setting out from the above definition of efficiency, it is important to look more closely at the distinction between technical and allocative efficiency. The former is achieved when it is technologically impossible to increase some output or reduce some input at the expense of another (Pareto optimality), while the latter (also called "price efficiency") means minimizing the waste of resources (Navarro and Torres, 2006), which is equivalent to choosing the cheapest option among the efficient input-output combinations. Since this study assumes that agents have asymmetrical information and a degree of risk aversion, it will focus on the analysis of technical efficiency.

The data envelopment analysis method can be used to study the relative individual efficiency of a set of production units in relation to the behaviour of similar units, starting from the construction of an efficient frontier (real and not ideal, relative and not absolute). This is done through non-parametric approaches that accommodate assumptions about production technology priorities and achievable production plans (Martínez, de Miguel and Murias, 2005; Restrepo and Villegas, 2007). According to Quindós, Rubiera and Vicente (2003), the data envelopment analysis method has two strengths: its degree of standardization and the ability to work with multiple inputs and outputs.

This study will make use of elements of both the Banker-Charnes-Cooper (BCC) data envelopment analysis model, which is output-oriented, and the original input-oriented Charnes-Cooper-Rhodes (CCR) version (Banker and others, 1990). However, the second method will be given greater weight because it can be used to identify differences in the production scales of decision-making units, because its modelling presents fewer restrictions and because it is more helpful when the processes and mechanisms whereby inputs are transformed into outputs are not explicit, as in this case.

In a traditional efficiency estimation context, data envelopment analysis suggests that, setting out from a production process in which p inputs ($x_1, x_2, \ldots, x_p$) are used to produce q outputs ($y_1, y_2, \ldots, y_q$) and in which n production units participate, the technical efficiency of a given unit 0 can be estimated from the following expression:

$$max_{u_r, v_i} \frac{\hat{A}_{r=1}^{q} u_r y_{r0}}{\hat{A}_{i=1}^{p} v_i x_{i0}}$$

subject to

$$\frac{\sum_{r=1}^{q} u_r y_{rj}}{\sum_{i=1}^{p} v_i x_{ij}} \leq 1$$

where , $j=1, \ldots, n$, $r=1, \ldots, q$ and $i=1, \ldots, p$. Furthermore, $u_i, v_i \geq e$, where e represents a value that is infinitesimally small but greater than zero. The underlying idea is to maximize a kind of total factor productivity index (units of output produced for each unit of input used) for each decision-making unit. The numerator of the index summarizes all the outputs in a single virtual output in the same way as in the denominator, where a single virtual input captures all the factors employed in the production process. What is used for these aggregates is not a conventional pricing system but a set of weights ($u_1, \ldots, u_q, v_1, \ldots, v_p$), whose value is to be sought, such that they maximize the ratio for each decision-making unit while keeping the ratios of the others below 1.

In addition to this basic result, the data envelopment analysis provides additional information such as virtual inputs and outputs, i.e., the contribution of each factor to the efficiency index estimated, or the levels of inputs and outputs that would make an inefficient unit efficient. One of the main attractions of this technique is that it makes it possible to balance the objective and subjective elements of the aspect to be investigated, facilitating identification of the strengths and weaknesses of each of the decision-making units being compared.

Data envelopment analysis has been used to measure and compare efficiency in sectors considered critical to countries' development, such as education, banking, health and innovation. In recent decades, new applications of this analysis have emerged in contexts other than that of production as such, and these are particularly relevant to regional analysis of development. Examples are the estimation of the social welfare and quality of life index (Hashimoto and Kodama, 1997) and the province-level index of economic well-being (Martínez, de Miguel and Murias, 2005).

However, the method also presents limitations and risks. One of the main disadvantages of data envelopment analysis lies in the challenge of adequately defining inputs and outputs (in the present paper this definition is based on an external classification). It also tends to be difficult to meet the requirement of homogeneity between the units being analysed and the uses they make of their inputs and outputs. This article will assume a priori that outputs are associated with levels of inputs and that decisions by the decision-making units (countries) about the latter have a short-term impact on the levels of the former. It is also important to mention that the inputs considered are associated with tangible and intangible costs to national economies, the financing of which represents an opportunity cost that is not considered in the analysis.

At the same time, the scale and quality of innovation outputs are partially determined by the specific regional structure of the units of measurement and the differences between the sectors that compose them. While it is true that taking these differences into account makes the results scientifically more accurate (Broekel, Rogge and Brenner, 2018), it also requires a greater amount of data and knowledge about the relative performance of economies, with the risk of value judgements arising. Given the exploratory nature of this paper and the advantages the use of general measurements has in policy discussion, no weights are applied to differentiate sectors or units of measurement.

V. Results

1. Efficiency results

The aim, within an input-oriented framework involving calculation of how far inputs can be reduced while maintaining a given output level, is to find efficiency in the creation of an innovative environment in the countries of Latin America and the Caribbean. The difference between the greatest possible efficiency value (100%) and the value observed in a unit of measurement represents its degree of inefficiency (Coelli and others, 2003).[18] The closer the value is to its maximum, the closer the decision-making unit is to the efficient frontier. Table 3 presents the management efficiency results for the inputs of each pillar relative to the level of outputs they generate.

According to table 3, the pillars having the greatest number of countries with overall and scale inefficiencies are the institutional and market sophistication pillars. Although, as already noted, the latter exhibits a poor association with outputs, inefficiencies in institutional mechanisms, which are closely associated with them, do represent a wasted opportunity in the region's development.

In particular, the infrastructure pillar presents the highest average value in terms of overall technical efficiency and pure technical efficiency. Countries such as El Salvador, Honduras and Peru show inefficiencies in four pillars, while Chile and Nicaragua display inefficiencies in three pillars. Brazil, Costa Rica, Mexico and Panama are the only countries that do not present inefficiencies in any pillar. Meanwhile, Chile, Colombia and Honduras tend to show decreasing returns to scale, so their output

[18] Overall technical efficiency depends on the occurrence of pure technical efficiency (operational aspects) and scale technical efficiency (dimensional aspects). Scale technical efficiency is calculated from the ratio between overall technical efficiency and pure technical efficiency.

is lower than expected, while the Bolivarian Republic of Venezuela, El Salvador and Peru generally present above-optimum figures. Chile and Honduras are also the countries that most often show good operational performance, even with scale inefficiencies.[19]

Table 3
Efficiency results by pillar, 2016
(Percentages)

Pillar	Country[a]	Technical efficiency			Returns
		overall	pure	scale	
Institutional	Chile	95.05	100	95.05	Decreasing
	Dominican Republic	97.83	100	97.83	Decreasing
	El Salvador	68.02	71.13	95.63	Decreasing
	Honduras	97.50	100	97.50	Decreasing
	Jamaica	72.79	72.80	99.99	Increasing
	Nicaragua	65.40	67.76	96.52	Decreasing
	Peru	93.82	94.77	99.00	Increasing
	Uruguay	99.98	100	99.98	Decreasing
	Other countries	100	100	100	Constant
Human capital and research	Argentina	79.01	80.22	98.60	Increasing
	Bolivia (Plurinational State of)	72.02	73.58	97.88	Decreasing
	Honduras	68.49	100	68.49	Decreasing
	Paraguay	93.42	100	93.42	Decreasing
	Venezuela (Bolivarian Republic of)	53.97	55.66	96.96	Increasing
	Other countries	100	100	100	Constant
Infrastructure	Colombia	98.39	100	98.39	Decreasing
	Ecuador	99.81	100	99.81	Decreasing
	El Salvador	89.82	94.25	95.30	Increasing
	Peru	90.72	92.57	98.00	Increasing
	Venezuela (Bolivarian Republic of)	80.28	98.07	81.86	Increasing
	Other countries	100	100	100	Constant
Market sophistication	Chile	98.12	100	98.12	Decreasing
	Colombia	90.57	100	90.57	Decreasing
	El Salvador	80.16	95.82	83.66	Increasing
	Guatemala	82.21	84.44	97.36	Increasing
	Honduras	96.92	100	96.92	Increasing
	Nicaragua	68.08	93.87	72.53	Increasing
	Peru	77.44	81.63	94.87	Increasing
	Other countries	100	100	100	Constant
Business sophistication	Chile	96.70	100	96.70	Decreasing
	El Salvador	96.94	100	96.94	Increasing
	Honduras	86.20	88.09	97.85	Decreasing
	Nicaragua	81.82	88.35	92.60	Increasing
	Peru	89.74	92.59	96.93	Increasing
	Other countries	100	100	100	Constant

Source: Prepared by the authors.
[a] Only countries presenting some degree of overall technical inefficiency in each pillar are included.

Chile's good performance in pure efficiency terms clearly shows that its poor scores on some measures are due to its weight in the aspects of scale and returns. It is also for this reason that three of the four countries that do not display inefficiencies hold the top three positions in the region for the efficiency ratio (which is based on the type of returns), while those with inefficiencies in four pillars rank below fifteenth in the region for this indicator.

[19] Lastly, the economies with the worst overall efficiency levels were the Bolivarian Republic of Venezuela, El Salvador, Honduras and Nicaragua. This was primarily due to the weakness of their institutions and human capital formation.

2. Results for slack and relative contributions

Slack analysis shows the direction and magnitude of the adjustment required in the levels of the indicators in the decision-making units to turn a weakly efficient country into an efficient one. Output slack indicates a need for increased outputs, while input slack is a sign of excess inputs, to the extent suggested by the aggregate value of their indicators (Lo, Chien and Lin, 2001). Table 4 shows, for example, that Peru requires changes in its input and output indicators in four pillars to close up with the efficiency frontier.[20] Peru is followed by El Salvador and Nicaragua, which require changes in three pillars, and the Bolivarian Republic of Venezuela, which needs changes in two pillars.

Table 4
Slack results by pillar, 2016
(Percentages)

Pillar	Country	Input slack			Output slack					
		IP1	IP2	IP3	OP1	OP2	OP3	OP4	OP5	OP6
Institutional	El Salvador	3.30	17.63	-	2.42	3.00	0.14	-	-	2.01
	Jamaica	-	1.65	-	-	-	1.04	-	8.61	3.12
	Nicaragua	-	35.84	11.48	3.03	0.88	-	1.04	4.51	3.75
	Peru	-	15.49	-	1.07	2.23	8.95	-	-	-
Human capital and research	Argentina	-	-	1.75	-	11.16	-	7.95	-	-
	Bolivia (Plurinational State of)	1.90	-	-	-	-	-	11.39	0.50	2.02
	Venezuela (Bolivarian Republic of)	-	13.44	5.68	-	10.06	1.10	3.35	-	-
Infrastructure	El Salvador	15.86	-	-	0.46	21.50	-	1.92	-	0.44
	Peru	-	-	4.46	-	3.85	12.90	3.11	-	-
	Venezuela (Bolivarian Republic of)	11.49	-	-	-	17.86	-	13.67	-	-
Market sophistication	El Salvador	-	-	-	2.25	14.98	9.62	-	15.91	3.26
	Guatemala	-	-	-	5.88	-	3.92	-	13.75	13.65
	Nicaragua	-	0.87	-	1.80	5.43	-	7.05	2.61	1.72
	Peru	10.20	-	-	-	1.94	20.68	5.93	9.10	3.99
Business sophistication	Honduras	-	12.07	-	1.49	1.21	-	-	7.14	6.28
	Nicaragua	-	-	-	3.43	19.12	-	11.27	5.66	11.83
	Peru	5.71	-	-	1.12	3.55	3.70	-	-	0.30

Source: Prepared by the authors.
Note: The inputs represented by IP1, IP2 and IP3 differ depending on the pillar. For institutional, IP1: Political environment; IP2: Regulatory environment; IP3: Business environment. For human capital and research, IP1: Secondary education; IP2: Tertiary education; IP3: Research and development (R&D). For infrastructure, IP1: Information and communication technologies (ICTs); IP2: Infrastructure; IP3: Ecological sustainability. For market sophistication, IP1: Credit; IP2: Investment; IP3: Trade, competition and market scale. For business sophistication, IP1: Knowledge workers; IP2: Innovation links; IP3: Knowledge absorption. OP1: Knowledge creation; OP2: Knowledge impact; OP3: Knowledge diffusion; OP4: Intangible assets; OP5: Creative goods and services; OP6: Online creativity.

The output indicator that most often exhibits slack is knowledge impact, followed by online creativity (both of which had already been found to be somewhat decoupled from inputs such as credit). For the former, countries such as the Bolivarian Republic of Venezuela, El Salvador and Nicaragua need to achieve increases of about 20% in some cases. Peru has problems with knowledge diffusion. However, Nicaragua has the largest deficit in its output indicators, requiring adjustments in almost all of them.[21] These problems come on top of others already identified (e.g., with the generation of intangible assets) when the relationships between inputs and outputs were analysed, with some negative associations even being found. It should also be noted that levels of infrastructure, knowledge absorption and trade, competition and market scale are optimally employed to improve efficiency in the 19 countries of the region, which reinforces the conjecture that the region's main problems lie in the institutional and human capital and research aspects.

[20] The average results do not place Peru among the four worst-performing economies, however.

[21] It even presents a regulatory environment (institutional pillar) that is very unproductive for its level of output, as do El Salvador and Peru.

In contrast to the slack analysis, the relative contribution of the indicators points to a country's strengths and weaknesses in managing for certain objectives. A country that presents a relative advantage in an indicator will tend to get a greater contribution from it (Martínez and Murias, 2011). The business environment was found to be the indicator with the highest average contribution to innovation efficiency in Latin America and the Caribbean in the institutional area, while the regulatory environment was the input that contributed least to this objective within the institutional pillar.

Where human capital and research are concerned, secondary education was the indicator on which innovation efficiency primarily rested, while R&D was the input that contributed the least. In the case of the infrastructure pillar, ICTs were the indicator that made the greatest contribution, which is consistent with what Bárcena (2008) suggested, although Brazil and Colombia preferred to give more weight to infrastructure to make the most of their innovation potential, while the Bolivarian Republic of Venezuela, Costa Rica, Ecuador and El Salvador gave more weight to ecological sustainability.

The indicators of the market sophistication pillar contributed very equitably to the strengthening of innovation, averaging between 30% and 35% each in the countries of Latin America and the Caribbean. With regard to business sophistication, the knowledge workers indicator was the one on which the countries of the region relied most, while innovation links contributed least. This is evidence that the countries of the region are struggling to take advantage of the indicator with the greatest potential impact in the pillar (knowledge absorption) to increase the level of outputs.

3. International comparison

To situate Latin America and the Caribbean in the international context, table 5 shows the percentage differential between this region and the other regions of the world for each of the input and output pillars, in addition to the efficiency ratio. North America was found to have the largest positive differential with Latin America and the Caribbean for all pillars, which to some extent was predictable given that this region ranks first on 17 of the 21 indicators (Europe has the other top four positions).

Table 5
Differences in scores for the innovation pillars and efficiency ratio between the different world regions and Latin America and the Caribbean, 2016
(Percentages)

Region	P1	P2	P3	P4	P5	P6	P7	ER
North America	67.58	109.17	54.56	89.41	60.77	169.38	89.19	28.07
Europe	43.59	77.75	31.07	17.75	31.26	107.68	67.15	31.58
South-East Asia, East Asia and Oceania	31.68	63.52	26.76	34.59	34.87	99.34	43.66	24.56
North Africa and West Asia	14.21	21.80	10.61	-0.43	-12.54	33.89	10.08	10.53
Central Asia and South Asia	-6.54	-5.55	-12.76	-3.95	-16.22	10.12	-20.62	3.51
Sub-Saharan Africa	-0.96	-31.61	-29.72	-15.08	-10.43	1.77	-27.18	1.75

Source: Prepared by the authors, on the basis of Cornell University/INSEAD/World Intellectual Property Organization (WIPO), *The Global Innovation Index 2016: Winning with Global Innovation*, Geneva, 2016.
Note: The pillars are identified in table 1. ER: Efficiency ratio.

Table 5 is also very revealing because it shows that, according to the pillar scores, only the Central and South Asia and Sub-Saharan Africa regions have levels below those of Latin America and the Caribbean for most of the pillars and that no world region performs less well overall than Latin America and the Caribbean. Strikingly, no region scores as low as Latin America and the Caribbean for the knowledge and technology output pillar (P6), or even for the efficiency ratio.[22]

[22] The information in table 5 comes not from the efficiency analysis conducted in this study but from analysis of the data from the source cited using descriptive statistics.

VI. Conclusions

The countries of Latin America and the Caribbean are trying to adapt to the constant changes demanded by the world economy in quest of development, and innovation has become a key element in this. However, as Navarro and Olivari (2016) anticipated, many of these economies are lagging behind in the incorporation of knowledge and technology into their production processes because of impediments arising from the complexity of their social and economic contexts, which not only jeopardizes the attainment of development goals but increases the risk that the gap with the industrialized countries will be perpetuated and even widen over time.

Using data from the 2016 Global Innovation Index and applying the data envelopment analysis methodology, this paper assesses the efficiency of the 19 economies that make up the Latin American and Caribbean region when it comes to creating environments conducive to innovation. The intention is to identify the main challenges for these countries in the management and exploitation of what are usually understood as inputs available for this, irrespective of the income level of these economies. In fact, the countries with the highest income levels in Latin America and the Caribbean were not at the forefront of efficiency management, confirming that there is only a modest correlation between these variables.

Moreover, the countries that rank highest in the general efficiency index (Chile, Costa Rica and Mexico) or are at the regional efficiency frontiers (Brazil, Chile, Colombia, Costa Rica and Uruguay) do not always maintain this position when what is being evaluated is the use of inputs to achieve certain innovation outputs, especially given the presence of decreasing returns to scale for these economies, which prevents them from achieving better results as their inputs increase. This becomes evident when the leading positions of Chile and Colombia in the general index for Latin America and the Caribbean are contrasted with their positions in the bottom half of the table for the efficiency ratio.

The best performance in terms of overall technical efficiency and pure technical efficiency was in the infrastructure pillar. The worst average performance in overall technical efficiency was in the human capital and research pillar. The institutional pillar came out worst for pure technical efficiency and market sophistication for scale technical efficiency, which reveals difficulties with the development of financial markets and with trade and competition. At the same time, while most individual input-output ratios are positive in Latin America and the Caribbean (although less so than in other regions, such as North America and Europe), non-positive ratios tend to involve indicators such as tertiary education, R&D, credit and investment. This is worrying because these variables should be the basis for creating an environment conducive to innovative development. Nor do knowledge workers and innovation linkages appear to have a strong impact on innovation outputs, while skill constraints prevent knowledge absorption from being properly exploited to achieve efficiency outcomes.

The countries of Latin America and the Caribbean have a well-established tradition of scientific and technological development policies (OECD/Eurostat, 2005), and this has ultimately had an impact on the number of innovation support programmes implemented and the level of participation by the different actors. Nevertheless, the long-standing constraints on the region, which include weaknesses in institutions (regulatory aspects among them), economic instability, informal activities and corruption problems (Schwab, 2016), indicate that it will be a long haul to position its countries at the top of the Global Innovation Index through efficient input management that is also reflected in greater social welfare and economic growth.

Although most of the policies and actions carried out by the countries of the region to foster innovative environments are consistent with their capacities and relative advantages in a heterogeneous context (Bárcena, 2008), some challenges remain. One of them is to strengthen inputs that have traditionally performed poorly and, above all, to strategically exploit the input-output ratios that have the most solid track record so as to maximize their impact, first on productivity and then on development.

It should be noted that this study is a partial analysis of the efficiency of the countries of Latin America and the Caribbean, since, owing to technical limitations, it only takes into account the most representative relationships of the phenomenon as indicated by the literature. In addition, the results are obviously limited by the fact that there is no follow-up of public and private investments in innovation and development, their opportunity cost or the degree to which each country's specific targets in this area have been met. In other words, the relationship between innovation inputs and outputs has been evaluated, but not the processes and mechanisms connecting them. Possible national priorities in what is a heterogeneous region have likewise not been taken into account.

With regard to future lines of research, it is important to identify criteria that can be used to incorporate variables associated with the impact on productivity and human development. Above all, considering the role played by the public sector, the extent to which local goals have been achieved and their strategic consistency could make the conclusions more widely applicable.

Bibliography

Álvarez, A. (coord.) (2001), *La medición de la eficiencia y la productividad*, Madrid, Ediciones Pirámide.

Atilano, Á., J. Mercado and H. Casanova (2015), *Indicadores de innovación tecnológica de los países de América Latina y el Caribe - 2015*, Caracas, Development Bank of Latin America (CAF).

Banker, R. and others (1990), "An introduction to data envelopment analysis with some of their models and its uses", *Research in Governmental and Nonprofit Accounting*, vol. 5, Emerald Group Publishing.

Bárcena, A. (ed.) (2008), "Innovación para el desarrollo: reflexiones desde América Latina y el Caribe", presentation at the IV Encuentro Empresarial Iberoamericano, San Salvador, 29 October.

Bogliacino, F. and others (2009), "Innovation in Developing Countries: The Evidence from Innovation Surveys", Milan, Bocconi University [online] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.455.3127&rep=rep1&type=pdf.

Broekel, T., N. Rogge and T. Brenner (2018), "The innovation efficiency of German regions – a shared-input DEA approach", *Review of Regional Research*, vol. 38, No. 1, Springer.

Cañibano, C. (2005), "El capital humano: factor de innovación, competitividad y crecimiento" [online] http://www.navarra.es/nr/rdonlyres/d696efd2-6aaa-4ef1-b414-e3a27109ea67/79785/14carolinacaibano.pdf.

Carro, R. and D. González (2015), *Administración de las operaciones: actividades para el aprendizaje*, Mar del Plata, National University of Mar del Plata.

Coelli, T. and others (2003), *A Primer on Efficiency Measurement for Utilities and Transport Regulators*, Washington, D.C., World Bank.

Cornell University/INSEAD/WIPO (World Intellectual Property Organization) (2016), *The Global Innovation Index 2016: Winning with Global Innovation*, Geneva.

COTEC Foundation (2001), *Innovación tecnológica: ideas básicas*, Madrid.

Etzkowitz, H. and L. Leydesdorff (2000), "The dynamics of innovation: from national systems and 'mode 2' to a triple helix of university-industry-government relations", *Research Policy*, vol. 29, No. 2, Amsterdam, Elsevier.

European Commission (1995), *Green Book on Innovation*, Brussels.

Guimón, J. (2004), "Relevance and impact of intangibles disclosure in capital markets", *Readings on Intangibles and Intellectual Capital*, L. Cañibano and P. Sánchez (eds.), Madrid, Spanish Association on Accounting and Business Administration.

Hashimoto, A. and M. Kodama (1997), "Has livability of Japan gotten better for 1956-1990?: a DEA approach", *Social Indicators Research*, vol. 40, No. 3, Springer.

Kline, S. and N. Rosenberg (1986), "An overview of innovation", *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, R. Landau and N. Rosenberg (eds.), Washington, D.C., The National Academies Press.

Lo, F., C. Chien and J. T. Lin (2001), "A DEA study to evaluate the relative efficiency and investigate the district reorganization of the Taiwan power company", *IEEE Transactions on Power Systems*, vol. 16, No. 1.

Martínez, F., J. C. de Miguel and P. Murias (2005), "El análisis envolvente de datos en la construcción de indicadores sintéticos: una aplicación a las provincias españolas", *Estudios de Economía Aplicada*, vol. 23, No. 3, Valladolid, International Association of Applied Economics.

Martínez, F. and P. Murias (2011), "Sistemas de pensiones y bienestar económico de la población mayor: un indicador sintético para los países de la OCDE", *Revista Galega de Economía*, vol. 20, Santiago de Compostela, University of Santiago de Compostela.

Navarro, J. C. and J. Olivari (eds.) (2016), *La política de innovación en América Latina y el Caribe: nuevos caminos*, Washington, D.C., Inter-American Development Bank (IDB).

Navarro, J. C. and Z. Torres (2006), "Análisis de la eficiencia técnica global mediante la metodología DEA: evidencia empírica en la industria eléctrica mexicana en su fase de distribución, 1990-2003", *Revista Nicolaita de Estudios Económicos*, vol. 1, No. 1, Michoacán, Institute of Economic and Business Research (ININEE).

OECD (Organization for Economic Cooperation and Development) (2012), *Innovation for Development: A Discussion of the Issues and an Overview of Work of the OECD Directorate for Science, Technology and Industry*, Paris, OECD Publishing.

OECD/Eurostat (Organization for Economic Cooperation and Development/Statistical Office of the European Communities) (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, third edition, Paris, OECD Publishing.

Quindós, M., F. Rubiera and M. Vicente (2003), *Análisis envolvente de datos: una aplicación al sector de los servicios avanzados a las empresas del Principado de Asturias*, Rect@, Actas 11, No. 1.

Restrepo, M. and J. Villegas (2007), "Análisis envolvente de datos: introducción y herramienta pública para su utilización", University of Antioquia [online] https://juangvillegas.files.wordpress.com/2013/08/restrepo-villegas-dea.pdf.

Rothwell, R. (1994), "Towards the fifth-generation innovation process", *International Marketing Review*, vol. 11, No. 1, Bingley, Emerald Publishing.

Saren, M. (1984), "A classification and review of models of the intra-firm innovation process", *R&D Management*, vol. 14, No. 1, Wiley.

Schwab, K. (2016), *The Global Competitiveness Report 2016-2017,* Geneva, World Economic Forum.

World Bank (2010), *Innovation Policy: A Guide for Developing Countries*, Washington, D.C.

Productive investment in Chile's economic development: trend and challenges[1]

Ricardo Ffrench-Davis and Álvaro Díaz

Abstract

This article reviews the trend of investment in Chile and its relationship with economic growth since the 1973 coup d'état; and it documents how investment remains the main growth driver. Notwithstanding that fact, innovation helps to mitigate diminishing returns from natural resources, while technology-intensive investment, such as broadband infrastructure, helps to diversify the production matrix. The article shows how a persistent increase in the investment ratio in 1990–1998 supported GDP growth of 7.1% per year; but since 1999 investment has wavered, and average growth dropped to below 4%. The article examines the macroeconomic environment and its real instability since 1999, along with investment in infrastructure, the quality of natural resources and environmental services; and it identifies challenges for boosting both investment and innovation, diversifying the production matrix and its agents, and moving towards inclusive growth.

Keywords

Investments, economic growth, productivity, macroeconomics, capital formation, natural resources, natural resources development, physical infrastructure, investment promotion, Chile

JEL classification

E22, F32, O11, O13

Authors

Ricardo Ffrench-Davis, PhD in economics from the University of Chicago (United States); winner of the National Prize for Humanities and Social Sciences (Chile). Email: rffrench@econ.uchile.cl.

Álvaro Díaz, PhD candidate in economics at the University of Campinas (Brazil); master's degree in economics from Consejo Superior Universitario Centroamericano (CSUCA)-UNAM (Mexico); Bachelor's degree in economics from the University of Costa ica (Costa Rica); Bachelor's degree in sociology from the University of Costa Rica (Costa Rica). Email: alvdiaz@gmail.com.

[1] The authors are grateful for comments made by Daniel Titelman and Miguel Torres, and for the cooperation provided by Andrea Costa and Claudio Aravena.

I. Introduction

Most studies of economic growth in Chile reference the neoclassical Solow-Swan model (Solow, 1956; CNP, 2017) which subdivides growth factors into labour, capital and a residual. The latter represents total factor productivity (TFP), which is interpreted as the result of technological change and resource reallocation.[2] This approach to growth accounting is used by many analysts to assess the importance of productivity in fuelling the economic growth process.

In this approach it is common to find claims that TFP is the key driver of growth, ahead of investment. Nonetheless, this statement is based on traditional methodologies that underestimate the contribution made by capital and overestimate the contribution of TFP. The LA-KLEMS project, coordinated by the Economic Commission for Latin America and the Caribbean (ECLAC), which uses more advanced methodologies, has found that capital contributed more to growth than TFP in 1981–2010. Moreover, the traditional measurement of TFP predominantly reflects fluctuations in the rate of existing capacity utilization, which generates a procyclical estimate. In other words, if greater use can be made of idle productive capacity, then growth can occur without investment —but only until there is no underused installed capacity left.

Traditional thinking on TFP also fails to adequately capture fluctuations in relative natural-resource wealth, which may be affected by the ore grade or the status of ecological systems. For example, changes in copper ore grade can have significant impacts on mining productivity; and the deterioration or recovery of ecological systems and externalities can impact the trend of GDP (see Sotelsek and Laborda, 2010). For this reason, for several years, the Central Bank of Chile has been making estimates that separate out mining or natural resources, which undoubtedly is very useful for understanding the domestic macroeconomic situation. In short, natural resources and the business cycle generate wide fluctuations in TFP which may have a non-technological origin (Calvo, Izquierdo and Talvi, 2006).[3]

Traditional neoclassical and modern estimations of factor contributions to economic growth recognize the decisive role that gross fixed capital formation (GFCF) —equipment, machinery, buildings and infrastructure— plays in development. A recent study to measure the long-term productivity of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico) shows that the more accurate the measurement of directly quantifiable inputs, the less relevant is TFP in the five countries (Coremberg and Pérez, 2010). According to these authors, GFCF was the main driver of growth in the region's economies in 1990–2006.

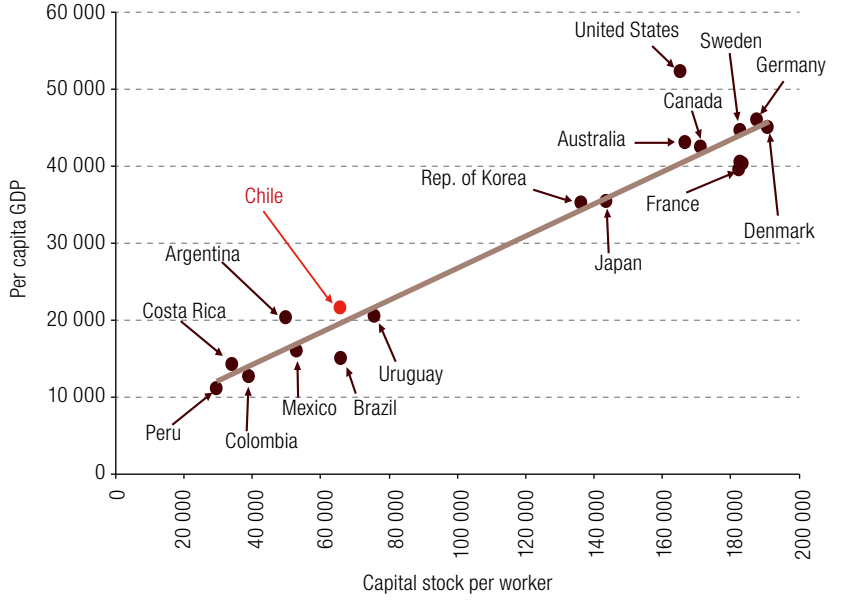
Aside from its direct growth effects, GFCF has a short-term macroeconomic impact on the level of economic activity, since it is a component of domestic demand; and this explains the importance of countercyclical policies targeted on investment.

The fact that the capital stock is a determinant of economic growth is evidenced by the much higher intensity of capital per member of the labour force in the advanced countries of the Organization for Economic Cooperation and Development (OECD) compared to those of Latin America. Figure 1, which is based on the Penn World Table, version 9.0, shows that the estimated average per capita GDP of selected OECD countries in the 2005–2014 decade (measured in 2011 United States dollars at purchasing-power-parity (PPP)) is 2.7 times the average for Latin American countries, closely reflecting the difference of 2.8 times in the capital stock per worker.

[2] In the Solow-Swan model, the growth literature has abandoned the assumptions of constant returns to scale, exogenous technical progress and the representative firm; and it has incorporated, for example, company creation and destruction, imperfect competition, technological diffusion, natural resources and pollution. Nonetheless, there are few studies that incorporate these factors for the case of Chile.

[3] These problems are compounded by structural heterogeneity between small and medium-sized enterprises (SMEs) and large firms, which has tended to increase since the 1970s; but its potential reduction offers an important source of increased average productivity. No less important is the potential impact of institutional and regulatory changes on productivity growth.

Figure 1
Latin America and selected developed countries: per capita GDP and capital stock per worker, 2005–2014
(2011 US dollars at purchasing power parity)



Source: Penn World Table, version 9.0 [online] www.ggdc.net/pwt; and R. C. Feenstra, R. Inklaar and M. P. Timmer, "The next generation of the Penn World Table", *The American Economic Review,* vol. 105, No. 10, Nashville, Tennessee, American Economic Association, 2015.

Although GFCF is decisive for growth, innovation helps overcome the obstacles that generate decreasing productivity. It also contributes new products and processes that offer opportunities for further diversification of the production matrix. In short, innovation triggers investment; but this is not always well reflected in growth accounting, for whereas robust and detailed statistics on capital and labour can be obtained, it is much harder to measure knowledge and innovation.[4]

Although decisive for GDP growth, the investment rate in Chile has fluctuated widely in recent decades, both in aggregate terms and in its composition. Changes in the trend of gross investment respond to several factors, including, from a macroeconomic standpoint, the ups and downs associated with divergences between actual and potential GDP (output or recessionary gap). To control for these fluctuations, this study examined the trends of investment and GDP in subperiods between the years in which output gaps were smallest, namely 1981, 1989, 1998, 2007/08 and 2013, in the period analysed (1974–2017).

Section II reviews the trend of total capital formation and its relation to GDP growth, firstly analysing gross investment in current prices each year, starting with global figures for the aforementioned subperiods. The mining sector is then separated out, given its importance in the national economy and the clearly defined cycles it has experienced. Foreign investment is also segregated, since its share in productive investment is clearly increasing. A distinction is made between investment that creates new capacity and investment to acquire existing assets. The figures are adjusted for inflation, and the section concludes with the net productive capital formation and the trend of the capital stock per member of the labour force.

[4] There are also measurement problems with labour and capital. In the latter case, only in the last two decades have methodologies been introduced that take account of rapid increases in quality and falls in the prices of items such as computers and telecommunications equipment, and software. This increases the contribution of capital (Jorgenson and Vu, 2001).

Section III considers the dynamics of investment in natural-resource- and infrastructure-based sectors, which generates a number of hypotheses to explain the divergences analysed in section II. The first is that, since the start of the last decade, the country has been facing a scenario of diminishing returns in the production and exportation of natural-resource-based goods and services, accompanied by a deterioration in nature's capacity to provide environmental services to restore ecosystems (such as H_2O) and to absorb emissions (CO_2, ozone, particulate matter (PM)) and both liquid and solid industrial wastes. The second is that public investment policy has lost momentum in the last decade relative to 1990–2005, particularly in terms of the ability to encourage new investments in transport infrastructure and telecommunications. In fact, it only managed to significantly boost investments in the electricity sector.

Section IV analyses the crucial role innovation plays in facilitating and encouraging —but not replacing— investment and the consequent capital accumulation. Firstly, although investment in research and development (R&D) is currently at a very low level (0.38% of GDP), a rapid and sustained increase in innovation, based on R&D, could trigger the recovery of increasing returns in natural-resource-based sectors and raise productivity in others such as transport and industry. Secondly, innovation in terms of new infrastructures (such as broadband or solar energy) can foster the development of high-productivity sectors and diversification of the production matrix. Nonetheless, this requires an entrepreneurial state to promote new public policies and institutional innovations (Mazzucato, 2013).

II. Trend of total capital formation and growth

Since the 1990s, the ratio of investment (or GFCF) to GDP in Chile has been above the Latin American average. This enabled Chile to outpace the region as a whole in 1990–2017 (4.6% annual growth compared to 2.7%), and also to surpass its own previous growth of 2.9% per year on average between 1974 and 1989. The higher investment rate prevailing since the 1990s was also reflected in an increase in the capital stock per member of the labour force, which has underpinned the growth of real wages since the return to democracy. Nonetheless, the trend of investment and the capital stock has experienced significant fluctuations and changes in its composition; and GDP growth has also fluctuated sharply throughout this period.

1. Fixed capital formation, 1974–2017[5]

The stock of capital goods is one of the variables that determines the productive capacity of an economy. The conventional definition used in the national accounts includes residential and commercial buildings, infrastructure, machinery and equipment.[6]

The capital stock is formed from gross flows of investment in productive goods and services, less depreciation or capital consumption (see Ffrench-Davis and Vivanco, 2016). Gross fixed capital formation is the most direct calculation of investment flows at current market prices, and is the information usually provided; it represents the total expenses incurred in each unit of time by productive investors operating in the domestic market. There are also three derived data items. One is GFCF expressed

[5] The reforms of the dictatorship and the changes made to economic policies since the return to democracy, along with their consequences, are discussed in Ffrench-Davis (2018).

[6] Methodological changes have required major modifications in the historical series of GDP and related variables. In the new chain-linked national accounts referenced to 2008, the central bank included products such as mining exploration and software, which generated a 5.6% increase in GFCF at current prices relative to the figure reported for the same year by the previous national accounts series (base 2003). Subsequently, further adjustments were made to the chain-linked national accounts (reference year 2013), such as repairs of machinery, mainly mining. This meant that, for 2013, GFCF in current pesos was 4.6% higher than the figure reported in the 2008-referenced series for that year. The accumulation of changes generates considerable differences; for example, in 1981–1985, the 2013-based series in current pesos reports a figure 13% higher than in the 1977 series (the base prevailing in those years).

in real terms, which enables intertemporal comparisons to be made, but entails the complex task of estimating deflators for machinery and equipment and the other components of fixed capital.[7] Another is depreciation, which is complex because of the numerous assumptions that have to be made about the useful life of the various productive assets. The third piece of data, constructed simply from the two previous ones, is the estimated capital stock, which represents the sum of the flows of GFCF minus depreciation of the existing stock.

This subsection focuses on the trend of gross and net annual investment flows and the stock of capital, from 1974 —at the start of the neoliberal reforms introduced by the dictatorship— until 2017. Given their heavy incidence and sharp fluctuations, first investment in mining and then foreign investment were disaggregated from the total. Section III makes a disaggregated analysis of the mining sector and two other sectors, starting with GFCF at current prices each year. This reflects the actual spending of economic agents who invest in productive capital, although not the trend of the purchasing power of that expenditure, which is addressed later.

Table 1 shows the trend of GFCF as a share of GDP (investment ratio), measured in current prices. Each subperiod is defined in a way that captures the trend of GDP between peaks in annual activity, to control for cyclical fluctuations in the rate of productive-capacity utilization.

Table 1
Chile: GFCF and GDP growth, 1974–2017
(At current prices[a])

Periods	Gross fixed capital formation *(percentages of GDP)* (1)	Gross fixed capital formation in the mining sector *(percentages of GFCF)* (2)	Gross fixed capital formation in other sectors *(percentages of GFCF)* (3)	GDP growth *(percentages)* (4)
1974–1989	17.3	-	-	2.9
1990–1998	25.2	-	-	7.1
1999–2003	21.3	-	-	2.6
2004–2007	20.8	14.1	85.9	5.7
2008–2013	23.7	22.8	77.2	3.8
2014–2017	23.0	21.7[b]	78.3[b]	1.7

Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years; and M. Marcel and P. Meller, "Empalme de las cuentas nacionales de Chile, 1960–1985. Métodos alternativos y resultados", *Colección Estudios CIEPLAN*, No. 20, Santiago, Corporation for Latin American Studies, December 1986.

Note: Column (1) series referenced to 2013; columns (2) and (3) series referenced to 2013 until 2008 inclusive, since 2007 spliced backwards with the 2003 series; for column (4) from 1974 to 2005, the central bank series at constant 2003 prices was used, spliced with revised figures by Marcel and Meller (1986); from 2006 inclusive the percentage changes in GDP are used according to the 2013 mobile-based chain-linked series.

[a] Except column (4).

[b] Average for 2014–2016, owing to data availability.

Column (1) shows that during the 16 years of the dictatorship (1974–1989) the investment ratio was 17.3%, the lowest of the entire period covered in this article. In contrast, in the first nine years after the return to democracy (1990–1998), investment averaged 25.2% of GDP, which was the highest rate in those 44 years and also generated the most vigorous economic growth at 7.1% per year. Since 1999, the investment rate has fluctuated cyclically between the two extremes, as explained in the following subsection.

The sectoral composition of capital formation has undergone major changes. A major boom in the prices of natural resources, including copper, in recent years fuelled a significant increase in mining investment, which grew gradually from an annual average of US$ 2.505 billion in 2003–2004 to US$ 19.771 billion in 2012–2013, when that cycle ended. As a result, between the two biennia, mining investment increased from an annual average of 14.0% to 29.2% of total GFCF, financed mainly out of the sector's burgeoning profits. In 2013, the mining investment cycle entered a downswing phase (see table 2 and figure 2).

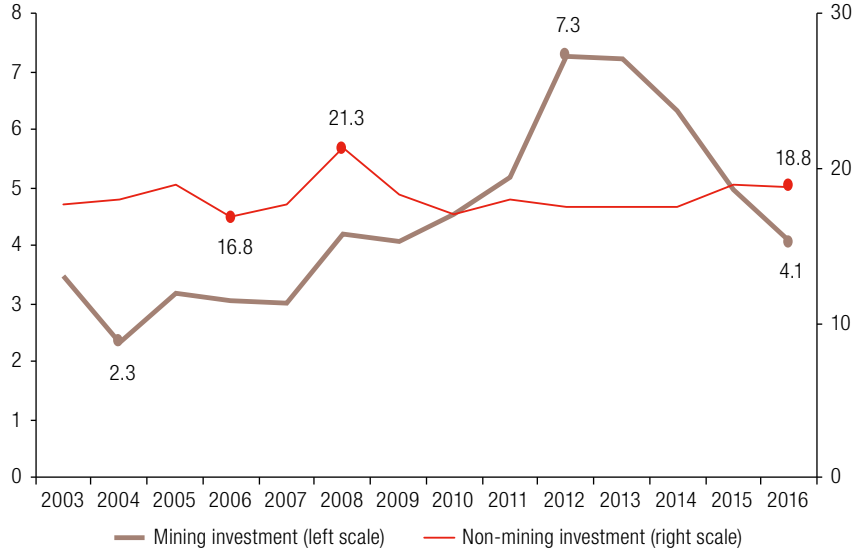
[7] Beyond this complexity, the change in the national accounts from series with a fixed base year to chain-linked series creates a set of methodological difficulties —so much so that the International Monetary Fund (IMF), the World Bank and ECLAC all still work with series that have a base year.

Table 2
Chile: mining investment and production, 2003–2017
(In current prices[a])

Periods	*GFCF (percentages of GDP)* (1)	GFCF in the mining sector *(percentages of GDP)* (2)	GFCF in other sectors *(percentages of GDP)* (3)	GFCF in the mining sector *(percentages of GFCF)* (4)	GDP of the mining sector *(percentages of GDP)* (5)	GDP of the mining sector, chain-weighted *(percentages of GDP)* (6)
2003	21.2	3.5	17.7	16.4	8.2	16.6
2004	20.3	2.3	18.0	11.6	12.5	15.7
2005	22.2	3.2	19.0	14.5	14.6	14.2
2006	19.9	3.1	16.8	15.6	20.7	13.6
2007	20.7	3.0	17.7	14.6	20.5	13.3
2008	25.5	4.2	21.3	16.5	14.0	12.4
2009	22.5	4.1	18.4	18.2	13.0	12.6
2010	21.6	4.6	17.0	21.1	15.9	12.2
2011	23.1	5.2	17.9	22.4	14.8	10.9
2012	24.9	7.3	17.6	29.3	12.5	10.8
2013	24.8	7.2	17.6	29.1	11.0	11.0
2014	23.8	6.3	17.5	26.5	10.9	11.0
2015	23.8	4.9	18.9	20.8	8.6	10.7
2016	22.9	4.1	18.8	17.8	8.1	10.3
2017	21.6	-	-	-	10.1	9.9
2003–2007	20.8	3.0	17.8	14.5	15.3	14.7
2010–2014	23.6	6.1	17.5	25.7	13.0	11.2
2015–2017	22.2	4.1[b]	18.8[b]	17.8[b]	9.1	10.1

Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years.
Note: All figures in current pesos except column (6) which reports chain-linked pesos; columns (1), (5) and (6) series referenced to 2013; columns (2), (3) and (4) for 2008–2016, series referenced on 2013; since 2007 backcast using rates of change from the 2003 series.
[a] Except column (6).
[b] Average for 2015–2016, owing to data availability.

Figure 2
Chile: investment in the mining and non-mining sectors, 2003–2016
(Percentages of GDP)



Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile,* Santiago, various years.
Note: Until 2008 inclusive, series referenced to 2013; for 2003–2007 it is spliced using rates of change from the 2003-based series, as in table 2.

The intensity of the cyclical force of mining clearly marked capital formation in more recent years, as reflected in columns (1) and (2). In contrast, the rest of GFCF experienced less intensive changes (see column (3) of table 2 and figure 2).

As shown in column 5 (in current pesos), the share of mining production in GDP fluctuated sharply; it did so alongside the price of copper. In column 6 (real chained series), this price effect is controlled for, to reveal a real share that declines steadily from 16.6% of GDP in 2003 to 12.2% in 2010 and 9.9% in 2017. This reflects the lags that exist between investment and higher production and also sharp reductions in ore grades. In addition, a study that corrects for factors that are endogenous and exogenous to mining operations reports a drop in TFP of 1% per year in 2000–2014 (CNP, 2017). In this context, two subperiods in mining production can be identified. The first spans 1990–2003, the golden age of Chilean mining, when production expanded by a multiple of 3.1 thanks to the coming-on-stream of 27 new deposits; and the second, lasts from 2004 to 2017, when copper production grew by just 3.6%.

Investment in the mining sector has increased significantly; mining operations in the 1980s and 1990s allowed for the exploitation of nearly 30 new deposits. In a study of the world's 100 most important copper deposits launched between 1988 and 2012, 29 of them, accounting for 39% of the world's mineral reserves, were located in Chile. Although the average grade of the Chilean deposits was only 50% of that of the 71 other deposits, they contained four times more copper because of their large size. The massive presence of mineral material in the Chilean deposits enabled the deployment of technologies that maximized the exploitation of major economies of scale. That is why the aggregate net present value of the 29 new deposits in Chile was almost equivalent to the net present value added of the other 71 new large deposits elsewhere in the world (Doggett and Leveille, 2010). Most of these new deposits began operations in 1990–2003; in 2004 there were only two new deposit (greenfield investments) and the bulk of the investments involved the expansion or restructuring of existing facilities (brownfield investments).

In this context, foreign investment (FDI), which had dwindled during the dictatorship,[8] burgeoned under democracy, particularly greenfield investment generating new productive capacity. This investment (which naturally includes that of foreign mining companies), contributed to the robust growth of capital formation that occurred between 1990 and 1998. Nonetheless, foreign investment —excluding acquisitions of existing firms— only accounted for 15% of GFCF in 1991–1995 (see table 3, column (7)), while the remaining 85% was undertaken by national, private and public investors in those years of rapid and inclusive development. Subsequently, FDI increased, but takeovers of existing domestic enterprises also grew, particularly in the years following the Asian crisis (see columns (2) and (3)). For example, in the 1999–2003 recession, FDI was equivalent to 40% of GFCF, but half of this corresponded to mergers and acquisitions (M&A).

In the short term, M&A investments tend to be confined to contributing liquid funds, which are often volatile and fuel temporary exchange-rate appreciation, or else are remitted abroad during macroeconomic crisis situations, as occurred in 1999.

In the subsequent years, FDI flows continued to flourish, averaging more than one third of total GFCF in 2008–2013 (see column (6));[9] and new FDI contributed more and more to capital formation (30% in the six-year period). As a result, national investors saw their share of both new FDI and GDP decline. In fact, in that period, only 16% of GDP corresponded to capital formation carried out by the domestic public and private sectors, compared to 20.6% in 1991–1995. In turn, part of the existing capital stock was acquired by foreign investors: acquisitions accounted for 7% of GFCF in 2004–2013.

[8] The massive investment made by the La Escondida mining firm began at the end of the dictatorship, partially financed with external debt equity swaps and the implicit subsidy that this entailed (Ffrench-Davis, 2003, section I.1).

[9] Greenfield FDI accounts for a relatively small share of total investment worldwide (it has fluctuated around one tenth).

National productive investments were losing the dynamism of the 1990s, as financial investments and productive investments abroad gained sway. This was accompanied by a sharp slowdown in TFP growth (see CNP, 2016; Beltrán, 2017). In 2014–2017, the final stage of the mining investment cycle was compounded by a steep fall in nominal copper prices, decreasing returns to natural resources and slow growth of the Chilean economy.

Table 3
Chile: gross fixed capital formation, domestic and foreign, acquisitions and GDP, 1991–2017
(Current prices and percentages)

Periods	GFCF/GDP (1)	FDI/GDP (2)	M&A/GDP (3)	(FDI-M&A)/GDP (4)	National GFCF/GDP (5) = (1)-(4)	FDI/GFCF (6)	(FDI-M&A)/ GFCF (7)
1991–1995	24.4	4.8	1.0	3.8	20.6	19.4	15.2
1996–1998	27.0	8.0	2.5	5.5	21.5	29.5	20.3
1999–2003	21.3	8.6	4.2	4.3	17.0	40.2	20.4
2004–2007	20.8	6.4	1.2	5.2	15.6	30.8	24.7
2008–2013	23.7	9.0	1.7	7.3	16.4	37.8	30.5
2014–2017	23.0	6.2	2.5	3.8	19.3	26.7	16.0

Source: Prepared by the authors, on the basis of figures from the Central Bank of Chile; R. Ffrench-Davis, "La inversión extranjera directa en Chile", *Hacia un Chile competitivo*, O. Muñoz (ed.), Santiago, Editorial Universitaria/Latin American Faculty of Social Sciences (FLACSO)-Chile, 2003; M. T. Cofré and T. Cornejo, "Medición de la inversión extranjera directa en la balanza de pagos", *Economía Chilena*, vol. 7, No. 3, Santiago, Central Bank of Chile, 2004; Central Bank of Chile, *Balanza de pagos, posición de inversión internacional y deuda externa*, Santiago, 2018; H. Fazio, *La transnacionalización de la economía chilena. Mapa de la extrema riqueza al año 2000*, Santiago, LOM Ediciones, 2000; and C. Álvarez, "Chile: oportunidades y desafíos para diversificar la inversión extranjera", InvestChile, 2017 [online] https://investchile.gob.cl/wp-content/uploads/2017/06/investchile-britcham.pdf.

Note: The data for gross FDI come from the following sources: between 1991 and 1998, Ffrench-Davis (2003); between 1999 and 2002, from the balance of payments as reported by Cofré and Cornejo (2004, table 1); since 2003, Banco Central de Chile (2018), 2013 series. Data on mergers and acquisitions between 1991 and 1998 come from Ffrench-Davis (2003) on the basis of UNCTAD; for 1999 the figure of US$ 11 billion reported by Fazio (2000, p. 9) is used; then M&A data are obtained from InvestChile/Foreign Investment Promotion Agency; the remainder of the figures come from the central bank, using rates of variation from the 2013 series at current prices; the figures in pesos were converted into dollars at each year's average exchange rate.

Foreign direct investment is a major participant in the export and technology-intensive sectors, and undoubtedly makes an important contribution (13 of the 20 leading export firms are foreign). Nonetheless, despite its boom, FDI remains a small minority in terms of GFCF. Moreover, the transmission of its technology is not automatic or free. Accordingly, an active policy is needed to selectively attract FDI, as the Foreign Investment Promotion Agency did between 2015 and 2017 (Álvarez, 2017).

Thus far this article has discussed investment flows in current prices. The trend of productive capacity is related to the capital stock in intertemporally comparable currency, so the gross investment flows of different years can be added together. It is also necessary to consider the trend of depreciation over the period analysed. The central bank calculates the stock of capital goods and depreciation or capital consumption in constant-currency terms (see Henríquez, 2008, and successive updates by the central bank). Table 4, column (2) shows how the depreciation of available productive capital has varied over time. Initially, it declined relatively to GDP (which is a flow) owing to rapid GDP growth of 7% per year in the 1990s, while depreciation increased more slowly because it depends on the stock of capital goods. Since the late 1990s, the rate has increased, driven by the shortening of the useful life of productive assets, owing mainly to technological innovation, the deteriorating quality of natural resources and the global spread of financial volatility, which increases the obsolescence of productive assets.

Table 4
Chile: gross fixed capital formation and depreciation, 1974–2017
(Percentages of GDP and rates of GDP growth at constant prices)

Periods	GFCF (1)	Depreciation (2)	GFCF minus depreciation (3) = (1)-(2)	GDP (4)
1974–1989	14.6	9.9	4.7	2.9
1990–1998	21.8	7.8	14.0	7.1
1999–2007	21.2	9.0	12.2	4.0
2008–2013	23.0	12.3[a] (10.8)	10.7	3.8
2014–2017	22.3	12.8	9.5	1.7

Source: Prepared by the authors, on the basis of estimations from the Central Bank of Chile; and Budget Office (DIPRES), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August 2018 [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.

Note: Based on central bank estimates of investment and the capital stock at constant 2013 prices; for 2016 and 2017 the rate of change of the chain-linked 2013 series is used for GFCF with depreciation of 13.1% and 13.4% of GDP, respectively, based on DIPRES (2018); since there is no GDP series at constant 2013 prices, column (4) uses the same series as table 1, column (4).

[a] Includes the destruction caused by the earthquake of February 27, 2010.

In recent years there has been an upward trend in depreciation as a proportion of the capital stock and GDP, rising from 8% to 13% of GDP, which represent a very large proportion of gross investment. Gross fixed capital formation is the measure that is usually published and commented on.

According to this depreciation data, net investment averaged about 10% of GDP in the 1960s before falling steeply in 1974–1989 to average just 4.7% (column (3)). This reveals a fundamental cause of the mediocre annual GDP growth of 2.9%, compared that recorded in the 1960s (4.6% between the peaks of 1962 and 1971). In 1990–1998, with democracy now restored, the net investment ratio rose to 14% and supported GDP growth of 7.1%. This accentuated the positive correlation between the stock of productive capital and GDP growth. Subsequently, net investment fell moderately, while GDP growth declined sharply, from 7.1% in 1990–1998 to 3.9% in 1999–2013.

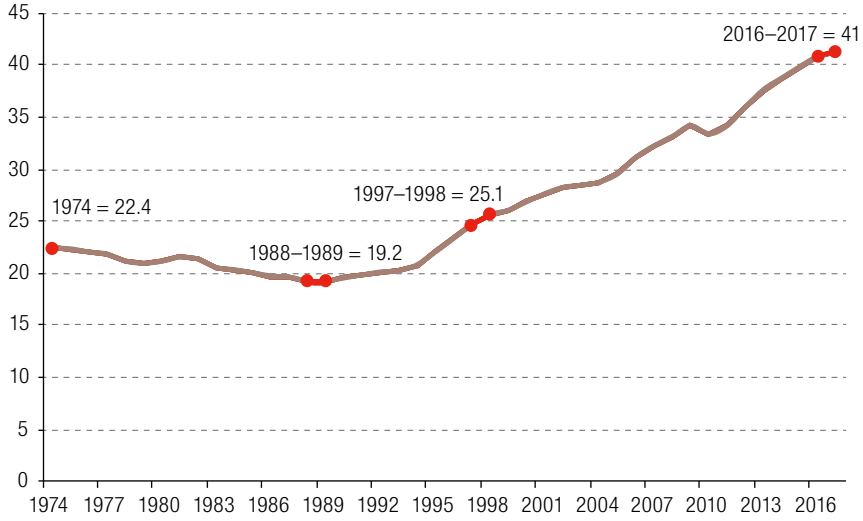
This changing relationship between GFCF, minus depreciation of the capital stock and growth requires three complementary explanations. The first concerns changes in relative prices. The national accounts record a diverging trend between the implicit deflator of GDP and that of machinery and equipment. While the machinery and equipment deflator fell by 3% between 1996 and 2015, that of GDP more than doubled in the same period (see Ffrench-Davis and Vivanco, 2016).[10] This implies a sharp drop in the relative prices of capital goods with respect to the other components of GDP and causes a sharp divergence between constant and current figures.

The second explanation relates to mining investments that account for a large share of GFCF. As discussed above and illustrated in table 2, mining investment has increased significantly, but has not yet fully matured. Moreover, part of it merely replaces the dwindling capacity of old deposits, which is why it is not reflected in an equivalent increase in potential GDP. A third explanation relates to the deterioration in the macroeconomic environment, particularly since 1999, which has kept actual GDP persistently below potential (output or recessionary gap).

Before concluding this subsection, the estimation of the stock of productive capital made by the central bank in constant 2013 prices is reviewed, to examine how it has evolved in relation to the labour force. Figure 3 shows that the coefficient deteriorated during the dictatorship, owing to the mediocre investment ratio and a sharp increase in the labour force. In the 1990s, a persistent increase began which supported substantial wage hikes in that decade, with a continuous growth in the ratio between the capital stock and the labour force in the ensuing years, albeit accompanied by smaller wage increases.

[10] The trend continued in the 2016-2017 biennium, with a fall of around 2% and a rise of 9%, respectively.

Figure 3
Chile: capital stock per member of the labour force, 1974–2017
(Millions of pesos at 2013 prices)



Source: Prepared by the authors, on the basis of estimates from the Central Bank of Chile; and Budget Office (DIPRES), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August 2018 [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.
Note: Net capital stock at constant 2013 prices and labour force as reported in the minutes of the Consultative Committee on Trend GDP (DIPRES, 2018).

2. Macroeconomic environment and investment ratio

The investment rate has fluctuated widely, responding sharply to imbalances in the macroeconomic environment —particularly the aforementioned recessionary gap and external-account imbalances resulting from procyclical exchange-rate appreciation. These are imbalances in the real macroeconomy, instead of nominal or inflationary ones. The rate of utilization of potential GDP has a major influence on the level of capital formation through four channels: (i) actual productivity (a recessionary gap implies a difference between actual productivity and potential or structural productivity); (ii) actual profits for self-financing through reinvestment; (iii) access to capital markets; (iv) business investment expectations, because if the existing productive capacity is underutilized and it is expected to remain that way for a while, then further expansion by potential investors in the same activities makes no sense. Investment in new product lines and the entry of new entrepreneurs is discouraged by a depressed environment caused by recurrent imbalances in the real macroeconomy.

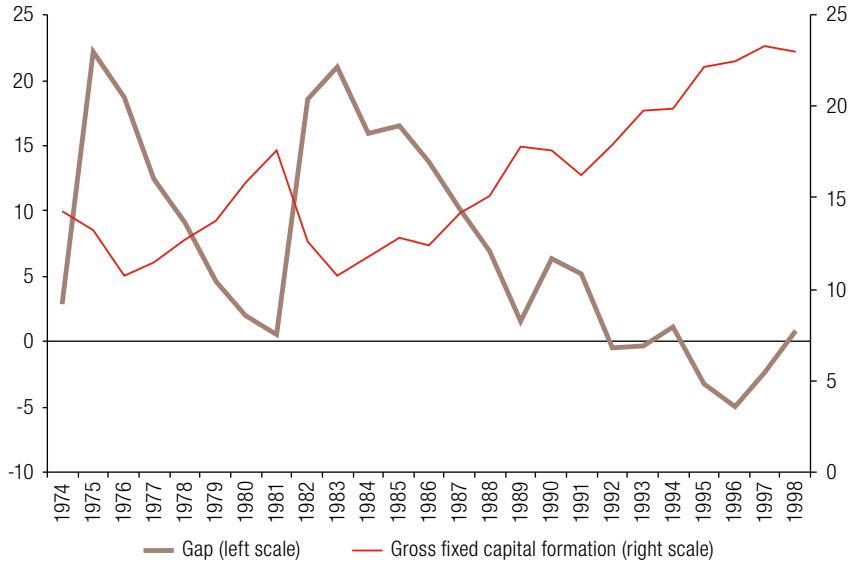
That is why the domestic and external macroeconomic environment in which specific productive development policies are implemented has a decisive influence on the volume of investment, the resource utilization rate, and the mentality and attitudes that permeate economic agents. Macroeconomic policy approaches that over-prioritize a given instrument, either exclusively or at the expense of the rest —for example, by prioritizing an inflation-targeting approach over growth, employment and investment targets— may generate high average rates of underutilization of the capital stock and thus discourage new capital formation.

Relatively greater real macroeconomic stability —in the sense of keeping aggregate demand consistent with potential GDP, along with sustainable external and fiscal balances— tends to provide an incentive for capital formation. This is worth reiterating, given its importance and the frequency with which more fashionable macroeconomic approaches are imposed, which prove to be procyclical,

with many imbalances in the real macroeconomy which ignore a number of fundamental facts: real macroeconomic stability provides an environment that fosters productivity improvements more than for speculative operations; there is a greater emphasis on capacity increases than the expansion of business groups through mergers and acquisitions; and there is greater effective productivity thanks to a higher rate of capacity utilization of existing physical capital and the labour force (ECLAC, 2010; Ffrench-Davis, 2010). Similarly, efforts to innovate (which often require long periods to mature) depend heavily on the existence of real macroeconomic "tranquillity" and expectations of sustainability.

Figure 4, which spans 1974–1998, shows the negative association between the recessionary gap and the investment ratio. It appears as a dominant force in 1974–1989 given the size of that gap (more than 20% of GDP in 1975 and again in 1982–1983). In 1990–1998, the gap was very small or non-existent and contributed to the continued expansion of investment until 1998. Since then, the sign of the relation has persisted: changes in the recessionary gap are followed by changes of opposite sign in GFCF; but the relation is weakened by the presence of the three variables discussed in the previous subsection which change the relationship between the size of the recessionary gap and the investment ratio.

Figure 4
Chile: output gap and gross fixed capital formation, 1974–1998
(Percentages of GDP)



Source: Prepared by the authors, on the basis of R. Ffrench-Davis, *Reformas económicas en Chile, 1973–2017*, Santiago, Taurus, 2018.

Note: The output or recessionary gap is estimated as the average of the two potential GDP estimates reported in Annex I of Ffrench-Davis (2018); GFCF and GDP series at constant prices from 2003 to 2005; since 2006 (inclusive), the percentage changes of both variables are used according to the mobile-based chain-linked series referenced to 2013.

The exchange rate has played a very important role in allocating productive resources between tradable and non-tradable goods; and it has had a significant impact on the composition of domestic demand. From the outset of each economic recovery process —given the procyclical behaviour of exchange-rate policy (Ffrench-Davis, 2018, chapter VIII and annex 2)— the real rate started to appreciate sharply and to unbalance the external accounts, except in 1990–1995. Thus, as investors noted that the exchange rate appreciated as the economy approached the production frontier. In general, currency appreciation not only discourages the production of tradable goods (exports and importing-competing goods), but also erodes their value-added. In turn, cyclical volatility impairs investment quality by inducing

investments in tradables in periods of excessive depreciation and by encouraging investments in non-tradable goods at times of excessive appreciation. In other words, cyclical volatility leads to inefficient resource-allocation decisions with consequences that tend to be irreversible.

In all cases —except when a countercyclical macroeconomic policy predominated, as in 1990–1995— exchange rate appreciation has persisted for prolonged periods, generating a growing current account deficit. This clearly means that economic agents —consumers and producers— have naturally adjusted their behaviour to the macroeconomic environment they perceive, which is abruptly reversed at the end of each cycle through sharp depreciations. This represents a clear failure of macroeconomic policy since 1999.

The continuity of recovery processes and the sustainability of the domestic and external balances that are achieved after eliminating a recessionary gap (see ECLAC, 2010, Titelman and Pérez Caldentey, 2015) are crucial for growth and inclusion. A more prolonged economic recovery gives more time and generates greater confidence among productive investors to develop their projects. In this context, the investment ratio rises gradually, facilitating the development of small and medium-sized enterprises (SMEs) and new entrepreneurs. In short, the dynamic effect will be more significant if economic actors gain solid expectations that public policies will keep effective demand close to the production frontier, and that the trend of the exchange rate is consistent with external-account sustainability. This set of conditions only tended to prevail in most of the period 1991–1998, when the investment ratio rose steadily until 1998.

In contrast, if greater activity is achieved at the expense of an imbalance in another variable (such as the external sector, for example because of volatility imposed by a free-floating exchange-rate policy), the positive effect will be diluted as soon as a major devaluation of the free exchange rate (and the likely need to reallocate resources between tradable and non-tradable goods) reopens the recessionary gap. This outcome was common with interventionist policies, but even more so under the neoliberal macroeconomic approach.

3. The globalization of financial volatility and real macroeconomic imbalances in Chile[11]

The instability of international financial capital flows has been a factor driving fluctuations in domestic demand and macro-prices, and has affected the level of capital formation and its quality. Financial flows have spearheaded the economic globalization process in the last three decades and have been strongly procyclical. Paradoxically, the composition of these flows has diversified towards volatility, intensively pursuing economic rents or capital gains, rather than productivity in generating GDP.

Financial creditors display traits that explain their procyclical behaviour. The leading lenders tend to specialize in liquid investments and operate with short horizons, so they are highly sensitive to changes in the variables that affect short-term gains. A second characteristic is the gradual dissemination of information among the various operators about the investment opportunities in the geographical destinations that are being targeted by the current operators and by a succession of latecomers during the boom process. This explains why the supply of capital flows has been a succession of increasing processes, each of which has lasted for several years. These processes have frequently received feedback from the existence of a significant recessive gap and a depreciated exchange rate at the outset (in the case of Chile, in 1976, 1990, 2004 and 2010). Moreover, in recent times, financial flows to Chile have been correlated with the price of copper, thereby accentuating procyclicality.

[11] The subject is discussed more extensively in Ffrench-Davis (2010).

All of this is self-reinforcing: some variables, such as stock prices, the exchange rate, the evaluations made by risk rating agencies, and bond and real estate prices, can move in a certain direction, first recovering and then overshooting in the adjustment of aggregate demand or the exchange rate. They thus diverge from sustainable equilibria for long periods; and in the adjustment process they stimulate financial flows that pursue capital gains (rent-seeking), fuelling a growing expansion of domestic demand, external imbalance and exchange-rate appreciation, and generating vulnerabilities, which then give way to a sudden reversal and a recessionary adjustment.

Unlike investment in fixed capital, which tends mainly to be irreversible, these financial capital flows can be fully reversed; but, in the process, their macroeconomic effects have led to irreversible and inefficient allocations of productive resources.

The key variables for financial operators are not related to the long-term fundamentals of the national economy, but rather to their short-term profitability. This explains why their opinion of a given country can change drastically and suddenly, even though the country's economic fundamentals are broadly similar before and after the abrupt flow reversal.

In short, financial flows have been procyclically highly volatile and, as a result, have made little direct contribution to the financing of GFCF. They have also exerted a strong adverse impact indirectly by generating macroeconomic instability in domestic demand and in the exchange rate. What usually happens is that these flows are used for consumption and the purchase of existing assets, thereby generating bubbles and crowding-out domestic savings. In fact, they have frequently destabilized domestic demand and the exchange rate, without making any significant contribution to the formation of productive capital (Ostry, Loungani and Furceri, 2016; Rodrik, 2015). The fact that Chile has been an active participant in this trend since 1999 implies the predominance of a "financialist" attitude over a "productivist" approach".

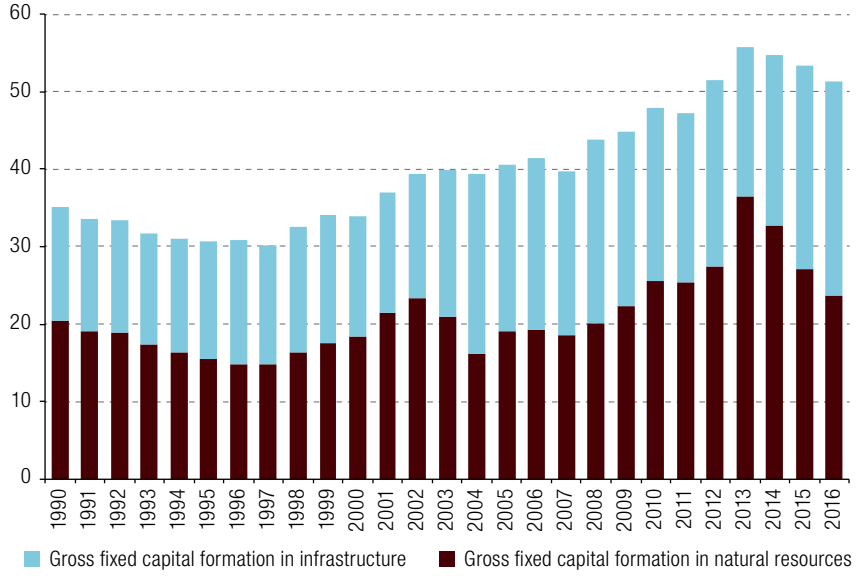
III. Sectoral trends of capital formation and growth

Gross fixed capital formation in the various sectors of the Chilean economy is determined by variables common to any investment decision, such as the gap between actual and potential GDP, effective external and domestic demand, the density of linkages with other sectors (Hirschman, 1958), the trend of the exchange rate, the quality of the long-term capital market and financial flows. However, the strategies pursued by business groups and firms that are constantly evaluating the allocation of resources towards productive or financial investments, whether in Chile or abroad, are also key factors. There are also institutional determinants such as macroeconomic policy, development policies, regulations governing public utility services, environmental regulations and taxation. In some sectors, such as transport infrastructure, public investments and the dynamism of the concession system, which in Chile was consolidated in the mid-1990s, also have an influence.

Disaggregated long series of GFCF by sector are available at chain-linked prices for reference year 2008. By splicing these with the data available for 2015 and 2016, a 1990–2016 series was constructed as shown in figure 5.[12]

[12] The Central Bank of Chile has not yet published disaggregated GFCF series at chain-linked prices referenced to 2013, except in respect of mining and housing services for 2008-2016. The methodological changes and the effects of taking base years 2008 and 2013 generate considerable differences in mining GFCF.

Figure 5
Chile: gross fixed capital formation in natural resources and infrastructure, 1990–2016
(Percentages of total GFCF at chain-linked prices referenced to 2008)



Source: Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years.
Note: Percentage changes for 2015 and 2016 were added to the series produced by Claudio Aravena on the basis of the Chilean national accounts, chain-linked series referenced to 2013.

This information makes it possible to highlight two sectors which accounted for an average of 34.0% of total GFCF in 1990–2003 and of 48.3% in 2004–2016.

One sector, the exploitation and processing of natural resources, represented on average 18.2% of GFCF for 1990–2003, rising to 25.3% in 2004–2016, led by the expansion of mining investment. The other sector, aggregate investment in physical infrastructure, transportation, health, gas, fuel, electricity and telecommunications, accounted for 15.8% of GFCF in 1990–2003 and had grown its share to 23.0% in 2004–2016. The trends in these two sectors contrast with the behaviour of industrial GFCF, which in 1990–2003 represented 8.8% of total GFCF, before declining to 6.9% in 2004–2016.

This article makes two claims. The first is that, since the early years of the 2000 decade, Chile has been facing a scenario of diminishing returns in the production and exportation of natural-resource-based goods and services. This is explained mainly by the diversion of business funds and energies towards the internationalization of large firms, a deterioration in the quality of natural resources and a reduction in nature's capacity to provide environmental services (without market prices) to restore ecosystems (such as H_2O), for the absorption of emissions (such as CO_2, ozone, particulate matter (PM)) and industrial liquid and solid waste. In addition, environmental conflict is raising the costs and lengthening the gestation periods of investments in mining, the forestry sector, aquaculture production and fishing; and this is further compounded by major exchange-rate instability caused by the policy adopted since 1999. The only sectors that have successfully implemented dynamic growth strategies are fruit growing and wine production.

The second claim is that public investment policy has lost momentum in the last decade compared to the period 1990–2005, particularly in terms of its ability to attract new investments in transport infrastructure, energy and telecommunications. Although investment in the electric power sector has recovered recently, it has not been possible to launch a wave of investments in the transport infrastructure or telecommunications sectors, particularly broadband infrastructure. This is very worrying,

since the positive externalities of infrastructure investment far outweigh those of investments in natural resources, particularly by opening up opportunities for new sectors to emerge in regions and in new technology-intensive subsectors.

1. Decreasing returns in the production of natural resources

Since the early years of the 2000 decade, a cycle of diminishing returns has been observed in the production of goods based on renewable and non-renewable natural resources. This is explained by two factors: first, the loss of density per unit volume or area (for example, kilograms of metallic and non-metallic products per metric ton of rock, as in the case of the declining purity of the copper deposits mentioned above, the metric tonnage of fish catches, and aquaculture production per km^2 of maritime or aquatic surface, cubic meters of wood per hectare, and so forth). It is also due to nature's reduced capacity to provide environmental services to replenish ecosystems, to supply water for agricultural production and the processing of raw materials, as well as to absorb liquid, solid waste and emissions.

In the past, Chile endured other cycles of growing shortage of raw materials that were overcome through the discovery of new reserves, the development of new products with global market demand and technological progress. Nonetheless, with the exception of horticultural and wine production, the country now faces hitherto unknown constraints. During the last decade, the growth of forest plantations has virtually stalled. Also, since the mid-1990s the marine biomass available for fishing has deteriorated and Chile no longer has new oceanic spaces with high fish density. Similarly, the recovery of the growth of aquaculture production cannot be based on the old production regime that went into crisis in 2007. No less important, it will be hard to repeat the extraordinary cycle in which nearly 30 new mineral deposits were opened, which was a global phenomenon.

Overcoming the cycle of diminishing returns from natural resources not only requires the incorporation of advanced process technologies, but also depends on complementary investments in water desalination, minimizing liquid and solid industrial waste and emissions, as well as socioenvironmental investments to overcome the growing conflict between firms and communities that live in the neighbourhood of natural-resource extraction sites. A document published by the National Council on Innovation for Development (CNID, 2017) notes that Chile is ranked fifth worldwide in terms of environmental conflicts per 100,000 inhabitants. Overcoming this problem requires a more advanced institutional framework than currently exists in Chile, both to promote science and innovation, and to combine competitive markets with institutional mechanisms that facilitate agreements between the public, private and civil-society sectors.

Having considered the case of mining, the following paragraphs analyse the forestry, fishing, salmon, fruit and wine subsectors in greater detail. Although the Central Bank of Chile does not publish a GFCF series disaggregated to this extent, changes in the rates of growth of physical production offer indirect evidence of investment dynamics, while qualitative data make it possible to construct an overview of the process that natural-resource-based sectors are experiencing.

In the forestry sector, the annual rate of growth of forest plantations dropped from 6.2% in 1978–1989 to 2.8% in 1990–2003, and then to 1.3% in 2004–2016 (see figure 6). The main causes of this decline are the depletion of the forest frontier in Chilean territory, the restriction of water resources, relative energy costs compared to other Latin American countries, the growing environmental demands of the population and social conflicts in southern Chile. The strategic response from the business groups involved was to internationalize their activities through investments in northern Argentina, Uruguay and southern Brazil using the technological package and business model developed in Chile, but also taking advantage of tax incentives in those countries.[13] In this connection, South America's Atlantic

[13] A report from the Directorate General of International Economic Relations (DIRECON) (2014) states that the foreign investments undertaken by firms resident in Chile total US$ 100 billion, equivalent to 50% of total FDI in Chile.

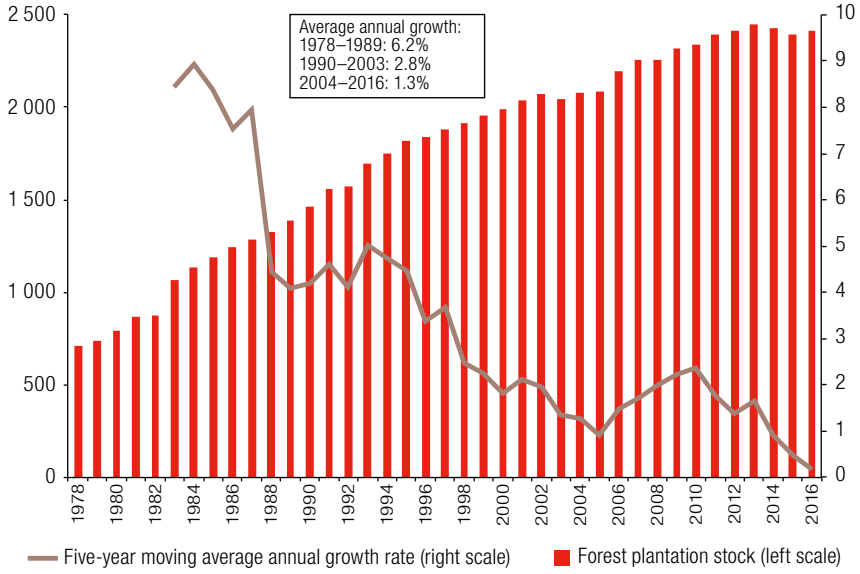
coast has ports that are at a relatively similar distance as Chile's are from the large Asian markets; but forest production in those countries entails lower energy costs and generates significant Ricardian rents relative to the situation in Chile. For example, in Brazil the eucalyptus forest species reaches maturity twice as quickly as in Chile.

As a result, the growth of forest plantations and the production of forest by-products has tended to decline significantly in Chile. The rate of forest plantation has virtually stagnated at around 100,000 hectares per year, nearly all of it reforestation. This has been accompanied by a significant reduction in the annual growth rate of the production of certain forest by-products. Comparing 1990–2003 with 2004–2016, the rate of growth of the physical production of wood pulp slowed from 9.9% to 3.7% per year, that of paper from 6.9% to 0.4%, while that of panels and veneers decreased from 13.1% to 4.3% (see figure 6). This is explained not only by the stagnation of forest plantations, but also by the evolution of the exchange rate and the internationalization of forestry investments.

Figure 6

Chile: stock of forest plantations and five-year moving average growth rate per year, 1978–2016

(Thousands of hectares and percentages)

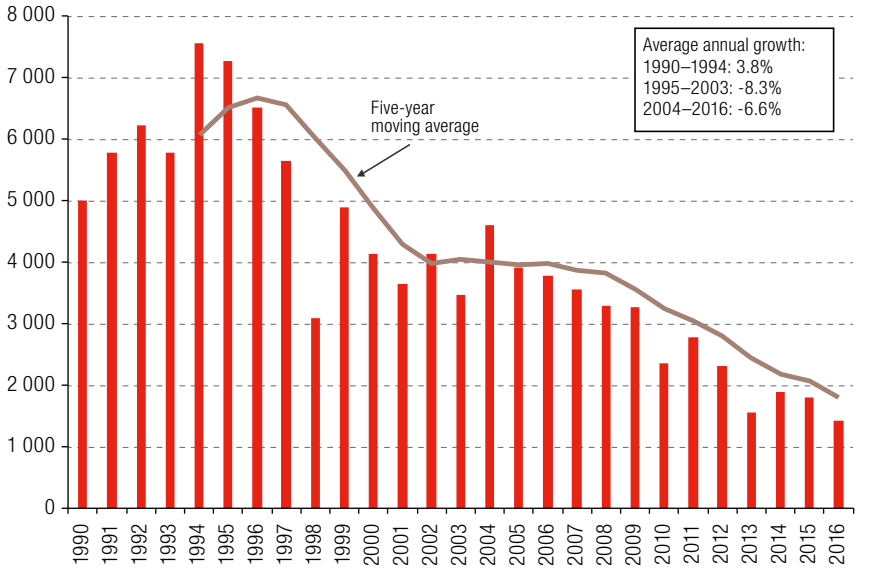


Source: Forestry Institute (INFOR), *Chilean Statistical Yearbook of Forestry 2018*, Santiago, 2018.

In the fishery sector, Chile's industrial fish catches have been trending down since the mid-1990s; and by 2016 they had dropped back to their 1978–1979 level. Although global demand is growing steadily, the collapse of marine biomass has drastically curtailed the great momentum displayed by this activity between 1965 and 1985, when it grew at an average annual rate of 10.2%. Since 1995 it has been declining, with average falls of 8.3% in 1995–2003 and 6.6% in 2004–2016 (see figure 7). This has led to the destruction and conversion of the capital stock: the number of industrial fishing vessels in the north has decreased, while in the south there has been a shift towards aquaculture activity and the production of crustaceans and molluscs. This mainly involves increasing the stock of artisanal fishing boats, many of which have been converted from industrial fishing vessels to comply with the legal regulations that allow a maximum length of 18m. As a result, the artisanal sector's share of total catches (including fish, molluscs and crustaceans) grew from 8.2% to 62.6% between 1990 and 2017. This represented a structural transformation of the extractive fishing sector in Chile.[14]

[14] See the reports on industrial and artisanal fishing [online] at www.sernapesca.cl. Between 1990 and 2003, artisanal fishery landings grew by 8.7% per year, while those of industrial fishing decreased by 6.0%. Between 2004 and 2017, artisanal fishery landings declined by 1.3% per year, while those of industrial fishing continued to decrease by 9.6% annually.

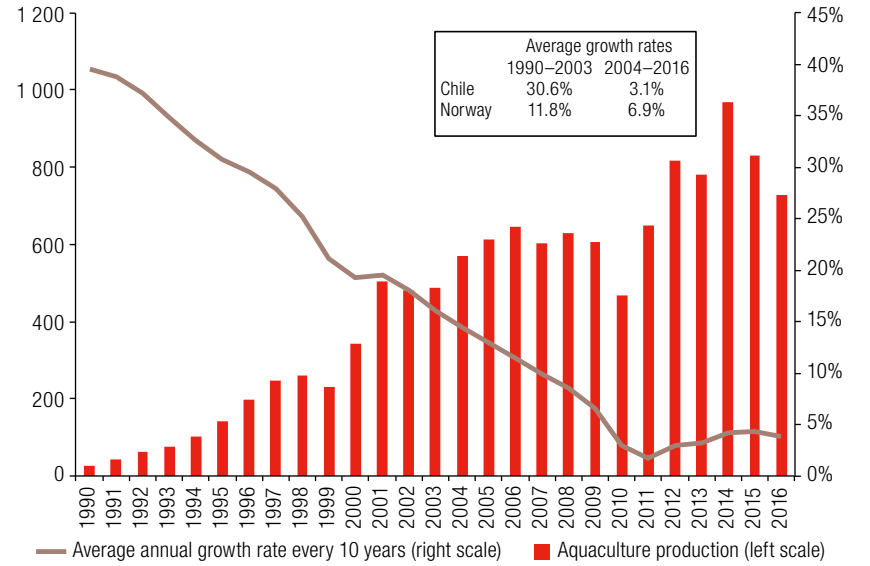
Figure 7
Chile: fish catches, 1990–2016
(Thousands of metric tons)



Source: Food and Agriculture Organization of the United Nations (FAO), "Global Capture Production, 1950–2016" [online] http://www.fao.org/fishery/statistics/global-capture-production/query/es

In the aquaculture sector, the crisis caused by the infectious salmon anaemia virus in 2007 resulted in the collapse and then structural stagnation of this activity, since the production model had overburdened the waters of lakes and marine channels (see figure 8). Whereas the annual growth rate of aquaculture production was 30.6% in 1990–2003, it slumped to 3.1% in 2004–2016, that is less than half of Norway's average annual growth in the same period.

Figure 8
Chile: aquaculture production: salmon, trout and other species, 1990–2016
(Thousands of metric tons and percentages)

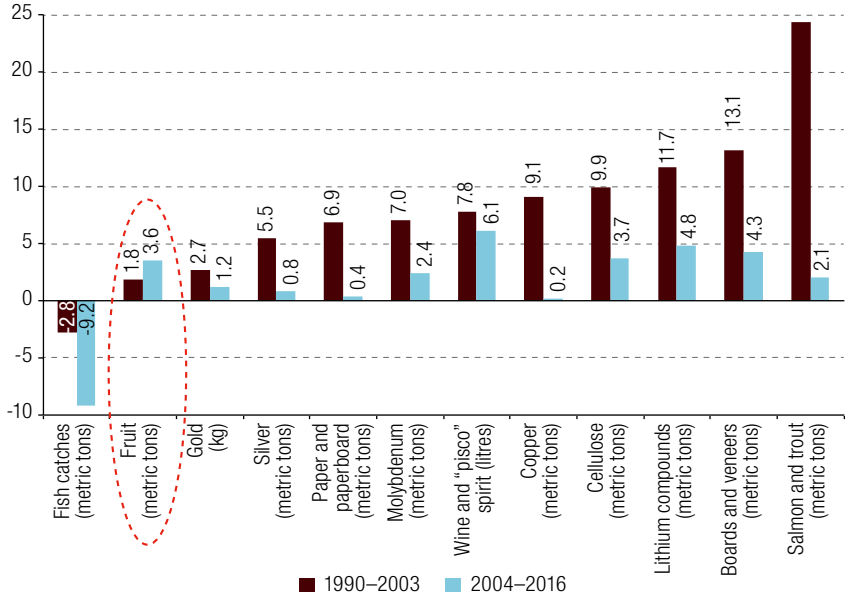


Source: Food and Agriculture Organization of the United Nations (FAO), "Global Aquaculture Production" [online] http://www.fao.org/fishery/statistics/global-aquaculture-production/en.

The salmon industry currently makes massive use of antibiotics, to the extent that these represent up to 19% of the industry's sales value. This has tarnished the prestige of Chilean exports, and resulted in price penalties and market exclusions since 2014. As a result, health regulations have become increasingly stringent and will require more capital-intensive investments, greater contracting of technological services and firms operating on larger production scales. The simple extensive model of salmon production is in full retreat, and the industry is undergoing a restructuring process that will drastically reduce the number of firms (Hosono, Iizuka and Katz, 2016). The salmon harvest is projected at nearly 700,000 metric tons by 2020, compared to 1 million metric tons in 2014.

Figure 9, which illustrates physical production growth rates in various natural-resource-producing sectors, reveals a worrying overall situation. A comparison of long periods shows that almost all sectors producing raw-materials based on natural resources saw their growth rates slowing between 1990–2003 and 2004–2016. The only exception is the horticultural sector, which is booming in the south of Chile and which adapts to the trends of global demand. This sector is growing strongly, thanks to the buoyancy of investments in fruit tree plantations and constant incorporation of technology. The other high-growth sector in recent times has been wine production. According to OECD R&D statistics, these two activities have the highest R&D growth rates in Chile, approaching the average of OECD countries.

Figure 9
Chile: physical production of commodities, 1990–2016
(Percentages, average annual growth rates)



Source: Chilean Copper Commission (COCHILCO), Food and Agriculture Organization of the United Nations (FAO) and Agrarian Research and Policy Office.

Chile certainly has the potential to overcome this cycle of diminishing returns, by intensifying research and scientific-technological development to diversify the natural-resource production matrix, increase productivity and reduce adverse environmental impacts. While this potential exists, however, major obstacles need to be overcome.

Lithium is a prominent example, since it has the potential for greater value added, with deposits mostly in State hands (Production Development Corporation – CORFO). Although its physical production growth rate slowed from 11.7% in 1990–2003 to 5.0% in 2004–2016, it is likely to increase between 2018 and 2030 thanks to CORFO's new agreements with the firms Sociedad Química y Minera de Chile

(SQM) and Albemarle. This will involve not only increasing production, but also reducing the extraction of water and brine, which means more efficient and sustainable management of salt flats. It remains to be seen whether these firms fulfil their contracts; and there is a strong current of public opinion that believes the best option for Chile is to set up a state enterprise to produce lithium.[15]

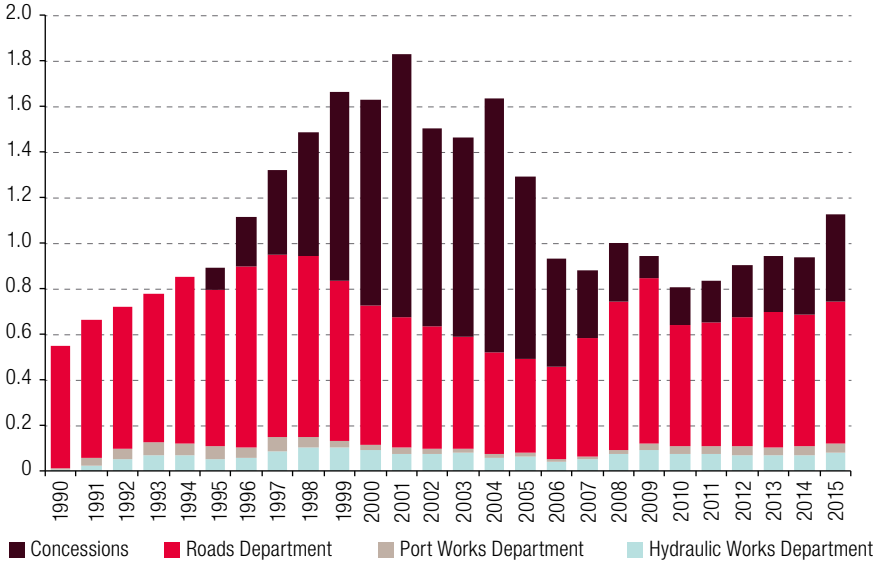
2. Loss of momentum in infrastructure investments

Investment in infrastructure is crucial for the country's growth; and it is vital for diversification of the production matrix, both in territorial terms and in facilitating the emergence of new technology- and knowledge-intensive sectors. Its dynamics are mainly codetermined by public-policy decisions and the expansion strategies being pursued by domestic and foreign business groups. In the case of public investments, financing constraints or government decisions influence transport infrastructure, health and education; and, in this regard, the Infrastructure Fund approved by Congress and then promulgated in 2018 could be a powerful tool. In the second case, business groups' rate-of-return expectations are important in the context of the rules of the game for construction and concession tenders.

In 1990–2016, infrastructure investment represented around 11% of total GFCF, which includes concessions that began in 1995 and peaked in 2005. The importance of infrastructure policy is measured not only by its GFCF share, but by the externalities it generates, which elicit new investments from the private sector. It is, therefore, worrying that its share has declined in the last decade.

Figure 10 shows that Chile experienced a cycle of increased investment in road, sanitation and port infrastructure based on the Public Concessions Law (1992–1996); the partial privatization of health infrastructures and the improvement of its regulatory framework (1997); and the Law of the Port Company of Chile (EMPORCHI), which calls for the expansion of State ports through private concessions; and the Law on Shared Urban Financing (2001). The only sector that has failed to set up an effective concession system is the railways.

Figure 10
Chile: road investments and concessions by the Ministry of Public Works
(Percentages of GDP at current prices)



Source: Ministry of Public Works.

[15] Chile also has the potential to produce "rare earths", including cobalt, which it stopped producing in 1944. Ongoing studies prove Chile's potential in this field, although mining exploration needs to confirm that the reserves in question can be profitably exploited with the technologies available (Townley, Díaz and Luca, 2017).

The result was an increase in investments in physical infrastructure which, in conjunction with MOP road concessions and public investments, represented an average of 1.5% of GDP in 1998–2005. The innovation was certainly the successful concession system. The institutional and macroeconomic context that attracted foreign investors into the country contributed to this, although domestic investors were crowded out. Nonetheless, the momentum of the 1998–2005 period slackened later. In relative terms, MOP investment and road infrastructure concessions stabilized around 0.9% of GDP, before partially recovering in the 2016–2017 biennium. The State also faces problems in the design and management of large-scale projects that are sufficiently attractive for private-sector tenders, while the concessions system encountered difficulties especially in the area of cost overruns, obtaining environmental authorizations, and regulation and inspection. Extending concessions to other areas, such as hospitals, has met with resistance in Chilean society. All this occurs in the context of a conservative fiscal policy that has made it difficult to relaunch public investments since 2017.

There are three large sectors that have been left behind in terms of infrastructure investment. The first is the cabotage system, owing to the persistence of legislation that has fostered a monopoly in cargo and passenger transport, which undermines its capacity to compete with road alternatives.

The second laggard sector is telecommunications, in which the deficit should be visualized in terms of future demands for digital services. Currently, broadband in Chile is concentrated in large cities and has an average speed of nearly 8 Mbps, which is insufficient for current and future requirements (see table 5). The development potential of advanced manufacturing, new technologies applied to education and training, telemedicine and other technologies applied to health, radar and air control systems, new mining, new digital requirements in terms of logistics, astronomy and interactive video, all require speeds above 70 Mbps (Yanyan and others, 2013). Until Chile develops a new-generation broadband infrastructure, the potential for diversifying its production matrix will not be realized. Nonetheless, as a CNID study conducted in 2017 in conjunction with the Chilean Telecommunications Department (SUBTEL) and CORFO warns, implementing this new type of infrastructure will probably require regulatory change and progress towards a system of concessions for the large fibre-optic backbones (see CNID, 2018).

Table 5
Japan, OECD and Chile: digital infrastructure, 2016–2017

Countries	Firms with high-speed connections *(> 30 Mbps)*[a]	Households with high-speed connections *(> 30 Mbps)*	Fibre optics as a percentage of fixed accesses	PPP dollar price of plan at > 30 Mbps	Download speed *(real, Mbps)*	Backbone resilience	Undersea cables	Average nominal investment in telecommunications *(US$/ inhabitant)*[b]
Japan	95%	54%	75%	28	20.2	National	18	180
OECD	50%–60%	25%	22%	37	16.2	All cities	12	152
Chile	12%	5%	7%	46	9.3	Santiago -Valparaíso	3[c]	120

Source: Department of Telecommunications; Chilean Economic Development Agency, "Programa Estratégico de Industrias Inteligentes", 2016 [online] http://seguimiento.agendadigital.gob.cl/download?filename=1507037460_20150122%20PENII%20Resumen%20Ejecutivo%20vF.pdf; Organization for Economic Cooperation and Development (OECD); International Telecommunication Union (ITU); and Akamai, *The State of the Internet*, 2017 [online] https://www.akamai.com/fr/fr/multimedia/documents/state-of-the-internet/q1-2017-state-of-the-internet-connectivity-report.pdf.

[a] Does not include microenterprises.
[b] In the case of Japan, 2013 data.
[c] Includes the Austral Fibre Optics project.

The third key sector embraces electric power generation, transmission and distribution; gas production, transmission and distribution; and sewerage networks. All are regulated public utilities, in which investments are determined by the relationship between installed capacity and the expected growth in demand for the services in question, plus supply factors such as available technologies, regulations and availability of resources. This sector has gained importance over the last 25 years, especially because the investment structure is becoming more complex and diversified. A comparison

of the averages of the 1990–2003 and 2004–2016 periods shows that its share of GFCF rises from 11% to 14% (at current prices). Overall, a recovery from the investment shortfall from which this sector had been suffering since the middle of the last decade now seems to have begun.

The rest of GFCF depends significantly on the degree to which domestic demand is aligned with potential GDP. A recessionary gap (Ffrench-Davis, 2010) between actual and potential GDP in these sectors acts as a significant discouragement to capital formation. In the case of sectors that produce tradable goods, such as the manufacturing industry and SMEs that compete with imports, exchange-rate instability and the reversal of countercyclical policies have stalled economic growth since 1999, thus reducing the capacity to reduce inequality given their depressive impact on the level and quality of employment.

IV. Capital formation, innovation and growth

As noted above, GFCF plays a decisive role in economic growth. In addition to its direct growth effects, it is a vehicle for incorporating technological innovations, improving productivity and creating jobs.

Although innovation and gross capital formation are complementary, one is not sufficient to lead to the other. Innovation is not enough to generate new investments: effective demand and adequate macroeconomic and institutional conditions are also necessary. Moreover, if investments do not incorporate technological progress in the machinery and constructions in question, and if they are not accompanied by innovations in the way they combine with each other and with labour, they end up lagging behind the global technological frontier. As a result, lesser or greater complementarity between investment and innovation depends crucially on the presence of productive development policies and adequate and inclusive regulatory frameworks with SMEs, in an environment of sustainable real macroeconomic equilibria.

As noted above, the evidence shows that rapid and sustained economic growth cannot be achieved with a low investment ratio. In aggregate terms, the volume of GFCF is more decisive for growth than TFP, as shown by the high intensity of the capital stock per member of the United States or European labour force, compared to those of Chile or elsewhere in Latin America (see figure 1).

Nonetheless, this does not detract from the importance of innovation as a component of a growth and development strategy. Chile has historical experiences in which investment and innovation complemented each other significantly, such as the railway in the nineteenth century and import substitution industrialization in the mid-twentieth century, which enabled new industries to emerge with new products and new production processes.

In the historical cycle defined by the open economy and natural resource exports, the innovation process was dominated by the production of new sources of food and raw materials that were already known in Chile in the first half of the twentieth century, but only came to be exploited on a massive scale as from the 1980s. The generation of new products and processes attracted new technologies, new investments and, therefore, new credit flows. All of this was founded on the strengthening of private property rights, in the context of an economic policy that favoured large firms rather than SMEs, through privatizations, regulations and financing. This was accompanied by incentives for the extensive exploitation of natural resources without regard to negative externalities. In short, it was a relatively simple model: imports of machinery and equipment with their embedded knowledge, and exports of raw materials, based on an unsustainable model of natural resource exploitation that caused a persistent deterioration of environmental resources.

This does not mean that no technological learning resulted from the introduction of new products, processes and forms of organization. Nonetheless, the foregoing discussion shows that the natural-resource economy is facing a cycle of diminishing returns that will only be overcome as investment regains momentum, together with systems of innovation and inclusive learning for entrepreneurs and SMEs. These firms usually harbour larger productivity gaps in terms of best practices and technologies than in large firms. Consequently, they offer the greatest opportunities to raise average TFP.

In the coming decades, Chile will continue to depend on natural resource exploitation (Codelco has 70 years' reserves for continued copper production); but it is becoming increasingly clear that it will no longer be able to exploit natural resources as it has done thus far. A set of institutional, natural and economic constraints will force a move from an unsustainable exploitation model with low technological content to a more knowledge- and innovation-intensive accumulation model.

This is currently becoming essential, when the accumulation process is being profoundly influenced by several waves of new technologies (biotechnology, nanotechnology, Internet of Things, big data, among others) which, unlike their predecessors in the nineteenth and twentieth centuries, tend to be incorporated quickly in Chile. As they evolve, however, they become more and more complex, so they require the creation of complementary capabilities that are not limited to firms, but extend to public-private networks and partnerships.

The historical problem currently facing Chile is that these investment opportunities no longer depend on guaranteed property rights alone, but on an adequate regulatory institutional framework. They also require an increasingly advanced digital infrastructure, trained human resources, as well as scientific and technological services. All this requires the State to venture into areas in which private companies cannot act alone, either because they involve very uncertain or high-risk investments; or because they are investments with high externalities which are not appropriable. In this effort, the State must overcome its own interagency coordination failures, and also provide support to overcome coordination failures between private entities.

The growth and diversification of the production matrix requires an active state rather than a passive one; and this means shedding the paradigm of the subsidiary state and adopting a new state paradigm based on innovation and development; or, as Mazzucatto (2015) would say, an "entrepreneurial state".

In short, gross capital formation will be more efficient and sustainable insofar as it is based on innovation, which is being facilitated by the technological revolutions currently under way. Nonetheless, new public policies, institutions and regulations are needed that generate incentives to ensure that new waves of investment are accompanied by technological and institutional innovations. This path offers more possibilities than a strategy that encourages investment by replicating what was done in the past and assumes that markets alone will encourage innovation and overcome the problems of environmental sustainability and economic-social inclusion.

Bibliography

Álvarez, C. (2017), "Chile: oportunidades y desafíos para diversificar la inversión extranjera", InvestChile [online] https://investchile.gob.cl/wp-content/uploads/2017/06/investchile-britcham.pdf.

Beltrán, F. (2017), "Productividad total de factores: una estimación estructural y sus determinantes en Chile: 1960–2015", thesis, Santiago, University of Chile.

Calvo, G., A. Izquierdo and E. Talvi (2006), "Phoenix miracles in emerging markets: recovering without credit from systemic financial crises", *NBER Working Pape*r, No. 12101, Cambridge, Massachusetts, National Bureau of Economic Research.

Central Bank of Chile (various years), *Cuentas nacionales de Chile*, Santiago.

CNID (National Council of Innovation for Development) (2018), "Propuesta estratégica del Consejo Nacional de Innovación para el Desarrollo: banda ancha de Visviri a Cabo de Hornos", January [online] http://www.cnid.cl/wp-content/uploads/2018/02/BandaAncha-CNID.pdf.

___(2017), *Ciencias, tecnologías e innovación para un nuevo pacto de desarrollo sostenible e inclusivo*, Santiago [online] http://www.cnid.cl/wp-content/uploads/2017/05/CTI-para-un-nuevo-pacto-de-desarrollo-CNID-2a-edicion.pdf.

CNP (National Productivity Commission) (2017), *Productividad en la gran minería del cobre*, Santiago.

___(2016), *La productividad en Chile: una mirada de largo plazo. Informe anual 201*6, Santiago.

Cofré, M. T. and T. Cornejo (2004), "Medición de la inversión extranjera directa en la balanza de pagos", *Economía Chilena*, vol. 7, No. 3, Santiago, Central Bank of Chile.

Coremberg, A. and F. Pérez García (2010), *Fuentes del crecimiento y productividad en Europa y América Latina*, Bilbao, BBVA Foundation.

DIPRES (Budget Office) (2018), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.

DIRECON (General Directorate for International Economic Affairs) (2014), "Presencia de inversiones directas de capitales chilenos en el mundo", Santiago [online] https://www.direcon.gob.cl/inversion-exterior/presencia-de-inversiones-directas-de-capitales-chilenos-en-el-mundo-1990-diciembre-2017/.

Doggett, M. and R. Leveille (2010), "Assessing the returns to copper exploration, 1989–2008", *Exploration and Mining Geology*, vol. 19, No. 1–2, Westmount, Canadian Institute of Mining, Metallurgy and Petroleum.

ECLAC (Economic Commission for Latin America and the Caribbean) (2010), *Time for equality: closing gaps, opening trails* (LC/G.2432(SES.33/3)), Santiago.

Fazio, H. (2000), *La transnacionalización de la economía chilena. Mapa de la extrema riqueza al año 2000*, Santiago, LOM Ediciones.

Ffrench-Davis, R. (2018), *Reformas económicas en Chile, 1973–2017*, Santiago, Taurus.

___(2010), "Macroeconomics for development: from 'financierism' to 'productivism'", *CEPAL Review*, No. 102 (LC/G.2468-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

___(2003), "La inversión extranjera directa en Chile", *Hacia un Chile competitivo*, O. Muñoz (ed.), Santiago, Editorial Universitaria/Latin American Faculty of Social Sciences (FLACSO)-Chile.

Ffrench-Davis, R. and D. Vivanco (2016), *Depreciación del capital físico, inversión neta y producto interno neto*, Santiago, Corporation for Latin American Studies/University of Talca, Santiago, November.

Henríquez, C. (2008), "Stock de capital en Chile (1985–2005): metodología y resultados", *Estudios Económicos Estadísticos*, vol. 63, and annexes, "Series de stock capital consumo capital fijo. Periodo 1985–2015, referencia 2008", Santiago, Central Bank of Chile [online] https://www.bcentral.cl/-/stock-de-capital-en-chile-1985-2005-metodologia-y-resultad-1.

Hirschman, A. O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.

Hosono, A., M. Iizuka and J. Katz (eds.) (2016), *Chile's Salmon Industry: Policy Challenges in Managing Public Goods*, Springer.

Iizuka, M. and J. Katz (2011), "Natural resources industries: 'tragedy of the commons' and the case of the Chilean salmon farming", *International Journal of Institutions and Economies*, vol. 3, No. 2, July.

Jorgenson, D. and K. Vu (2001), "Accounting for growth in the information age", Cambridge, Massachusetts, Department of Economics, Harvard University.

Marcel, M. and P. Meller (1986), "Empalme de las cuentas nacionales de Chile, 1960–1985. Métodos alternativos y resultados", *Colección Estudios CIEPLAN*, No. 20, Santiago, Corporation for Latin American Studies, December.

Mazzucato, M. (2015), *The Entrepeneurial State: Debunking Public vs. Private Sector Myths*, London, Anthem Press.

Ostry, J., P. Loungani and D. Furceri (2016), "Neoliberalism: oversold?", *Finance & Development*, vol. 53, No. 2, Washington, D.C., International Monetary Fund (IMF), June.

Rodrik, D. (2015), *Economics Rules: The Rights and Wrongs of the Dismal Science*, New York, W. W. Norton & Company.

Solow, R. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, vol. 70, No. 1, Oxford University Press.

Sotelsek, D. and L. Laborda (2010), "Latin America: incorporating environmental factors into the measurement of production efficiency and technical change", *CEPAL Review*, No. 101 (LC/G.2455-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Titelman, D. and E. Pérez Caldentey (2015), "Macroeconomics for development in Latin America and the Caribbean", *Neostructuralism and Heterodox Thinking in Latin America and the Caribbean in the Early Twenty-First Century*, A. Bárcena and A. Prado (eds.), ECLAC Books, No. 132 (LC/G.2633-P/Rev.1), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Townley, B., A. Díaz and R. Luca (2017), "Recursos minerales por cobalto en Chile: potencial de exploración y explotación minera", Chilean Economic Development Agency/Non Metallic Mining Committee/National Geology and Mining Service [online] https://www.corfo.cl/sites/Satellite?blobcol=urldata&blobkey=id&blobtable=MungoBlobs&blobwhere=1475166619428&ssbinary=true.

Yanyan, Z. and others (2013), "Future Internet bandwidth trends: an investigation on current and disruptive technologies", *Technical Report*, No. TR-CSE-2013-04, New York, New York University [online] https://ssl.engineering.nyu.edu/papers/tr-cse-2013-04.pdf.

Local economic development policies in Chile's municipalities: beyond welfarism

Felipe Correa and Marco Dini

Abstract

To what extent are local economic development policies limited to a welfare approach in Chile? The hypothesis pursued in this work is that, taken together, these policies far exceed this paradigm. For the study, a register of 40 policy categories was taken by means of a reading and systematization of local economic development policies run by Chile's municipalities through 69 District Development Plans (PLADECO). On average, municipalities propose actions in 16 of the 40 categories, but these, overall, are capable of encompassing in a satisfactory manner the various local economic development challenges faced by each municipality depending on the district's production structure and situation.

Keywords

Economic development, local development, development policy, development plans, employment, human resources, productivity, enterprise development, development indicators, municipal government, Chile

JEL classification

H75, O18, R58

Authors

Felipe Correa is Research Assistant in the Division of Production, Productivity and Management of the Economic Commission for Latin America and the Caribbean (ECLAC). Email: felipe.correa@un.org.

Marco Dini is Economic Affairs Officer in the Division of Production, Productivity and Management of the Economic Commission for Latin America and the Caribbean (ECLAC). Email: marco.dini@un.org.

I. Introduction

The importance of the local economic development approach has been emphasized in a vast body of literature, which has also drawn attention to territorial dynamics in the generation and diffusion of knowledge, especially the adaptive and tacit knowledge that arises from the interaction between members of local production systems. The literature also underlines the contribution of social cohesion to stimulating the diffusion of good practices and shared learning in terms of strengthening resilience and capacity to adapt in response to external shocks and the generation of the social capital of mutual trust that underpins the external organization of labour models promoted by firms' production specialization (especially smaller firms) and the complementarity of independent firms (Alburquerque and Dini, 2008; Alburquerque, 2004 and 2013; Becattini, 2002; Bianchi and Labory, 2014; Camuffo and Grandinetti, 2005).

To this disciplinary aspect is added the political importance exemplified by the declarations of the United Nations Conference on Human Settlements (Habitat II, held in 1996) and the more recent United Nations Conference on Housing and Sustainable Urban Development (Habitat III, held in 2016). The outcome document of Habitat III attributes a key function to the concept of local economic development because it equates local intuitions with those operating at the national or regional level and expresses the commitment of the signatory governments to taking steps to strengthen local institutions to support local economic development (United Nations, 2016).

Local governments throughout the world are key actors in the design and implementation of economic and development policies. Their knowledge of local realities and, especially, of the needs, interests and potential that define and drive local stakeholders gives them important tools for designing relevant and effective programmes. At the same time, their proximity to members of the community gives them more opportunities to generate spaces for dialogue and effective participation that will help to activate the area's human and material resources and harness them for the design, implementation and ongoing review of economic development activities.

To understand how and to what extent local governments have put into practice those elements that make them drivers of the economic development process, it is essential to analyse the progress of the policies they have put forward. This analysis should become more frequent as more and better information becomes available.

However, although it is recognized that local governments make just as important a contribution to shaping development policies as national or regional institutions (United Nations, 2016), reflection and study of the matter has been notably lacking within economic thinking, at least with regard to Latin America, and certainly to Chile. It may be that the unitary nature of the State in Chile —unlike other Latin American States, where federal organization affords greater importance to the local aspect of development policy— has led to municipalities being historically treated as "the poor relation" of the State (Salazar, 2013).

This study contributes to the necessary reflection —almost absent today— on local economic development policies in Chile. Although there has been a certain amount of literature involving qualitative study and synthesis of local development policies and experiences in Latin America (Alburquerque, 2004), this has not been true of Chile and there is an acknowledged lack of study on the topic (Bravo, 2012).

By reviewing the District Development Plans (PLADECO) of 69 of the country's largest *comunas*, or administrative districts, we identified 40 categories of local economic development policy action, involving a broad range of aspects related to the matter. This analysis is thus intended as a first attempt at a systematic study this of type of policy in Chile.

The local economic development policies analysed also revealed innovative experiences in specific districts, beyond the traditional approach of production development policies typically applied by local governments. Traditional policies, confined to training, labour intermediation and the provision of information on central government development schemes, fall within what several authors consider to be a primarily welfarist approach (Alayón, 1991; Ziccardi, 2004; Artigas, 2005; Illanes, 2010), referring to a policy philosophy that treats agents of production more as passive recipients of programmatic assistance than as active subjects. The question behind this study is the extent to which local economic development policies are limited to this welfarist approach. In this regard, isolated knowledge of Chile's diverse local economic development initiatives led us to raise the hypothesis that the country's municipalities, seen as a group, far exceed the welfarist framework in terms of local economic development policies.

The research findings suggest that a significant number of municipalities in Chile exceed the traditional framework of actions governed by the welfare perspective. Each municipality has done so in its own manner, obliged perhaps by the pressure that comes with understanding economic development as a responsibility of the local government as much as of the central government.

However, economic development policies that go beyond the traditional framework do not entirely abandon the welfare approach —which represents the starting point— but, by broadening their range of responsibility, they integrate the welfare-type action into a more linked-up development strategy. Economic development plans with public participation, production activities directly based within local government agencies and institutional schemes of public-private coordination are examples of this transformation.

The rest of this article is organized as follows. Section II contains a description of the information sources used and the method applied. Section III describes the local economic development policies that it was possible to capture, ordered by 40 proposed categories. It includes a description of each policy and some elements that could contribute to models for policymaking. Section IV offers reflections on the characteristics of the most and least active districts, with a view to arriving at an initial identification of factors that determine the most dynamic policies. The last section concludes with a summary of the main findings and proposes future lines of research.

II. Method and data sources

Under the framework law on municipalities (*Ley Orgánica Constitucional de Municipalidades*), municipalities are exclusively responsible for preparing, adopting and amending their District Development Plan (article 3) and essential part of this is executing the Plan and the programmes necessary for its accomplishment (article 5). The District Development Plan is thus one of the four basic instruments of municipal administration (article 6).[1] Under the law, the District Development Plan, the guiding instrument of local development in the district, contains actions aimed at meeting the needs of the local community and promoting its social, economic and cultural advancement (article 7). In other words, the Plan is acknowledged as perhaps the most important element of local policy.

Among the studies that have used information from District Development Plans are those by Montecinos (2006), Arredondo, Toro and Olea (2007), Valenzuela (2007), Olea (2011), Ruz and others (2014) and Orellana, Mena and Montes (2016). However, as in most of the cases mentioned, these studies have focused on the analysis of processes. That is, they evaluate formal characteristics of the process of preparation of District Development Plans, such as public participation, transparency and accountability and, in general, formal institutional and governance-related aspects. Although it captures essential elements of the local planning process, this approach does not necessarily capture the contents of these plans, which could possibly be beneficial for comparative study of policies.

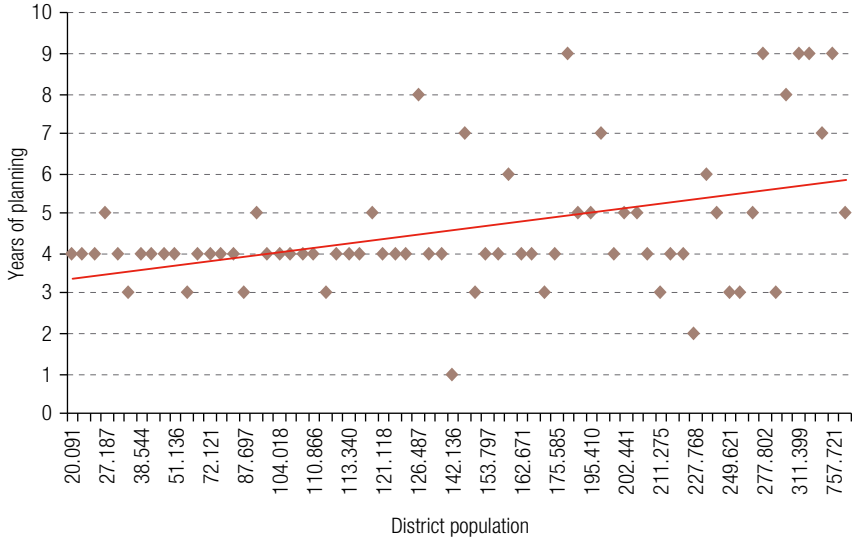
[1] The other three are the District Land Use Plan, the annual municipal budget and the human resources policy.

As part of this work, each District Development Plan was fully read individually to prepare statistics on the frequency of each policy category. Software was not used, as it was considered that the complexity of the classification required, at least at the initial stage, a non-mechanical interpretation of the texts.

In 2017, Chile was divided into 15 regions, divided in turn into 54 provinces, made up of 346 districts (*comunas*) and 345 municipalities.[2] At the district level, according to the 2012 census, 52 districts had over 100,000 inhabitants, and a further 107 had between 20,000 and 100,000 inhabitants. The choice of districts for the study of District Development Plans was based on the criterion of the Chilean Unemployment Fund Management Company (AFC Chile),[3] which began operating in 2013 with branches located in districts that met one of the following conditions: (i) a regional capital; (ii) a provincial capital, or (iii) over 100,000 inhabitants. Provincial capitals with less than 20,000 inhabitants were also disregarded.[4] This study thus reflects principally the particularities and needs of the large and mainly urban districts.

Of the 69 District Development Plans analysed, 55 —80% of them— were in operation at the time of the study and most of the municipalities where this was not the case were engaged in updating them. The framework law on municipalities (article 7) establishes that a District Development Plan must encompass at least four years, but sets no maximum duration. The information in the sample of 69 plans yielded an average duration of 4.6 years, with considerable dispersion and a positive correlation between the size of the district and the planning timeframe: the more populous districts have a longer planning horizon, while the smaller districts come close to the four-year statutory threshold (see figure 1).[5]

Figure 1
Chile: planning horizon of District Development Plans in relation to district population
(Number of years and of inhabitants)



Source: Prepared by the authors, on the basis of District Development Plans.

[2] The Municipality of Cape Horn administers the districts of Cape Horn and Antarctica.

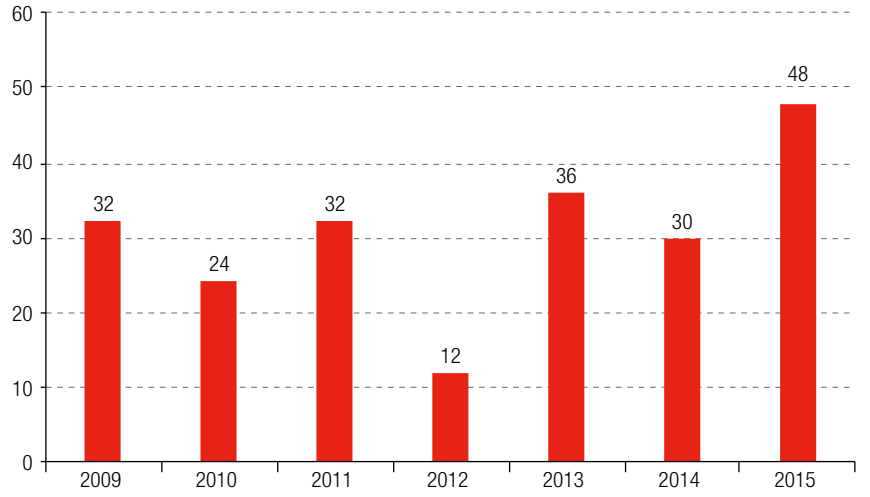
[3] AFC Chile administers unemployment funds and thus has a direct link with some municipalities through local development and labour intermediation agencies (such as Municipal Labour Intermediation Offices, OMIL), which certify unemployment in the case of insurance claims through the solidarity-based unemployment fund. This ensures that municipalities have at least a threshold level of institutionality and policy geared towards employment, labour intermediation, training and development.

[4] Previous studies analysing District Development Plans and including a larger number of districts are those by Ruz and others (2014), which covers 30 districts, and Orellana, Mena and Montes (2016), which covers 58.

[5] The following districts have a planning horizon of nine years: Puente Alto, Antofagasta, Viña del Mar, San Bernardo and Curicó.

Another matter to consider is the process of preparation of District Development Plans. According to data from the Public Procurement Department (ChileCompra), between 2009 and 2015 a total of 214 tenders were awarded in relation to updating these plans (see figure 2). In 2015 alone, there were 48 tenders, which shows that many municipalities are outsourcing this function. Crossing the information contained in the sample used and that from ChileCompra shows that at least 58% of the plans consulted were prepared by external consultancy firms.

Figure 2
Chile: tenders related to the preparation and updating of District Development Plans, 2009–2015
(Number of tenders)



Source: Prepared by the authors, on the basis of information from the Public Procurement Department of the Ministry of Finance.

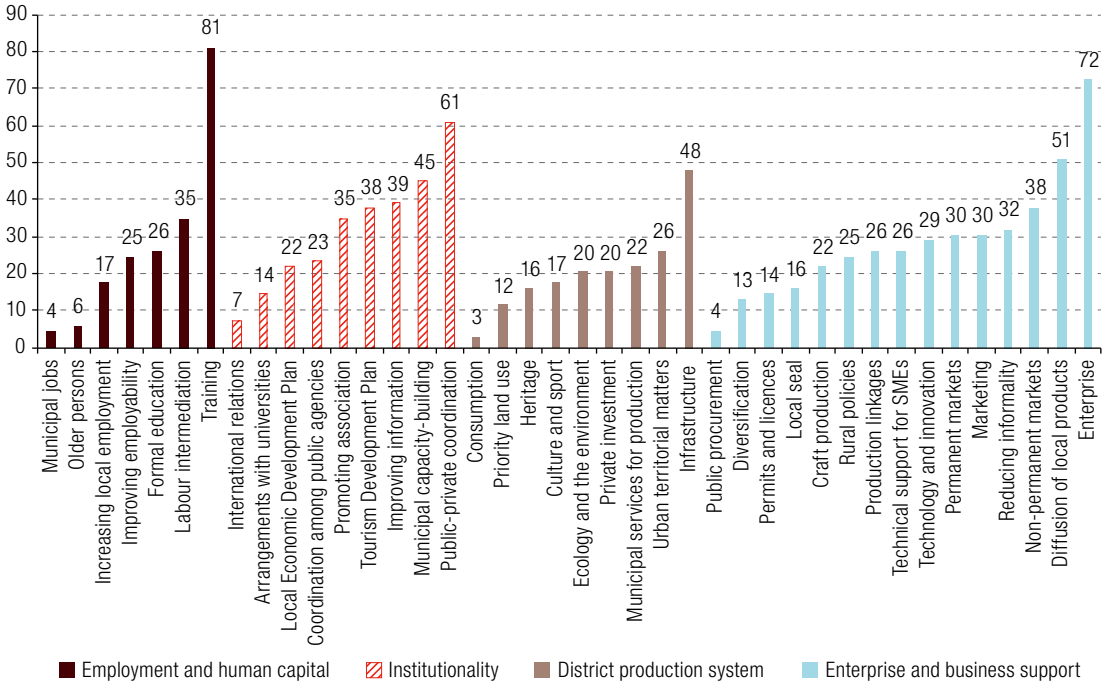
The shortage of staff with the skills needed to perform this task likely accounts in part for this situation. However, the decision to delegate this function to an entity external to the municipality may seriously limit the effectiveness of the proposal and weaken the creation of autonomous capacities within the municipality. When it is carried out in direct contact with local stakeholders, the process of interpreting the economic and social reality is not merely an exercise in information-gathering, but also a key instance for building trust between the municipality and the members of the respective community, which is vital if the proposals that arise from the process are to enjoy the support and legitimacy needed for implementation, on the part of both the local government and the citizens.

III. Register of local economic development policies

The sections of District Development Plans that address economic and productive development sometimes include plans, programmes or activities that are not directly linked to the subject. At the same time, some measures that have to do with economic and productive development are spread across different sections of the Plans, such as education, rural development, indigenous issues, the environment and urban development. These measures are not included in the study, since the idea is to present only what is considered part of economic and productive development in each Plan: a self-definition of economic development policy, as it were. However, as will be seen below, economic and productive development intersects with many other aspects that are not themselves strictly economic. This must be borne in mind to obtain a systematic vision of the development process and for the coordination between different public and private agents working in the territory.

Furthermore, where a plan, programme or activity relates to two or more categories, they are all included for the purposes of statistical preparation. Figure 3 shows the 40 categories into which local economic development plans were classified and the frequency with which they appeared in District Development Plans.

Figure 3
Chile: local economic development policies in municipalities' district development plans, 2016
(Percentages of municipalities analysed)



Source: Prepared by the authors, on the basis of District Development Plans.

In the first place, it may be seen that three policies are the most common in the municipalities: those on training, enterprise and public-private coordination. Conversely, the least frequent, although not necessarily the least important (for example, in terms of resource investment), are policies on consumption, municipal jobs, public procurement, older persons and international relations or agreements. At the same time, generally speaking, there are four major policy dimensions: (i) employment and human capital; (ii) institutionality; (iii) development of the local production system; and (iv) enterprise and business support. For the purposes of organization, the 40 categories are briefly reviewed below, framed within the four main lines of action.

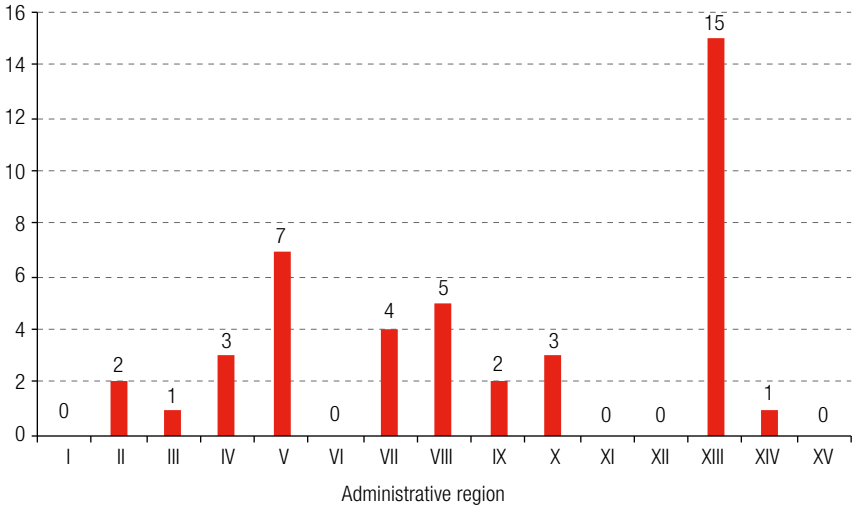
1. Employment and human capital

Training-related policies are those that arise most often. They may refer to the teaching of skills to improve labour force employability, support for small enterprise (through training on mechanisms for starting a business, applying for funds or managing a business), training for municipal staff or training of community leaders on production development issues. As shown in figure 3, 81% of municipalities propose to carry out training activities. Prominent in this sphere are investments in building purpose-built physical spaces;[6] planning of the supply of training according to the needs of the local production structure,

[6] The most common actions include the establishment of local training or trade schools.

for which many municipalities carry out studies of the district production system; and the creation and implementation of training agencies, Technical Training Agencies (OTEC).[7] On this last point, according to data from the National Training and Employment Service (SENCE), in 2016 there were 43 municipal OTEC, 15 of them in the Metropolitan Region (see figure 4). The importance of these certified agencies for municipalities is that they afford access to public and private resources to pursue training activities.

Figure 4
Chile: municipal technical training agencies by administrative region, 2016
(Number of units)



Source: Prepared by the authors, on the basis of data from the National Training and Employment Service.

Another policy area that concerns local human-capital-building is formal education, especially technical training. Municipalities today are responsible for the administration of technical secondary schools, and 26% of them envisage measures in this area in their District Development Plans. This enables them to plan the supply of technical education in keeping with the needs of the current and future production base and combine it with their vision of the local production system. This category also includes internships through arrangements with the private sector, training plans in the area of community work (as in the case of the district of El Bosque), active schooling recovery measures, preschool education and the establishment of municipal technical training centres (as in the district of Cerro Navia), among other areas.

Twenty-five per cent of municipalities have policies to increase workforce employability, through training, formal education and other types of activities, workshops on job-search preparation and certification in workforce occupations, competencies and quality (districts of Villa Alemana and Cerro Navia).

The concern with employment is also expressed in measures directed at reducing unemployment. Within that policy line, the most frequent are traditional labour intermediation tasks, which 35% of municipalities propose to strengthen. Here the focus of attention is on improving the work of Municipal Labour Intermediation Offices (OMIL) through a variety of mechanisms, such as the OMIL capacity-building (FOMIL) programme under SENCE; the use of better information technologies within the municipality and the National Employment Exchange (BNE) to administer information relating to labour intermediation, and active linkaging of the municipality with the large private companies to capture more and better employment opportunities.

[7] OTEC are institutions exclusively accredited by the National Training and Employment Service (SENCE) to perform training activities that may be eligible for tax concessions, and to be contracted by SENCE to impart publicly-funded courses. To obtain accreditation, a municipal OTEC must comply with Chilean standard 2.728 and ISO standard 9001:2008.

Reducing unemployment is one of the local priorities of many municipalities, especially in so-called "dormitory" districts. Seventeen per cent of municipalities have proposed several lines of action in this respect, including incentives for private companies to hire local labour (this is the case of the plan in Maipú, for example) or bonus points for firms entering municipal tenders if they use local staff to perform the scheduled work (the district of Ovalle, for example). Similar unemployment-reducing measures have also been proposed for the work of the municipality itself. Four per cent of the plans examined contained measures of this sort, including preference for local labour in services provided by the municipality (Maipú), the use of public investment in the district as a mechanism for absorbing labour (Temuco) and an interesting idea associated with the concept of guaranteed work (Garzón and Guamán, 2015), whereby the municipality provides emergency jobs for those who need them as part of a continuous programme of urban upgrading in the district (Melipilla). Some municipalities gear employment-related programmes especially towards women and youth, which have specific lines of financing from the central government. In turn, 6% of municipalities include policies focusing on education, training, enterprise and employability of older persons.

2. Institutionality

The areas in the institutional sphere cover: the preparation of studies and the creation of information systems; the establishment of offices specializing in local economic development; the incorporation of technical staff in the municipality; local planning on the matter; public-private coordination and linkages among public institutions; and the promotion of partnerships in the private sector.

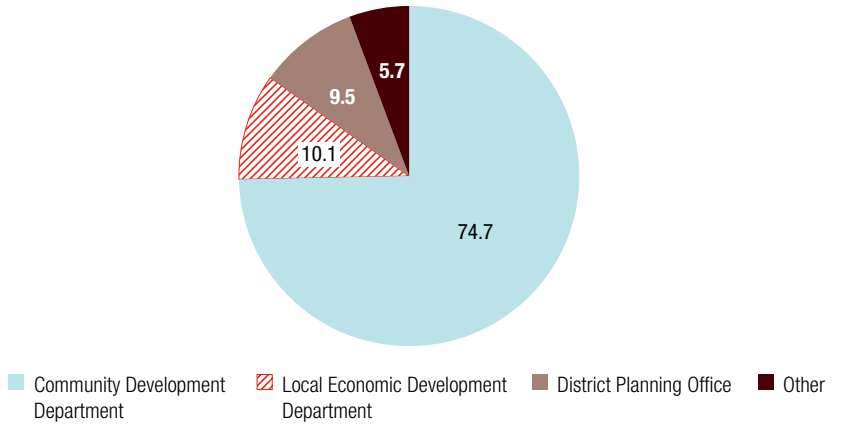
For proposals on training and formal education, as with policies on employability, it is again necessary to have more information about the production sphere in the district. In this connection, 39% of municipalities propose specific measures to improve the quality of their information. These include both the preparation of studies on the production sphere and the establishment of ongoing information systems. In relation to the latter, there are many proposals to draw up registers of firms and enterprises —including formal and informal activities and different sizes of firm— and of sources of employment. In the new scenarios, comprehensive, up-to-date information is crucial to be able to continually assess challenges.

Forty-five per cent of municipalities consider it necessary to strengthen local economic development. In this regard, and although it is not explicitly included in the framework law on municipalities as one of the units of municipal organization, many municipalities have begun to set up Local Economic Development Departments (DIDEL) with a view to stepping up action in this area and bringing together in one office those which were previously spread across several departments. A review of the websites of 158 Chilean municipalities of districts of over 20,000 inhabitants shows that 10% of them have a local economic development department (see figure 5), either formally established by municipal regulation or as a de facto arrangement. However, in most municipalities (74.7%), the function of local economic development still resides in Community Development Departments (DIDECO), either as a unit or as a thematic office not devoted to local economic development exclusively.[8]

In some District Development Plans, municipal capacity-building also includes the incorporation of professionals specialized in advising entrepreneurs and firms that so require, and have full knowledge of the government plans and programmes to which firms and municipalities can apply for resources.

[8] In this ranking, priority was afforded to research on the location of production development as a main or core activity of local economic development.

Figure 5
Chile: departments where production development functions reside in municipalities, 2016
(Percentages)



Source: Prepared by the authors, on the basis of municipalities' websites.

The category of municipal strengthening of economic and production development is closely tied in with the creation of a Local Economic Development Plan (PLADEL),[9] a task in which 22% of the municipalities consulted report engaging. Another type of planning policy are Tourism Development Plans (PLADETUR), which are prepared by 38% of the municipalities studied. Interestingly, examining the municipalities that prepare Local Economic Development Plans and those that prepare Tourism Development Plans, only 9% propose developing both plans, while 29% make proposals on tourism without inserting them into a broader strategy of local economic development.

For preparing these plans —a task that should possibly be performed by Local Economic Development Departments— it is necessary to consider not only the points of view and fields of action of the municipality, but also those of other public bodies, civil society, trade union bodies and even other municipal departments. To this end, 61% of municipalities explicitly propose policies on strengthening public-private coordination. In addition, 23% make proposals on improving coordination with other State agencies and even with other municipal units whose spheres of action intersect with economic and industrial development activities, something that has been noted as crucial for the efficacy of local industrial development policies in Chile (Bravo, 2012). Most municipalities that propose public-private coordination refer to committees for different branches of activity.

Several District Development Plans also suggest establishing committees on the themes of the district production base under the auspices of the District Council of Civil Society Organizations.[10] The challenge is to open up permanent instances of coordination that can offer a long-term perspective and contain the vision both of the municipality and of trade union bodies and civil society.

One of the problems identified in relation to public-private coordination is that industrial entities sometimes do not have union bodies. To address this issue, the municipality can foster association in its diverse forms, something that is included in 35% of District Development Plans. This means fostering

[9] Local Economic Development Plans are documents that 15 of the municipalities analysed propose to develop as complements to District Development Plans and which, from the point of view of the present study, reflect the intention of a fuller proposal on local economic development. They should not be confused with the economic or production development sections of the District Development Plans, which are the main sources of information in this analysis. The difference between the two plans is that the local economic development section of the District Development Plan refers to a medium- or long-term vision, while Local Economic Development Plans operationalize the proposals set forth in the District Development Plan by looking at the viability of concrete actions.

[10] The District Council of Civil Society Organizations (COSOC) is a district body established under the framework law on municipalities (article 94) which operates as a counterweight to the mayor and the municipality in preparing and adopting municipal management tools (District Development Plan, the District Land Use Plan, the budget), among other matters of district interest.

forms of association such as cooperatives, chambers of commerce, trade union bodies or simpler coordinating entities. For example, the district of Quinta Normal had a participation-related issue in that the idea of collective activity lacked opportunities for legitimization, making it the responsibility of the municipality to generate such opportunities while fostering the formation of trade union associations, that is, it had to act as a "legitimizer".

Another alternative that some municipalities (such as Recoleta and Maipú) have begun to adopt for fostering the establishment of associations, especially of workers and microenterprise owners, is the formation of cooperatives. This is often done in collaboration with the Division of Associations and Social Economy (DAES) of the Ministry of the Economy, Development and Tourism.

A special type of public-private coordination occurs between municipalities and international bodies, and between municipalities and universities. While 7% of municipalities propose policies in the first of these cases, 14% do in the second. International agreements are conducted with local governments in other countries to coordinate thematic issues in tourism or port cities, among other things. Arrangements with universities are mainly about attracting student internships and performing specific studies on local industry.

3. Development of the district production system

In this area, the main proposals have to do with promoting private investment, creating production infrastructure, urban territorial and land use policies, municipal production services and policies on the environment —prepared from an economic and industrial standpoint—, heritage, culture and consumption.

Private investment is an important topic, given that 20% of municipalities propose policies in this connection. Most of these emphasize the need to design mechanisms to attract investment to the area, which in turn is related both to the dissemination of investment opportunities and to the incentives contained in the district land use plan. With respect to the latter, 12% of municipalities afford priority to land use for certain types of investment, including technology parks, industrial parks and industrial, agro-industrial and commercial zones —in some cases with infrastructure provided by the municipality— or areas in which the commercial operating licence is cheaper, which means that this parameter is being used as a mechanism of organizing the district's commercial and industrial activity.

The need for municipalities to provide infrastructure for development is evident in their plans in 33% of cases. These policies relate mainly to tourist infrastructure (such as signage, viewpoints, waterfronts, parks and museums), but also include the provision of production infrastructure for rural sectors (in the form of dikes, dams, irrigation and energy, among others) and commercial activities (markets, fairs and so on). Related to infrastructure is the provision of municipal production services (22%), which are services supplied directly by the municipality or to its production activities. This category encompasses a very wide range of proposals, from the establishment of a municipal technical training centre (district of El Bosque) to construction of a composting plant (Los Ángeles), municipal city tours (Temuco) and the creation of municipal camping areas (Melipilla), among other initiatives.

The economic development policies set forth in District Development Plans are closely related to the strategic definitions on land use in the District Land Use Plans and include urban territorial policies, a category in which 26% of municipalities envisage activities. This sort of policy refers to the revitalization of neighbourhoods and central and commercial areas. Another related policy is adding value to heritage (related to the registry and refurbishment of heritage sites), which is undertaken by 16% of local governments in their economic and industrial plans and is linked in most cases to tourism in the district.

In relation to heritage, 16% of municipalities also included policies relating to art and culture, generally linked to tourism and activities that take place in the summer season or at special dates.

Finally, two further topics are associated with district development: environmental policies and consumption policies. While 20% of municipalities consider the environmental or sustainable development aspect within their industrial and economic policies, only 3% include policies on consumption. The first revolve around the creation of a recycling industry, the revitalization of parks and green spaces, the inclusion of non-conventional renewable energies in the local production structure (and in the municipality itself), the strengthening of environmental oversight, the dissemination of good sustainable business practices and the fostering of organic agriculture, among others. As for consumption, concern lies above all in the protection of consumer rights through the creation of a Consumers Office in collaboration with the National Consumers Service (SERNAC).[11]

Notably, several of the policies mentioned (especially those on heritage, culture, environment and urban development) are really more numerous than appears here. This is because several district development plans contain specific proposals on urban, environmental, cultural and other ad hoc sections other than those on economic and production development, the area under analysis in this article. Even so, some administrations show an interesting capacity to link up these measures, demonstrating a more comprehensive understanding of the process of local economic development.

4. Enterprise and business support

The category of enterprise is present in 72% of municipalities and, after training, it is the most extensive area of local economic development policy. Enterprise promotion policies consist of business incubators, advice for applying for public and private development funds, the provision of information on government programmes and legal procedures, and training and technical assistance workshops, among others. Direct technical support by municipalities for SMEs, which occurs in 26% of cases, means having professionals able to support and advise businesses and has been mentioned as a key element both in the category of enterprise and in that of technical support.

Thirteen per cent of municipalities include production diversification polices, involving enterprise support targeting innovative activities in the district and the identification and diffusion of possible new production niches for entrepreneurs in the area.

Another type of policy in this sphere refers to technology and innovation, which is targeted by 29% of municipalities. This category includes, for example, policies on digital literacy —including training—, the creation of technology parks and technology transfer programmes through agreements with universities.

Four per cent of municipalities propose to strengthen public procurement mechanisms and 26% propose policies associated with production linkaging. Activities in the former case revolve around training to become a supplier to the public system through the national web portal ChileCompra, and in the latter case they include studies to assess the local industrial situation and foster local SMEs as suppliers to large firms in the district.

Another way in which municipalities have sought to promote local industrial activity has been through policies to disseminate the local supply, a category in which 51% of municipalities have policies. This sort of policy includes mainly the diffusion of tourism attractions over the Internet, leaflets and advertising plans, and the development of web platforms on local and neighbourhood commerce and

[11] This type of arrangement is in place in several Chilean municipalities and it involves bringing consumer rights legislation closer to districts with less access to central government institutions.

products. As well as dissemination, 30% of municipalities propose activities to improve the marketing of local products, which in most cases means setting up permanent websites to showcase and sell these products, especially geared towards craftspeople, small businesspeople and microenterprises, and agricultural products.

There are similar policies promoting the marketing of local products in relation to craft and rural production, which are addressed by 22% and 25% of municipalities, respectively. In the case of crafts, policies are aimed largely at marketing through fixed sales points. With respect to rural policies, there is a clear will to increase the coverage of the Local Action Development Programme (PRODESAL),[12] since the demands are highly varied and relate to specific needs in each particular district.

Another policy category has to do with local seals for products and services, something that 16% of municipalities include in their plans. This includes plans aimed at increasing the certification of denomination of origin[13] and certification seals in areas such as forestry and tourism.

In relation to the exhibition and sale of local products are non-permanent markets (such as street markets) and established markets (farmers' markets, producers' markets, flea markets and municipal market stalls, among others), which correspond to policy categories on which 28% and 31%, respectively, of municipalities have policies. With respect to regular markets, the purpose is to show and offer local products (made by entrepreneurs or craftspeople), sometimes in coordination with craft fairs or other activities organized by the municipality. This type of policy is geared mainly towards non-everyday-consumption products. In the category of permanent markets, the proposals are in the line of establishing municipal markets in districts that lack them; ordering, regulating and revitalizing producers' markets, as well as providing sanitary and cleaning infrastructure, and redirecting itinerant and street commerce into markets, as well as inspecting these, especially in those where food is sold.

The last two categories refer to informal economic activities (32%) and policy on municipal licences and permits (14%). The two are related to each other and to policies on permanent markets. In relation to informality, a third of municipalities that refer to this category in their planning afford great importance to the formalization of small enterprise and, especially, itinerant commerce. One of the forms this takes is help for formalizing activities through the establishment of family microenterprises.[14] In general, the proposals involve drawing up registers of itinerant sellers and encouraging their formalization, as well as offering them training and the option of relocating and, in some cases upgrading their enterprise. They also involve inspection, since the formalization procedures are carried out under municipal by-laws. There are also a number of policies in the category of municipal permits and licences, which are related to the financing of the municipal procedures necessary for micro-entrepreneurs to formalize their activities. Finally, some municipalities seek to improve the procedures for granting permits and licences by preparing or simplifying the respective protocols, setting up one-stop-shops for starting up commercial activities, reviewing and possibly amending the district's commercial by-laws and publicizing the potential benefits of formalization.

[12] The Local Action Development Programme (PRODESAL) of the Agricultural Development Institute (INDAP) —which reports to the Ministry of Agriculture— is geared towards improving agriculture and livestock production by small producers through technical advice and access to investment funds. PRODESAL is executed by the municipalities or, exceptionally, private entities to which INDAP transfers resources through technical consultancies or investment —under an agreement or contract— complemented by resources contributed by the executing agencies.

[13] Denominations of origin protect the products that originate in a country, region or locality, providing that their quality, reputation or other characteristic can be attributed to the geographical origin. There also have to be other human and natural factors that influence the characterization of the product. Today, any kind of product, not only agricultural, can be protected through recognition of denomination of origin, providing that it meets the requirements set down in the Industrial Property Act, in its ordinances or in other special rules.

[14] The advantage of creating a family microenterprise is the possibility of opting for public grants or loans, and the lifting of bans from operating in commercial or industrial areas included in the respective municipal by-laws, upon due authorization by sanitary authorities or those required by law, as well as access to a simplified business start-up scheme.

IV. District characteristics

This section moves towards the formulation of an analytical hypothesis aimed at verifying the possible connections between the characteristics of municipalities and the activities that each local government proposes to undertake (expressed in the number of categories of activities included in District Development Plans).

To this end, a sample of 20 districts was taken, drawn from the 69 studied. After sorting the 69 municipalities by the number of categories of their respective District Development Plan, the sample was formed by choosing the 10 municipalities or districts whose plans covered the largest number of categories and the 10 whose plans covered the fewest categories. The aim of this sampling modality was to use the municipalities with the most extreme differences in order to pinpoint more easily the characteristics that are most important in the preparation of the more complex District Development Plans.

The 10 most diversified municipalities, in descending order, were: La Florida (21), Los Andes (21), Iquique (20), Temuco (20), Coquimbo (19), Santiago (19), Villa Alemana (19), Aysén (18), Lebu (18) and Maipú (18). Conversely, the 10 districts with fewest categories in their plans were, in descending order: Arica (5), Estación Central (4), Quilpué (4), Rancagua (4), Renca (4), Castro (3), Quillota (3), San Felipe (3), Ñuñoa (2) and Puente Alto (2).

The method used was a multivariate regression with the number of categories as the dependent variable. The independent variables, classified in three groups, were:

- Relating to the district: if it is a regional or provincial capital or belongs to the Metropolitan Region, total population,[15] percentage of income poverty and percentage of multidimensional poverty.[16]
- Relating to the municipality: whether the mayor signing the District Development Plan is on the left or right of the political spectrum[17] and the total municipal budget.[18]
- Relating to the District Development Plan: the year of preparation, its duration, whether it was prepared by an external consultant and whether the process involved public participation.[19]

Given the small number of subjects making up the sample, the results summarized in table 1 should not be treated as definitive proof of relations between the characteristics of municipalities and the actions they plan, but rather as preliminary suggestions for the study of such relations.

The columns in the table represent four difference sets of dependent variables. Although the list of these variables varies, the result remains unchanged: in all cases, the only significant variables are the municipal budget, external consultancy and the fact of being a regional capital.

The positive correlation of the number of categories with the budget is to be expected and it may be interpreted that municipalities with greater resources are more likely to plan activities encompassing a wider range of categories of action.

[15] In 2016, according to National Statistical Institute data.

[16] Both are data from the 2015 edition of the National Socioeconomic Survey (CASEN).

[17] The political right includes Alianza por Chile and the left includes Nueva Mayoría. Independents were classified as left or right by the coalition for which they ran or by their previous party memberships if they ran outside a coalition. The information comes from the Electoral Service of Chile (SERVEL) and the media.

[18] In 2016, according to the National Municipal Information System (SINIM).

[19] Public participation was determined using information provided by the Office of the Undersecretary for Regional and Administrative Development (SUBDERE).

Table 1
Chile: characteristics in relation to the number of categories concerning local economic development policies
(Coefficients and standard deviations)

	(1)	(2)	(3)	(4)
District				
Regional capital	-19.68 (13.03)	-17.75* (8.87)	-17.81* (8.25)	-17.06* (8.14)
Provincial capital	2.25 (10.46)	-	-	-
Part of the Metropolitan Region	-12.67 (9.55)	-13.14 (8.71)	-13.17 (8.20)	-12.78 (8.12)
Total population	-0.04 (0.03)	-0.04 (0.03)	-0.04 (0.02)	-0.04 (0.02)
Income poverty	0.01 (0.63)	-0.04 (0.03)	-	-
Multidimensional poverty	0.51 (0.66)	0.57 (0.56)	0.55 (0.38)	0.54 (0.38)
Municipality				
Political orientation	5.99 (8.18)	4.80 (5.69)	4.92 (4.68)	5.37 (4.61)
Total budget	0.48** (0.19)	0.47** (0.16)	0.47** (0.15)	0.46** (0.15)
District Development Plan				
Year	-1.11 (0.94)	-1.10 (0.88)	-1.09 (0.83)	-1.23 (0.81)
Duration	-1.98 (2.69)	-1.54 (1.65)	-1.54 (1.56)	-1.47 (1.54)
Consultant	11.24 (6.57)	10.72* (5.74)	10.67* (5.28)	9.95* (5.18)
Public participation	-7.55 (9.07)	-7.23 (8.40)	-7.25 (7.90)	-
Constant	2 227.06 (1 898.41)	2 205.75 (1 779.26)	2 197.71 (1 667.82)	2 476.07 (1 627.06)
R^2 squared	0.05	0.16	0.25	0.27

Source: Prepared by the authors.
Note: *: significant at 10%, **: significant at 5%, ***: significant at 1%.

There is also a positive correlation with the use of consultancy firms. In this case, however, the reading is less evident. A positive interpretation would be that the presence of a consultant as a backstop to the municipality's planning capacity enables mayors with that facility to broaden the spectrum of actions in their plans. A less positive reading is the possibility that the more numerous categories reflect the fact that the consultants, having no direct responsibilities in the implementation of the plans they design, propose all the actions that appear theoretically interesting, without applying the stricter filter of what the municipality can do in reality.

The third variable that correlates with the number of categories —in this case negatively— is the fact of being a regional capital. One possible explanation for this is the "displacement" effect of national development institutions. Those institutions concentrate much of their support for development outside Santiago on the regional capitals, which to an extent could lead local governments to leave the issue of local economic development to them and concentrate on other priorities.

Lastly, it is interesting to venture an interpretation of the results with respect to the non-significant variables. First, the intensity of the planning effort does not seem to have any particular political colour, since the adhesion of mayors to different coalitions is not a variable in explaining complexity of District Development Plans in terms of local economic development. The poverty level is not relevant either, which suggests that the motivation to plan actions across more categories is related to a broad range of needs.

The fact that participation does not explain plan complexity means that plans may be complex either in municipalities that undertake participation strategies or in those that do not, which indicates that those strategies are not an obstacle to preparing more complex plans.

With respect to duration, it might be expected that the longer the planning horizon, the greater the number of categories. The fact that this variable is not significant suggests that there are a large number of municipalities that propose highly diversified activities for short time horizons, which suggests a degree of ingenuity or arbitrariness in the proposals. Lastly, the year of the formulation of the plan could be a sign of a learning process, since, the older the plan, the more likely it is to be out of date and not to have incorporated successive lessons by the formulation of new plans. This was not verified empirically, however.

V. Conclusions

The analysis of local economic development policy is a field little explored hitherto in Chile and within economic discipline more broadly. This is probably because of the shortage of information and data for research on the local economic and production structure, and the fundamentally national conception of economic development processes. This research thus aspires to contribute to understanding of the local economic development policies that exist in practice.

A number of reflections and conclusions may be drawn from the analysis of local economic development policies embedded in district development plans. In the first place, it must be noted that the total policies identified in the group of municipalities far exceeds what each one does individually. Of the 40 policy categories identified, the municipalities consulted address on average 16, i.e. 40% of the existing policy possibilities. At the same time, the existence of these 40 categories reveals the possibility of transcending the welfare-based understanding of local economic development policy, which in practice comes down to lending targeted assistance to the unemployed through workshops, training, labour intermediation and support for microenterprise which, as some District Development Plans indicate, often do not provide lasting solutions to families' economic circumstances.

A second innovative element in the management of local economic development policies has to do with the creation of offices or departments specializing in the subject, which implies moving that responsibility from the existing Community Development Offices (DIDECO) to the recently established Local Economic Development Offices (DIDEL) or unifying the task under Local Economic Development Offices within a department.

A third important aspect concerns the planning horizon, which averages 4.6 years in municipalities. To ensure a clearer alignment with national and regional development plans (which exceed 10 years in length), it would be useful to explore the possibility of establishing 10-year minimum for District Development Plans, in combination with 4-year municipal plans —or government programmes— covering the current term in office, always geared towards the strategic planning set forth in the District Development Plan. Long-term planning proposals and greater involvement of local government in the institutional aspects of development are also important when it comes to analysing this new type of approach, since these undoubtedly —as District Development Plans make clear— treat public participation and active coordination with local agents of production as pillars of planning and of related proposals.

Fourth, although many municipalities delegate the preparation of District Development Plans to external consultants, others prepare them themselves. An evaluation of the execution of these plans would require an analysis which clearly exceeds the scope of the present study, but it is important to acknowledge that many municipalities have the basic resources to perform this planning task, which should aim to forge trust between local governments and the public and to obtain the backing and

legitimacy needed to carry policies to fruition. The place of consultants in plan preparation should be supporting the elaboration of the plan, not so much with respect to the content.

Lastly, municipal characteristics matter as well. Those that appear to be most relevant in explaining more joined-up planning work include the size of the municipal budget, the presence of consultancy firms and the fact of being a regional capital.

Considering the findings of the research, a preliminary response can be made to the initial question underlying the study: the extent to which local economic development policies in Chile are confined to a welfare approach. The evidence set forth indicates that the working modality of local governments is varied. Although the welfare function—a key area of their work— is still present, it is integrated with important actions and decisions concerning the organization of planning work, in which municipalities show great dynamism that set them well apart from the stereotype of passive agencies taking a solely welfarist approach. This is clearly not a consolidated reality or a homogenous phenomenon, but it is evident from the analysis that many municipalities have explored and developed a new way of policymaking, with a more active approach and a more direct assumption of responsibility in promoting local economic development.

Finally, the present study could constitute a useful and interesting analytical tool for local policymakers, who seldom have access to economic studies on the subject. In addition, and in relation to future lines of study, a classification such as the one used here would enable subsequent research including a register of local economic and production development policies actually implemented, which could be prepared on the basis of surveys of agents responsible for local economic development or the review of information contained in the accountability reports of the local administration established under the law (article 67 of the framework law on municipalities). Evaluation of the real impact of each of these policies and initiatives actually carried out is thus another possible avenue of research.

Bibliography

Alayón, N. R. (1991), *Asistencia y asistencialismo: ¿pobres controlados o erradicación de la pobreza?*, Rio Piedras, University of Puerto Rico.

Alburquerque, F. (2013), "Economía del desarrollo y desarrollo territorial" [online] http://www.conectadel.org/wp-content/uploads/downloads/2015/03/E%C2%AADesarrollo-y-Desarrollo-Territorial-3.01.pdf.

___(2004), "El enfoque del desarrollo económico local" [online] http://www.flacsoandes.edu.ec/sites/default/files/agora/files/1251776298.area_enfoque_del_0.pdf.

Alburquerque, F. and M. Dini (2008), "Módulo 1: empresas, cadenas productivas y territorio. Introducción a los conceptos de innovación, productividad y competitividad" [online] http://www.conectadel.org/wp-content/uploads/downloads/2013/02/modulo1resumenpdf2011-110623131205-phpapp02.pdf.

Arredondo, J., F. Toro and F. Olea (2007), *Política pública y planificación participativa: una mirada desde el ámbito local*, Santiago, Ministry of Planning and Cooperation/Regional Secretariat for Planning and Coordination.

Artigas, C. (2005), "Una mirada a la protección social de los derechos humanos y otros contextos internacionales", *Social Policy series*, No. 110 (LC/L.2354-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Becattini, G. (2002), "Del distrito industrial marshalliano a la 'teoría del distrito' contemporánea: una breve reconstrucción crítica", *Investigaciones Regionales*, No. 1 [online] https://old.aecr.org/images//Imatges Articles/2007/01-Becattini.pdf?_ga=2.249296007.1471150742.1538998641-2111654584.1538998641.

Bianchi, P. and S. Labory (2014), "The role of governance and government in the resilience of regions: the case of the 2012 earthquake in the Emilia-Romagna region in Italy" [online] https://halshs.archives-ouvertes.fr/halshs-01166138.

Bravo, S. M. (2012), "Implementación de la política de fomento en Chile: una aproximación a partir de la experiencia de las unidades de desarrollo económico a nivel municipal", Santiago, University of Chile [online] http://repositorio.uchile.cl/bitstream/handle/2250/112502/cf-bravo_ss.pdf?sequence=1&isAllowed=y.

Camuffo, A. and R. Grandinetti (2005), "I distretti industriali come economie della conoscenza", *Argomenti*, No. 15 [online] https://www.francoangeli.it/riviste/Scheda_Rivista.aspx?IDArticolo=26026&Tipo=Articolo%20PDF&idRivista=100.

Garzón, A. and A. Guamán (coords.) (2015), *El trabajo garantizado: una propuesta necesaria frente al desempleo y la precarización*, Madrid, Akal.

Illanes, M. A. (2010), "La república de la gratitud: pérdida de democracia y 'chorreo' capitalista en Chile actual", *Ciencias, tecnologías, culturas. El desafío del conocimiento*, C. Parker and F. Estenssoro (eds.), Santiago, Explora/University of Santiago.

Montecinos, E. (2006), "Descentralización y democracia en Chile: análisis sobre la participación ciudadana en el presupuesto participativo y el plan de desarrollo comunal", *Revista de Ciencia Política*, vol. 26, No. 2, Santiago, Catholic University of Chile.

Olea, F. (2011), *Los Planes de Desarrollo Comunal (Pladecos). Región Metropolitana de Santiago*, Santiago, Regional Secretariat for Planning and Coordination.

Orellana, A., J. A. Mena and M. Montes (2016), "Plan de desarrollo comunal: ¿el instrumento rector de la gestión municipal en Chile?", *Revista INVI*, vol. 31, No. 87, Santiago, University of Chile.

Ruz, M. Á. and others (2014), "Planes de desarrollo comunal: propuestas para mejorar su efectividad como instrumento de planificación, participación y rendición de cuentas municipal", *Propuestas para Chile*, I. Irarrázaval, C. Pozo and M. Letelier (eds.), Santiago, Catholic University of Chile.

Salazar, G. (2013), "Una perspectiva social sobre la historia del municipio en Chile", *Revista Iberoamericana de Estudios Municipales*, year 4, No. 7, Santiago, Autonomous University of Chile.

United Nations (2016), "Draft outcome document of the United Nations Conference on Housing and Sustainable Urban Development (Habitat III)" (A/CONF.226/4), New York, General Assembly.

Valenzuela, J. P. (2007), *Análisis prospectivo de las capacidades institucionales y de gestión de los gobiernos subnacionales en Chile*, Washington, D.C., Inter-American Development Bank (IDB).

Ziccardi, A. (coord.) (2004), *Participación ciudadana y políticas sociales del ámbito local*, Mexico City, National Autonomous University of Mexico.

Argentina's competitiveness matrix: the natural resource controversy and the country's evolving trade position[1]

Virginia Laura Fernández and Marcelo Luiz Curado

Abstract

This paper uses Fajnzylber and Mandeng's competitiveness matrix to analyse the evolving structure of Argentine exports between 1985 and 2010. In particular, it seeks to identify links between the country's export pattern, in which natural resources predominate, and the evolving structures of different markets: the Organization for Economic Cooperation and Development (OECD), the Southern Common Market (MERCOSUR), the developing countries of Asia and the world. One of the main conclusions is that, although historically it has been the developed countries that have been responsible for the dominance of commodities in Argentina's export pattern, in recent decades it has been the developing countries of Asia. In MERCOSUR, on the other hand, there has been an improvement in the pattern of Argentine exports. The article suggests that this has been driven by the bilateral agreements between Argentina and Brazil, especially in the automotive sector.

Keywords

Competitiveness, measurements, exports, trade statistics, markets, OECD, MERCOSUR, East Asia, Argentina

JEL classification

F10, O54, Q18

Authors

Virginia Laura Fernández is a professor with the Faculty of Political Science and International Relations of the National University of Rosario (Argentina) and with the Department of Economics and the professional master's degree course in Economic Development of the Federal University of Paraná (UFPR) (Brazil). Email: virginialaurafernandez@yahoo.com.ar.

Marcelo Luiz Curado is a professor with the Department of Economics and on the postgraduate programme in Economic Development of the Federal University of Paraná (UFPR) (Brazil) and a fellow in Research Productivity with Brazil's National Council for Scientific and Technological Development (CNPq). Email: mlcurado@gmail.com.

[1] This article is part of the doctoral thesis prepared by the first-named author with guidance from the second. A shorter version received the 2015 award for the best academic article in the New Ideas for Development competition of the Argentine Association of Development Economics (AEDA). The authors are grateful for the assistance of Gabriel Porcile, the Economic Commission for Latin America and the Caribbean (ECLAC) and the Federal University of Paraná (UFPR), and for the financing provided by the Committee for the Advancement of University Academic Staff (CAPES) of Brazil.

I. Introduction

The Latin American economies have traditionally been characterized by heterogeneous production structures combining technology-intensive sectors with non-industrialized low-productivity primary sectors, by a lack of productive diversification, by dependence on foreign capital, by the small share of national income going to workers and by trade balances which, whether in deficit or surplus, are driven by commodity exports.

For a group of Latin American authors such as Raúl Prebisch (1950 and 1951), Celso Furtado (1962 and 1964), Aníbal Pinto (1960), Aldo Ferrer (1973) and Fernando Fajnzylber (1983, 1988 and 1991), who contributed to the development of the Latin American structuralist thinking that played a major role in the establishment and consolidation of the Economic Commission for Latin America and the Caribbean (ECLAC), these characteristics have limited the region's potential for growth and development, since its role in the international economy and in the international division of labour were shaped by external dependency. This dependency originated on the demand side, since the region's commodity exports and pricing are determined in the international market, which is very volatile and unstable. Moreover, dependency is exacerbated by external capital flows, which act as an external constraint on the growth of investment and financing in the economies of Latin America.

Industrialization and diversification of the export pattern, especially between 1950 and 1980, reduced the problem of external dependency to some extent, but did not solve it. Trade imbalances and external vulnerability continued to be recurrent phenomena that called for economic analysis by ECLAC. Bielschowsky (2016, p. 17), for example, argues: "With variations that are adapted to the different contexts of world trade and the various conditions of international financing, the external vulnerability argument is present throughout the five decades of ECLAC thought."

The transformations in international trade that began in the early years of the twenty-first century, especially the emergence of China and the renewed dominance of commodities in the export pattern of Latin America, gave a new impetus to international research in this area.[2] It is against this background that the present study seeks to make its contribution.

This article seeks to analyse the peculiarities of Argentina's pattern of exports and international competitiveness in the new world order, characterized as this is by radical changes in global patterns of production, consumption and trade. It also highlights the relevance of using a specifically Latin American body of theory to interpret Argentina's growth and development process.

The main objective is to analyse Argentina's export pattern in the period from 1985 to 2010, using Fajnzylber and Mandeng's competitiveness matrix. Specifically, the study seeks to identify links between the country's export structure and the evolving market structure of various destinations, namely the Organization for Economic Cooperation and Development (OECD), the Southern Common Market (MERCOSUR), the developing countries of Asia and the world. A final aim is to establish causalities between a pattern of exports dominated by natural resources and competitiveness.

The method of analysis combines conceptual elements from the competitiveness matrix and the Competitive Analysis of Nations (CAN) which Fajnzylber and Mandeng presented in the CEPAL Review in 1991 (Fajnzylber, 1991; Mandeng, 1991a). The data are sourced from the ECLAC TradeCAN database, which covers more than 90% of international trade and contains information on 73 countries. Although this database was developed out of the joint study by the authors mentioned, it has not been widely used to estimate the competitiveness of nations in recent years. For this reason, the proposed use of this methodology entails an additional effort of research and operationalization of the system.

[2] To cite just one example of the importance of this debate, in 2015 Latin American Perspectives (2015) devoted a whole issue to discussing the effects China was having on Latin America, with a focus on trade and on the debate about the impact of the shift back to commodities in the Latin American export pattern.

The article presents the following: the concepts and model of Fajnzylber and Mandeng's competitiveness matrix within the framework of the structuralist theoretical debate about natural resource dependency (section II); an empirical analysis of the Argentine competitiveness matrix during the period 1985–2010 (section III); and reflections on the importance of natural resources in the evolution of the Argentine export pattern and the influence of each market on that pattern (section IV).

II. Fajnzylber and Mandeng's competitiveness matrix

In 1991, Fernando Fajnzylber and Ousmène Mandeng analysed the relationship between countries' export patterns and competitiveness. The objective was to provide tools for the design of national and sectoral strategies and policies in the economies of Latin America and to analyse the structure of a number of mainly Latin American countries' exports and their level of competitiveness during the decade from 1979 to 1988.

Before presenting the methodology, we shall present four points that Fajnzylber highlighted regarding the link between countries' competitiveness and natural resources that are relevant to our analysis. The first is that, of a total of 51 countries analysed, the export patterns of winning countries (those that increased their share of the OECD market between 1979 and 1988) were less natural resource-based than losing countries'.

The second point is that there were OECD member countries that ran trade surpluses in natural resource-related activities but deficits in the manufacturing sector, and that in those countries, which included Canada, the United States, Norway, Denmark and the United Kingdom, technical progress in manufacturing was inexorably linked to and enhanced by natural resources.

The third element that Fajnzylber highlighted is that Latin America was not the main supplier of natural resources to OECD or the world. In 1989, the region supplied 10% of OECD natural resource imports and 5% of natural resource-based manufactures (Fajnzylber, 1991, p. 158).

Lastly, the author points out that, during the period analysed, the share of imports of natural resource-based manufactures in OECD fell from one third of the total to one quarter. According to Fajnzylber, this "reflects and confirms the downward trend in the use of natural resources (especially energy) in the economic activity of the developed countries" (Fajnzylber, 1991, p. 158). This aspect, in a demand-driven conception of competitiveness, concerned the author and prompted him to propose economic policy strategies to change the export pattern of the Latin American economies.

These observations will be considered in the light of the most up-to-date information on Argentina. One element that was not considered by Fajnzylber (and could not have been, since he died in 1991) and that is important for the analysis of the behaviour of international trade in the period under study is the rise of China, India and other emerging economies in the world market for production and consumption. This was to reverse the trend towards stagnating demand for raw and manufactured natural resources.

1. Methodology

The methodology used by Fajnzylber and Mandeng to measure a country's competitiveness analyses data on the country's export structure strictly in relation to the OECD import structure. Countries are defined as winning or losing depending on whether their OECD market share has increased or decreased, and the competitiveness matrix is then applied to ascertain which areas their market share has increased or decreased in. It is within this framework that it becomes important to discuss a country's natural resources, technology and production matrix.

A good example is the case of two countries considered in the analysis, namely Argentina and Brazil, the latter being the former's main trading partner. In the period analysed by Fajnzylber, Argentina's share of the OECD market fell from 0.4% to 0.25%, making the country a loser. In contrast, Brazil's market share had increased by 20% to 1.19% by 1988, placing it among the winners (Fajnzylber, 1991, pp. 142–143).

After classifying countries as winners and losers, Fajnzylber analyses the composition of their exports, combining the concepts of efficiency and positioning.[3] The authors call this combination the competitiveness matrix, and it allows four situations in the export pattern to be identified:

(i) An optimum situation, with favourable positioning and high efficiency. Exports in this situation are that portion of trade in which the country specializes, i.e. has a productive advantage over other suppliers, while also involving product categories that are dynamic in OECD imports. When a large proportion of a country's exports are in an optimum situation, it means that the country is competitive from a production standpoint and that it specializes in sectors that are gaining ground in the OECD market.

(ii) A situation of vulnerability, with unfavourable positioning and high efficiency. Having exports in this situation means that the country is specializing in categories that are not dynamic in the OECD market. Specifically, the current situation (that in the period analysed) is one in which positive results are being obtained, but the outlook could be negative for future periods if the decline in demand in these product categories were to worsen over time. In the case of Latin America, where natural resources determine the pattern of trade specialization, a sustained fall in demand for these resources would be indicative of export vulnerability.

(iii) A situation of missed opportunities, involving favourable positioning and low efficiency. This situation is one where exports are in product categories that are becoming more dynamic in OECD demand, but for which the country analysed is losing market share relative to other suppliers, meaning that the structure of the country's exports in these categories is not adapting to changes in the OECD import structure. In this case, it is also relevant to analyse whether the upward trend of imports in these categories is cyclical or whether it will strengthen over time. In the latter case, the country's strategy should be to attain or improve on the levels of competitiveness it formerly achieved.

(iv) A situation of retreat, entailing unfavourable positioning and low efficiency. This is the situation of export categories in which the country has lost market share and for which OECD demand is declining. This classification is not negative in all cases, as it could indicate that the country's export structure is proving adaptable to changes in OECD imports.

The competitiveness matrix data for Argentina and Brazil between 1979 and 1988 are shown in table 1.

Table 1
Argentina and Brazil: competitiveness matrix, 1979–1988
(Percentages of total exports)

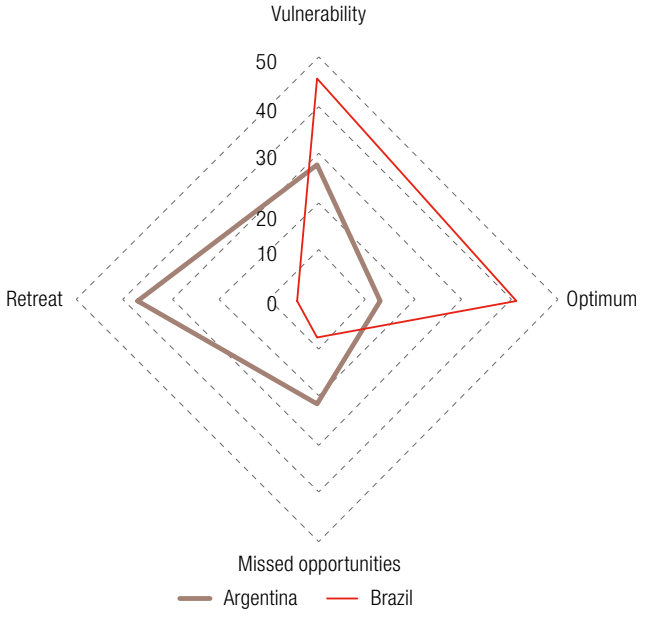
Country	Situation of vulnerability	Optimum situation	Situation of missed opportunities	Situation of retreat
Brazil	46	41	8	4
Argentina	28	13	22	37

Source: F. Fajnzylber, "International insertion and institutional renewal", *CEPAL Review*, No. 44 (LC/G.1667-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 1991.

Brazil is a winner, with a large proportion of its exports in an optimum situation and low proportions in situations of retreat and missed opportunities. Argentina is a market loser, with just the opposite happening. Figure 1 shows the two countries' matrices in a radial chart.

[3] Mandeng approaches positioning from the point of view of market attractiveness and efficiency from the point of view of specialization and adaptability. For the sake of simplicity, we shall use Fajnzylber's terminology.

Figure 1
Argentina and Brazil: competitiveness matrix, 1979–1988
(Percentages of exports)



Source: Prepared by the authors, on the basis of F. Fajnzylber, "International insertion and institutional renewal", *CEPAL Review*, No. 44 (LC/G.1667-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 1991.

Lastly, as already mentioned, technical progress has a pervasive impact on competitiveness. It does so through positioning, since dynamism is associated with the technological content of products in terms of design and manufacturing, and through production efficiency, via the systemic and organizational capacity to produce at international frontier levels, approximating to the productivity of competitors in the international market.[4]

The composition of Argentina's and Brazil's exports will now be analysed. As has been suggested, countries whose exports are concentrated in natural resources tend to be market losers. On the other hand, those whose structure is dominated by non-natural resource-based manufactures tend to be winners. This is borne out by the situations of the two countries mentioned (see table 2).

Table 2
Argentina and Brazil: export structures, 1988
(Percentages)

Country	Natural resources	Energy	Manufactures	
			Natural resource-based	Non-natural resource-based
Argentina	36	3	43	18
Brazil	30	3	29	38

Source: F. Fajnzylber, "International insertion and institutional renewal", *CEPAL Review*, No. 44 (LC/G.1667-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 1991.

2. The model

The model proposed by Mandeng (1991a and 1991b) is an adaptation of constant market share analysis (Magee, 1975), which analyses firms' competitiveness' vis-à-vis the world market. This analysis was radically adapted to describe and identify changes in countries' competitiveness and specialization in world trade.

[4] Positioning and efficiency can be understood as variables representing the Keynesian and Schumpeterian perspectives, respectively, on the dynamics of countries' exports.

The starting point is a single constant market share analysis equation, which is reduced to a two-dimensional approach (sectoral competitiveness and adaptability to the market).[5] The analysis is based on the concept and methodology of country competitiveness analysis, according to which the overall position of an economy is determined by its sectoral competitiveness and its ability to adapt to the evolution of the market structure. The approach assumes that the market has an atomistic structure and that no sector is important enough to influence the total import pattern (Mandeng, 1991a, p. 27).

Thus, a country's total share (S_j) at a given time will be equal to the weighted product of the share of its imports in a particular sectoral group (s_{ij}) and the share of this group in the market's imports (s_i):

$$S_j = \sum_{i=1}^{n} \frac{M_{ij} M_i}{M_i M} = \sum_{i=1}^{n} s_{ij} s_i, \qquad (1)$$

where:

i: is a sectoral product or group, denominated group,

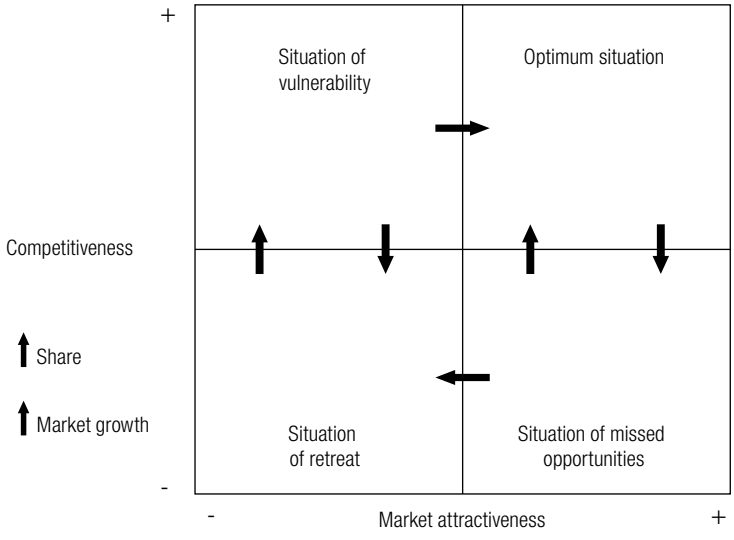
j: is a country, and

M: are total OECD imports.

Changes in S_j over time are determined to evaluate the orientation of competitiveness in relation to the shifting structures of the market. The constant share hypothesis requires ΔS_j to be equal to 0, and the differential evolution of the groups (or their market attractiveness) is obtained from the changes in s_i.

A competitiveness matrix of two rows and two columns based on equation (1) is shown below. Its horizontal axis measures the evolution of the groups (Δs_i) and its vertical axis the evolution of the country (Δs_{ij}) (see diagram 1). Thus, a group is considered to be rising when $\Delta s_i \geq 0$, while a country is considered competitive in a given group when $\Delta s_{ij} \geq 0$.

Diagram 1
Competitiveness matrix



Source: O. J. Mandeng, "International competitiveness and specialization", *CEPAL Review*, No. 45 (LC/G.4687-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 1991.

Note: For greater clarity and consistency with Fajnzylber's terminology, the terms used by that author have been employed instead of the titles of the quadrants in the original diagram, which were (clockwise from top left): Declining stars, Rising stars, Missed opportunities and Retreats.

[5] Constant market share analysis considers four elements that affect the evolution of a country's overall market share: (i) growth in world trade, (ii) differential growth by product, (iii) differential growth of the market and (iv) a competition factor or residual.

The competitiveness matrix summarizes the situations a given country might be in:

- Optimum situation: rising groups in which the country is gaining market share.
- Situation of vulnerability: declining groups in which the country is gaining market share.
- Missed opportunities: rising groups in which the country is losing market share.
- Situation of retreat: declining groups in which the country is losing market share.

Furthermore, the relative importance of each competitive position in the matrix can be ascertained from the country's trade structure. To this end we define the variable c_{ij}, which measures the contribution of each group in a given country, where $c_{ij} = M_{ij}/M_j$. Changes in c_{ij} indicate diversification of the trade structure, with $\Delta c_{ij} \geq 0$ meaning that the contribution of the group is growing and $\Delta c_{ij} < 0$ meaning that its contribution is declining.

A variable k is also used to represent market specialization. This allows the contribution of each group in a country to be related to the OECD import structure:

$$k_{ij} = \frac{c_{ij}}{s_i} \text{ and } k_{ij} = \frac{s_{ij}}{s_j} \text{ where } k_{ij} \geq 1 \text{ when it refers to the groups in which the country specializes.}^{6} \quad (2)$$

Thus, changes in k_{ij} are determined by the changes in c_{ij} and s_i, and reflect the degree to which the trade structure moves further from or closer to the OECD import structure: $\Delta k_{ij} \geq 0$ in the first case and $\Delta k_{ij} < 0$ in the second.

$$\Delta c_{ij} \gtreqless \Delta s_i \gtreqless \Delta k_{ij} \gtreqless 0 \quad (3)$$

Thus, Δk represents the interaction between changes in a country's trade structure and the evolution of the market structure: k_{inc} is for groups whose share is increasing and k_{dec} is for groups whose share is decreasing. Furthermore, Δk may reflect the evolution of sectoral competitiveness in relation to the country's overall trade results (S_j).

Lastly, the overall adaptability of a country to the market, K_j, is expressed by the overall specialization and the competitiveness of an economy relative to the evolution of the market:

$$K_j = \frac{k_{iincj}}{k_{idecj}} \text{ and } K_j = \frac{s_{iinci}}{s_{ideci}} \quad (4)$$

This derives from $(M_{iincj}/M_j : M_{inc}/M) : (M_{idecj}/M_j : M_{idec}/M) = (M_{incj}/M_{inc}) : (M_{idecj}/M_{idec}) = s_{iincj}/s_{idecj})$. The conclusion is that K_j admits of two criteria of interpretation. In the first, the shares of increasing and decreasing groups are set against each other, and $K_j > 1$ means that absolute competitiveness is greater in increasing than in decreasing groups. The second combines the market orientation of increasing and decreasing groups, and $K_j < 1$ means there is more specialization in decreasing than in increasing groups.

In these cases, the evolution of K over time, $\Delta K = K_j^1/K_j^0$ represents one of the following two options: (i) the redistribution of a country's competitiveness relative to the evolution of the market, or (ii) the change in specialization relative to the growth of the market.

According to the author, changes in K reveal the weighting of the sectoral groups, which increases or decreases within the country's trade structure, and describe how countries compete and specialize globally in relation to the evolution of the market.

[6] The variable k follows Balassa's (1965) index of revealed comparative advantage. Given the equation $k = M_{ij}/M_j : M_i/M$, changing the denominators yields the following equation: $k = M_{ij}/M_i{}^* M/M_j = s_{ij}/S_j$.

To conclude, the model has three limitations that coincide with those of the constant market share analysis. The first concerns sectoral disaggregation, which is typical in any aggregation problem. The second concerns the period selected and could be resolved using index numbers. The author also argues that the model is sensitive to this aspect. And the third limitation concerns the reference market.

The disaggregation in Fajnzylber and Mandeng's study was carried out on the basis of the Standard International Trade Classification (SITC, revision 2), which classifies 239 sectoral groups at the three-digit level. The period taken was 1979–1988 and the reference market was OECD.

The same sectoral disaggregation is used in this article, although in some cases the Mandeng (1993) classification is followed and sectors are regrouped into branches, namely natural resources, energy, natural resource-based manufactures and non-natural resource-based manufactures. The analysis period is divided into four. The years between the two extremes reflect the full series of the TradeCAN database.[7] The subperiods are associated with the run-up to the creation of MERCOSUR (1985–1990), implementation of the Washington Consensus and the Convertibility Plan (1990–2000), the expansion of the Asian countries as global consumers and suppliers (2000–2007) and the global crisis of 2007–2008 (2007–2010). The reference markets are the world, OECD,[8] MERCOSUR[9] and the developing countries of Asia.[10]

III. Constructing the competitiveness matrix for Argentina

This section presents the relationship between Argentina's trade structure and the structure of markets. The market is first characterized by reading data. The structure of Argentine exports to each destination is then analysed. After this, the top 10 export categories are presented to ascertain the specificities of this trade structure. Lastly, the country's competitiveness matrix is constructed.

1. Market structure

A common feature of the markets analysed is that, across the periods, demand for natural resources and low value added manufactures is proportionately low (see table 3). And while no radical alterations are seen in the structure of demand in the world and OECD markets, it is evident that the market structures of MERCOSUR and the developing countries of Asia presented dynamics of their own that deserve attention, not least because, as will be seen, they radically influenced Argentina's trade structure.

In MERCOSUR, it can be seen that there was a radical structural change that made it more permeable to manufactured products. In that market, the share of demand for natural resources and energy fell from 50% to 15%. Conversely, over time there was an increase in demand for non-natural resource-based manufactures, whose share rose from 46% to 75%. The movement is straightforward, clear and constant.

[7] The TradeCAN database is being updated. At the time of the research, the latest official data available were for 2010.

[8] There are currently 34 OECD member countries. To maintain a degree of analytical consistency and allow for a more accurate comparison, however, only the 24 countries that were members at the time of Fajnzylber and Mandeng's analysis are considered in this paper: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

[9] The members of MERCOSUR are Argentina, Brazil, Paraguay and Uruguay.

[10] The developing countries of Asia are China, Cyprus, Hong Kong Special Administrative Region of China, India, Indonesia, Jordan, Macao Special Administrative Region of China, Malaysia, Nepal, Oman, Pakistan, the Philippines, Qatar, the Republic of Korea, Saudi Arabia, Singapore, the Syrian Arab Republic, Thailand and Turkey.

Table 3
OECD, MERCOSUR, developing countries of Asia and world: market structure of imports, by sector, 1985–2010[a]
(Percentages)

Sector	World					OECD				
	1985	1990	2000	2007	2010	1985	1990	2000	2007	2010
Natural resources	16.33	14.54	10.31	10.43	11.34	16.11	14.56	10.48	10.18	10.98
Agriculture	13.40	11.96	8.81	7.91	8.71	13.27	12.17	9.15	8.42	9.39
Textile fibres, minerals and metals	2.93	2.58	1.51	2.52	2.63	2.84	2.39	1.32	1.75	1.59
Energy	17.35	9.71	9.31	10.21	9.93	17.82	9.78	8.94	10.57	10.35
Manufactures	64.86	73.98	77.85	71.77	70.05	64.54	73.82	77.48	71.47	69.51
Natural resource-based manufactures	5.67	5.79	4.78	5.02	4.78	5.89	5.85	4.75	4.81	4.16
Non-natural resource-based manufactures	59.19	68.20	73.07	66.74	65.28	58.66	67.97	72.72	66.66	65.35
Other	1.47	1.78	2.53	7.60	8.68	1.54	1.84	3.10	7.78	9.16
Sector	MERCOSUR					Developing countries of Asia				
	1985	1990	2000	2007	2010	1985	1990	2000	2007	2010
Natural resources	16.97	15.41	9.52	7.74	7.16	16.01	13.10	9.37	10.50	12.00
Agriculture	13.58	11.11	7.88	5.56	5.73	12.53	9.61	7.07	5.87	6.73
Textile fibres, minerals and metals	3.40	4.29	1.64	2.18	1.43	3.49	3.49	2.31	4.63	5.27
Energy	34.12	23.18	11.54	9.92	7.91	14.81	8.82	11.50	10.36	10.26
Manufactures	48.83	61.33	78.80	73.50	77.60	67.75	76.80	78.30	72.41	70.18
Natural resource-based manufactures	2.90	3.31	2.71	3.05	2.56	4.89	6.26	5.61	5.84	6.53
Non-natural resource-based manufactures	45.93	58.02	76.09	70.46	75.04	62.86	70.54	72.69	66.57	63.65
Other	0.08	0.09	0.15	8.84	7.33	1.43	1.27	0.82	6.74	7.57

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

[a] OECD is the Organization for Economic Cooperation and Development and MERCOSUR is the Southern Common Market.

On the other hand, the changes that have occurred in the market structure of developing countries in Asia are slightly subtler and require a more detailed exposition. From 2000 onward, there was a reversal of the downward trend in the share of certain natural resource-related product categories, especially textile fibres, minerals and metals, and natural resource-based manufactures. The slowdown in energy, meanwhile, tailed off.

This is a key point for our analysis, since it is vital to consider the peculiarities cited when reflecting on Fajnzylber's (1991) observations on the OECD market (which he analysed) and the developing countries of Asia (whose historical evolution has been different). In fact, Fajnzylber noted a trend towards a reduction in demand for natural resources, energy and natural resource-based manufactures in the OECD countries in the 1980s, something he viewed as a concern for the Latin American economies, which relied on commodity exports. The developing countries of Asia are the only market analysed in which the trend has been reversed, albeit subtly. This is all the more important when it is considered that these countries have driven world demand: in 2010, their share of global imports was 28%. This was not considered by Fajnzylber and Mandeng.

Two other movements, perhaps less significant, can also be distinguished. In the world, OECD and MERCOSUR markets, there was also a turning point in 2000 when textile fibres, minerals and metals, energy and natural resource-based manufactures ceased to show a definite trend (even if they did not recover the shares they had in 1985). Another exception is the group of natural resource-based manufactures in the case of MERCOSUR, which had a greater share in 2007 than at the start, although this situation was not maintained in 2010.

2. The Argentine trade structure

In the evolution of Argentina's trade structure, the share of manufactures improved between 1985 and 2010 for all destinations except the developing countries of Asia (see table 4). This improvement was more subdued for products exported to OECD than for those exported to the world. Although the value of non-natural resource-based manufacturing exports to OECD was higher in 2007 than in 2010, that value had remained close to 17.5% since 1990, while the value of those exports to the world reached 31% of total exports.

Table 4
Argentina: export structure, by destination, 1985–2010
(Percentages)

Sector	World					OECD				
	1985	1990	2000	2007	2010	1985	1990	2000	2007	2010
Natural resources	68.83	59.41	49.10	59.49	55.94	71.64	67.41	60.76	69.55	65.52
Agriculture	65.77	55.81	46.57	56.39	53.06	68.24	63.66	57.13	64.41	60.82
Textile fibres, minerals and metals	3.06	3.60	2.52	3.11	2.88	3.40	3.74	3.63	5.14	4.71
Energy	6.38	6.49	17.86	7.50	7.53	6.32	5.10	12.44	5.79	5.85
Manufactures	24.13	33.64	32.41	32.55	36.09	21.09	26.81	25.35	23.99	27.64
Natural resource-based manufactures	6.99	7.25	5.01	3.79	5.07	7.72	9.12	7.90	5.54	9.78
Non-natural resource-based manufactures	17.15	26.38	27.40	28.77	31.01	13.37	17.69	17.45	18.45	17.86
Other	0.50	0.47	0.63	0.45	0.44	0.51	0.56	1.45	0.66	0.99
Sector	MERCOSUR					Developing countries of Asia				
	1985	1990	2000	2007	2010	1985	1990	2000	2007	2010
Natural resources	54.40	49.80	31.53	28.82	25.34	74.20	49.10	79.79	85.04	85.94
Agriculture	52.37	48.03	30.01	27.37	24.55	70.68	40.94	75.39	80.73	81.19
Textile fibres, minerals and metals	2.03	1.77	1.52	1.46	0.79	3.52	8.17	4.39	4.31	4.75
Energy	13.68	7.50	19.03	5.03	4.35	0.00	3.19	4.91	6.20	4.54
Manufactures	31.88	42.44	49.44	66.14	70.30	23.87	46.56	15.18	8.74	9.36
Natural resource-based manufactures	9.68	4.58	2.47	2.29	1.76	6.08	6.83	6.82	3.68	4.27
Non-natural resource-based manufactures	22.20	37.86	46.98	63.86	68.55	17.79	39.74	8.36	5.06	5.09
Other	0.04	0.01	0.00	0.01	0.01	1.79	0.26	0.08	0.02	0.03

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

The fact that the share of manufactures increased less in exports to OECD than in those to the world is crucial, since it reflects the difficulties involved in trying to improve the pattern of exports from the Argentine economy to industrialized countries. However, the structural shift in exports to the world points to other destinations playing a decisive role in altering the trend in Argentina's trade position. In this regard, the following four results are noteworthy: (i) the share of industrialized products with higher value added in exports to the developing countries of Asia fell dramatically; (ii) these products' share of exports to OECD remained unchanged; (iii) their share of exports to the world increased slightly; and (iv) their share of exports to MERCOSUR increased greatly. These results, which represent the extreme cases, are worth detailing as they shed light on the proposed objective.

Although there was a large increase in the share of commodities in exports to the developing countries of Asia, this shift, which began in 1990, was preceded by a positive period for the Argentine export pattern, thanks to an increase in the share of manufactured products in general (from 24%

to 47%) and of non-natural resource-based manufactures in particular (from 18% to 40%). This meant that manufactured goods made up a very high proportion of Argentina's exports to the developing countries of Asia in 1990. This export pattern, with manufacturing accounting for almost half of trade, is untypical of the country and, since 2000, has only been observed in exports to MERCOSUR.

The progress made by Argentina with industrial exports to the developing countries of Asia was reversed during the 1990s, so that by 2000 the manufacturing share of exports was only 15.18% and the share of the most sophisticated manufactured products (those not based on natural resources) had fallen by three quarters to 8.36%. This clearly reflects the weakening of the industrial production system and the effective constraint on manufactured exports resulting from exchange rate appreciation. These were some of the consequences of the simultaneous implementation of the neoliberal policies of the Washington Consensus and the Convertibility Plan in Argentina during the 1990s.[11]

MERCOSUR, for its part, played a very important role in improving Argentina's export structure. In fact, there was a significant structural shift in the composition of the country's exports to that destination, matching the change in the demand structure. Thus, in 1985 the share of manufactured exports was about 32% and that of natural resources and energy 68%. By 2010, however, the values had been reversed: manufacturing exports represented 70% and natural resource and energy exports 30%. The shift looks all the more remarkable if the share of non-natural resource-based manufactures is analysed, since it more than tripled.

If attention is paid to the subperiods, manufactured exports to MERCOSUR are found to have performed less well from 1990 to 2000. The trade relationship was more robust and industry-centred during the Alfonsín government (1983–1989) and the governments subsequent to the 2001 crisis, namely those of Duhalde (2001–2003), Kirchner (2003–2007) and Fernández (2007–2010). Conversely, Carlos Menem's governments (1989–1999) relied on trade liberalization and a rigid exchange rate set at a high value, which hampered industrial production and particularly the export of goods with higher value added.

It is also striking that when the evolution of exports to MERCOSUR is compared with the dynamics of the other markets, the former was clearly the most receptive to Argentine industrialized products. In other words, MERCOSUR energized Argentine domestic industry by importing products with medium and high value added. This aspect is very important, because it makes it possible to measure the results that the work of creating and strengthening MERCOSUR had on the Argentine trade pattern.

3. The top 10 Argentine export categories

The list of the top 10 export categories shows the great concentration of the Argentine trade pattern. In 2010, these categories represented 54% of exports to the world and 64% of exports to OECD (see tables 5 and 6). The main categories exported to the world already presented a considerably lower concentration than those exported to OECD. It is possible to link the increasing concentration of world demand with demand from developing countries, with these being responsible for world trade becoming more concentrated in the main export items.

[11] The Convertibility Plan implemented the Austral Convertibility Act (Law No. 23928 of 1991), which established that as of 1 April 1991 the exchange rate between the Argentine and United States currencies would be fixed at US$ 1 for every 10,000 australs, with the austral subsequently being replaced by a convertible peso. The main objective of the Act was to stabilize the economy and put an end to the hyperinflation of the 1980s. After a decade of implementation, the plan had led to unemployment rising to 18.3% while 57.6% of the country's population lived below the poverty line, with about half of this population being indigent.

Table 5
Argentina: top 10 categories exported to the world, 1985–2010[a]
(Percentages)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1985	1990
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Retreat	10.23	8.47
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Retreat	9.87	6.43
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Optimum	4.72	6.02
Agriculture	423	Fixed vegetable oils	Vulnerable	4.97	4.56
Energy	334	Petroleum products, refined	Vulnerable	4.89	4.34
Natural resource-based manufactures	611	Leather	Missed opportunity	4.60	4.06
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	2.92	3.94
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Retreat	5.73	3.10
Agriculture	14	Preserved and processed meat and edible offal	Vulnerable	2.41	3.00
Agriculture	34	Fresh fish (alive or dead), chilled or frozen	Optimum	1.33	2.68
				51.68	46.60

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1990	2000
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Vulnerable	1.33	10.22
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	8.47	9.26
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Vulnerable	6.43	5.15
Energy	334	Petroleum products, refined	Vulnerable	4.34	4.85
Agriculture	423	Fixed vegetable oils	Vulnerable	4.56	4.76
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Vulnerable	3.10	4.59
Agriculture	44	Unmilled maize	Vulnerable	2.04	3.65
Non-natural resource-based manufactures	781	Passenger vehicles	Optimum	0.25	3.15
Natural resource-based manufactures	611	Leather	Vulnerable	4.06	3.09
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	3.94	2.51
				38.51	51.24

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2000	2007
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	9.30	12.51
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Optimum	6.03	8.94
Agriculture	423	Fixed vegetable oils	Optimum	4.38	8.93
Agriculture	44	Unmilled maize	Optimum	3.74	4.68
Non-natural resource-based manufactures	781	Passenger vehicles	Vulnerable	3.11	3.93
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Missed opportunity	10.37	3.67
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Missed opportunity	4.54	3.61
Energy	341	Natural and artificial gas	Missed opportunity	2.24	3.22
Non-natural resource-based manufactures	782	Motor vehicles for the transport of goods	Vulnerable	2.10	2.90
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Vulnerable	2.17	2.60
				47.98	55.00

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2007	2010
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Missed opportunity	12.51	13.94
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Missed opportunity	8.94	8.12
Agriculture	423	Fixed vegetable oils	Retreat	8.93	6.50
Non-natural resource-based manufactures	781	Passenger vehicles	Vulnerable	3.93	6.15
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Vulnerable	3.67	4.81

Table 5 (concluded)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2007	2010
Agriculture	44	Unmilled maize	Retreat	4.68	3.98
Non-natural resource-based manufactures	782	Motor vehicles for the transport of goods	Vulnerable	2.90	3.55
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Optimum	2.60	2.84
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Missed opportunity	2.49	2.29
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Vulnerable	2.54	2.26
				53.19	54.44

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

[a] Products are ranked by exports in the final year.

Table 6
Argentina: top 10 categories exported to the Organization for Economic Cooperation and Development (OECD), 1985–2010[a]
(Percentages)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1985	1990
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Retreat	14.22	13.42
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Retreat	13.82	9.51
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Optimum	5.98	8.72
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	3.17	5.00
Agriculture	14	Preserved and processed meat and edible offal	Vulnerable	3.44	4.92
Natural resource-based manufactures	611	Leather	Missed opportunity	4.62	4.86
Agriculture	34	Fresh fish (alive or dead), chilled or frozen	Optimum	1.64	3.60
Energy	334	Petroleum products, refined	Vulnerable	5.05	3.41
Natural resource-based manufactures	684	Aluminium	Missed opportunity	2.18	2.37
Agriculture	58	Processed and preserved fruit	Optimum	1.30	2.20
				55.41	58.02

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1990	2000
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	13.42	17.57
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Vulnerable	1.17	6.70
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	5.00	5.61
Energy	334	Petroleum products, refined	Vulnerable	3.41	5.25
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Retreat	9.51	4.77
Natural resource-based manufactures	611	Leather	Vulnerable	4.86	4.47
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Retreat	8.72	4.35
Agriculture	36	Crustaceans and molluscs, shelled or unshelled	Vulnerable	1.62	4.33
Agriculture	44	Unmilled maize	Vulnerable	1.74	3.50
Agriculture	34	Fresh fish (alive or dead), chilled or frozen	Retreat	3.60	3.02
				53.06	59.57

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2000	2007
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	17.57	22.86
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	5.61	6.05
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Vulnerable	4.35	4.99
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Missed opportunity	6.70	4.84
Agriculture	423	Fixed vegetable oils	Optimum	1.42	4.54
Agriculture	44	Unmilled maize	Missed opportunity	3.50	4.35

Table 6 (concluded)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2000	2007
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Missed opportunity	2.55	4.32
Agriculture	36	Crustaceans and molluscs, shelled or unshelled	Vulnerable	4.33	3.38
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Retreat	4.77	2.84
Agriculture	58	Processed and preserved fruit	Vulnerable	2.09	2.27
				52.89	60.43
Mandeng code	**Product code**	**Product**	**Position on competitiveness matrix**	**Year**	
				2007	2010
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Missed opportunity	22.86	24.44
Non-natural resource-based manufactures	598	Miscellaneous chemical products	Optimum	2.10	5.55
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Vulnerable	4.84	5.51
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Missed opportunity	6.05	5.28
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Optimum	4.99	5.17
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Vulnerable	4.32	4.22
Natural resource-based manufactures	971	Non-monetary gold	Optimum	0.29	3.88
Agriculture	112	Alcoholic beverages	Optimum	2.26	3.32
Agriculture	36	Crustaceans and molluscs, shelled or unshelled	Optimum	3.38	3.23
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Missed opportunity	2.84	2.95
				53.94	63.56

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

[a] Products are ranked by exports in the final year.

It is striking that, throughout the period analysed, almost all exports to the world and OECD were of natural resources and energy. In the period 1985–1990, exports to the world consisted almost exclusively of agricultural products, accompanied by energy (refined petroleum products) and natural resource-based manufactures (leather). In addition, there were aluminium exports to OECD. As can be seen, these are exports with low value added.

Products in the oilseed and meat complex featured very strongly in exports to the world and OECD, although somewhat more so in the case of the latter. The oilseed complex is without doubt the most important economic sector in Argentine exports to both destinations, and its share has been increasing. It consists of animal feed, oilseeds and oleaginous fruits, and fixed vegetable oils. Although in 1985 the complex's share of exports to the world was 25%, by 1990 it had fallen to 20%; an increase can only be seen in 2007, when it reached 30%. A similar dynamic can be observed in exports to industrialized countries: in 2007, the complex accounted for 28% of exports, the same share as in 1985. In 2010, the impact on world exports of demand from the developing countries of Asia can be seen. That year the oilseed complex's share of exports to the world exceeded its share of exports to OECD for the first time.

Since 1990, one of the top 10 categories exported to the world has had high value added: passenger automobiles. In 2000, another item from the same production chain was added, namely motor vehicles for the transport of goods, and by 2010 the two categories combined accounted for 10% of Argentine exports. It is striking that the same did not happen with exports to OECD.

Refined petroleum products also appear among the top 10 items exported to the world and OECD, although only in the first two periods. The share of the oil chain, which includes the group of crude petroleum oils and crude oils from bituminous minerals, peaked in the period 1990–2000 at 15% and 12% of exports to the world and OECD, respectively. In the other periods, however, its share was about one third of those values.

The mining complex entered the list of the top 10 product categories exported to OECD in 2000–2007 and to the world in the following subperiod. This is the category of base metal ores and concentrates, which in 2010 represented 2.26% of exports to the world and 4.22% of exports to OECD.

In summary, it can be said that the world and OECD have driven demand for the oilseed complex and, to a lesser extent, for oil and minerals, essentially extractive activities. However, it is only in the world market that the motor vehicle parts production chain has been strengthening since 1990. That is very important, since this is a group of activities whose consolidation shows that there is an incorporated learning, knowledge and innovation process that can be disseminated to other production chains which generate greater export value added.

There is another noteworthy finding. Non-natural resource-based manufactures, in the form of miscellaneous chemical products, appeared among the top 10 products exported by Argentina to OECD only in 2007. It may also be noted that, while the automotive chain became more dynamic in world demand, in OECD the demand for products from the meat and other foods complex was maintained, with market share progressively being ceded to the mining complex. This clearly demonstrates the growing importance of MERCOSUR, and Brazil in particular, for Argentina's trade structure. The 1990 Economic Complementarity Agreement No. 14 between Argentina and Brazil and specific agreements relating to the motor vehicle parts complex have had a direct effect in improving Argentina's trade.

What can also be observed in the top 10 categories of exports from Argentina to MERCOSUR is the high concentration of the trade pattern (see table 7). Concentration was lower in 1990, when these categories accounted for 46% of exports, but by 2010 they accounted for 59%. In addition, there was a radical shift in the products that predominated, from natural resources to non-natural resource-based manufactures.

Table 7
Argentina: top 10 product categories exported to the Southern Common Market (MERCOSUR), 1985–2010[a]
(Percentages)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1985	1990
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Vulnerable	16.34	8.77
Agriculture	48	Preparations of cereals and flour	Optimum	0.55	7.09
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Optimum	5.89	5.65
Agriculture	54	Fresh, chilled, frozen and preserved vegetables	Optimum	4.20	5.09
Energy	334	Petroleum products, refined	Missed opportunity	10.70	4.76
Natural resource-based manufactures	611	Leather	Missed opportunity	8.74	3.56
Non-natural resource-based manufactures	784	Motor vehicle parts and accessories	Vulnerable	3.74	3.15
Agriculture	44	Unmilled maize	Vulnerable	4.91	3.00
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Vulnerable	1.93	2.48
Agriculture	34	Fresh fish (alive or dead), chilled or frozen	Vulnerable	1.26	2.43
				58.25	46.00
Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1990	2000
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Optimum	8.77	11.95
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Vulnerable	1.03	8.97
Non-natural resource-based manufactures	781	Passenger vehicles	Optimum	1.12	8.85
Energy	334	Petroleum products, refined	Optimum	4.76	6.65
Non-natural resource-based manufactures	782	Motor vehicles for the transport of goods	Optimum	0.26	5.65
Non-natural resource-based manufactures	784	Motor vehicle parts and accessories	Missed opportunity	3.15	3.09

Table 7 (concluded)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1990	2000
Energy	341	Natural and artificial gas	Vulnerable	0.86	2.98
Agriculture	22	Milk and cream	Vulnerable	1.93	2.45
Agriculture	54	Fresh, chilled, frozen and preserved vegetables	Vulnerable	5.09	2.33
Non-natural resource-based manufactures	583	Polymerization and copolymerization products	Missed opportunity	2.19	2.10
				29.16	55.02
Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2000	2007
Non-natural resource-based manufactures	781	Passenger vehicles	Missed opportunity	8.85	14.78
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Retreat	11.95	9.93
Non-natural resource-based manufactures	782	Motor vehicles for the transport of goods	Retreat	5.65	6.73
Non-natural resource-based manufactures	784	Motor vehicle parts and accessories	Optimum	3.09	5.33
Non-natural resource-based manufactures	583	Polymerization and copolymerization products	Vulnerable	2.10	4.70
Energy	341	Natural and artificial gas	Missed opportunity	2.98	3.84
Non-natural resource-based manufactures	591	Disinfectants, insecticides, fungicides, herbicides	Optimum	0.88	2.44
Agriculture	54	Fresh, chilled, frozen and preserved vegetables	Vulnerable	2.33	2.18
Agriculture	48	Preparations of cereals and flour	Vulnerable	1.29	1.85
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Vulnerable	1.16	1.57
				40.28	53.35
Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2007	2010
Non-natural resource-based manufactures	781	Passenger vehicles	Optimum	14.78	23.52
Non-natural resource-based manufactures	782	Motor vehicles for the transport of goods	Optimum	6.73	9.95
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Retreat	9.93	5.92
Non-natural resource-based manufactures	784	Motor vehicle parts and accessories	Optimum	5.33	5.38
Non-natural resource-based manufactures	583	Polymerization and copolymerization products	Missed opportunity	4.70	3.73
Energy	341	Natural and artificial gas	Missed opportunity	3.84	2.41
Agriculture	54	Fresh, chilled, frozen and preserved vegetables	Missed opportunity	2.18	2.40
Agriculture	48	Preparations of cereals and flour	Optimum	1.85	2.24
Non-natural resource-based manufactures	591	Disinfectants, insecticides, fungicides, herbicides	Missed opportunity	2.44	1.85
Agriculture	57	Fruit and nuts (not including oil nuts), fresh or dried	Missed opportunity	1.57	1.70
				53.35	59.11

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

[a] Products are ranked by exports in the final year.

In the period 1985–1990, almost all exports were of agricultural products, accompanied by exports of energy (petroleum products, refined). Exports of non-natural resource-based manufactures began to appear in this period, in the form of motor vehicle parts and accessories.

The leading natural resources in this period were the cereal complex, the fruit and vegetable complex and the meat complex, although their importance progressively diminished. The share of the cereal complex fell from 19% to 8% and that of the fruit and vegetable complex from 11% to 4%, while the meat complex, which initially accounted for more than 5% of exports, dropped out of the top 10.

The motor vehicle parts and automotive complex was the leader among non-natural resource-based manufactures, with its share rising from 3% in 1990 to 17% in 2000. The share of this complex was 27% in 2007 and 39% in 2010, this increase being by far the largest change that occurred.

The chemical industry began to gain in importance in 1990 with polymerization products, plus disinfectants, insecticides, fungicides and herbicides since 2000. The first product category is associated with the automotive complex and the last with the oilseed complex.

It can be concluded that the top 10 categories exported to MERCOSUR ceased to be mostly natural resources and became non-natural resource-based manufactures, especially those belonging to the categories that make up the vehicle parts and automotive complex. Another point to note is that natural resource-based manufactures, in the form of leather, only appear among the top 10 in the first subperiod.

In exports to the developing countries of Asia, the concentration is even more radical (see table 8). In fact, the top 10 categories are responsible for almost all exports, accounting for 91% in 2010. This level of concentration is not seen for any other destination.

Table 8
Argentina: top 10 product categories exported to developing countries of Asia, 1985–2010[a]
(Percentages)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1985	1990
Agriculture	423	Fixed vegetable oils	Vulnerable	12.20	15.33
Non-natural resource-based manufactures	678	Iron and steel pipes and pipe fittings	Vulnerable	2.34	12.82
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Retreat	26.55	8.57
Non-natural resource-based manufactures	672	Ingots and other primary forms of iron and steel	Optimum	3.21	6.43
Non-natural resource-based manufactures	674	Universals, plates and sheets of iron or steel	Optimum	0.00	5.69
Natural resource-based manufactures	611	Leather	Optimum	4.23	5.24
Textile fibres, minerals and metals	263	Cotton	Optimum	1.58	4.92
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Vulnerable	2.52	3.26
Energy	334	Petroleum products, refined	Vulnerable	0.00	2.97
Non-natural resource-based manufactures	583	Polymerization and copolymerization products	Optimum	0.37	2.67
				52.99	67.90

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				1990	2000
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Optimum	2.55	32.55
Agriculture	423	Fixed vegetable oils	Vulnerable	15.33	16.40
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	1.72	14.04
Agriculture	44	Unmilled maize	Vulnerable	2.05	6.59
Natural resource-based manufactures	611	Leather	Optimum	5.24	6.59
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Vulnerable	0.34	3.25
Non-natural resource-based manufactures	678	Iron and steel pipes and pipe fittings	Retreat	12.82	2.55
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Missed opportunity	3.26	1.32
Non-natural resource-based manufactures	651	Textile fibre threads	Retreat	2.39	1.17
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Retreat	8.57	1.04
				54.26	85.51

Table 8 (concluded)

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2000	2007
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Optimum	32.55	34.63
Agriculture	423	Fixed vegetable oils	Optimum	16.40	22.18
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Vulnerable	14.04	13.61
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Optimum	4.77	5.78
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Missed opportunity	3.25	3.89
Natural resource-based manufactures	611	Leather	Vulnerable	6.59	3.46
Agriculture	44	Unmilled maize	Retreat	6.59	3.42
Agriculture	41	Wheat (including spelt) and meslin, unmilled	Vulnerable	1.04	2.22
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Vulnerable	1.32	1.91
Non-natural resource-based manufactures	678	Iron and steel pipes and pipe fittings	Missed opportunity	2.55	0.74
				89.11	91.84

Mandeng code	Product code	Product	Position on competitiveness matrix	Year	
				2007	2010
Agriculture	222	Oilseeds and oleaginous fruits, whole or broken, soft	Missed opportunity	34.63	33.13
Agriculture	423	Fixed vegetable oils	Missed opportunity	22.18	19.25
Agriculture	81	Feeding stuff for animals (not including unmilled cereals)	Missed opportunity	13.61	17.72
Energy	333	Petroleum oils, oils from bituminous minerals, crude	Retreat	5.78	4.39
Agriculture	44	Unmilled maize	Vulnerable	3.42	4.25
Natural resource-based manufactures	611	Leather	Vulnerable	3.46	3.95
Textile fibres, minerals and metals	287	Base metal ores and concentrates	Retreat	3.89	3.87
Agriculture	11	Meat and edible offal, fresh, chilled or frozen	Optimum	1.91	2.84
Agriculture	121	Raw tobacco and tobacco waste	Optimum	0.39	0.83
Non-natural resource-based manufactures	541	Medicinal and pharmaceutical products	Missed opportunity	0.41	0.58
				89.69	90.81

Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database; and O. J. Mandeng, "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2, 1993.

[a] Products are ranked by exports in the final year.

The top 10 categories changed substantially during the period under review. The non-natural resource-based manufactures categories were the most important to begin with, accounting for almost 28% of exports, followed by the agriculture categories, which accounted for approximately 27%. In the following decade, however, the agriculture categories came to account for nearly three quarters of exports and non-natural resource-based manufactures for only 3.72%. The relationship between agriculture and non-natural resource-based manufactures remained the same in the following subperiods, although the gap widened, as they came to represent 78% and 1% of exports, respectively.

It can also be seen that the top 10 categories were more diversified between 1985 and 1990 than in the other periods. By way of example, three production complexes were preeminent up to 1990: iron and steel (non-natural resource-based manufactures), oilseeds (agriculture) and meat and leather (agriculture and natural resource-based manufactures). However, from 1990 to 2000 the share of the oilseed complex increased and left little room for other categories. In fact, this complex accounted for 63% of exports in 2007 and 70% in 2010, with no sign of the situation being reversed.

Although there are two well-defined stages in the structure of exports of the top 10 product categories to the developing countries of Asia, with a turning point in 1990, some peculiarities can be observed in the composition of the categories of textile fibres, minerals and metals, energy and natural resource-based manufactures. Thus, in the case of the first category, exports of cotton (an input for the textile industry) gave way to exports of base metal ores and concentrates (mainly an input for the construction industry). Energy exports shifted from refined petroleum products to crude petroleum oils and crude oils from bituminous minerals. The leather industry is the only category of natural resource-based manufactures to rank in the top 10 throughout the years analysed.

Among the more sophisticated manufactured product categories, the iron and steel complex predominated up to 1990, represented by the iron and steel pipes and pipe fittings group, together with a category that contributes to the motor vehicle parts complex: polymerization and copolymerization products. The first group held its own in the 1990s but declined sharply from 1990 to 2000, with its share coming to be less than a quarter of what it had in the previous period, and it fell out of the ranking in the last period.

It should be noted that the production and export of iron and steel pipes are carried out by one of the leading Argentine firms with an international dimension, the Techint business group.[12] In 1990, exports of iron and steel tubes accounted for almost 13% of the country's exports. The abrupt decline in the share of this category is very important for our analysis, as it shows the missed opportunity for Argentina to maintain a strategic position in the Asian market. On the other hand, the appearance of the medicinal and pharmaceutical products category among the top 10 from 2007 shows the rise of the more sophisticated chemical industry.

When the comparison is made with exports to other destinations, oilseed complex exports to developing countries of Asia are found to have grown extremely rapidly from 1990 to 2000, something that was not seen for the other destinations. This growth was maintained until the last year analysed: in 2010, this complex represented 70% of exports to the developing countries of Asia and around 28% of exports to the world and OECD. Remarkably, it was not even among the top 10 product groups exported to MERCOSUR. Lastly, while the non-natural resource-based manufactures categories began to appear among the top 10 products exported to OECD only in 2007, until 1990 they featured much more prominently in the composition of exports to the developing countries of Asia.

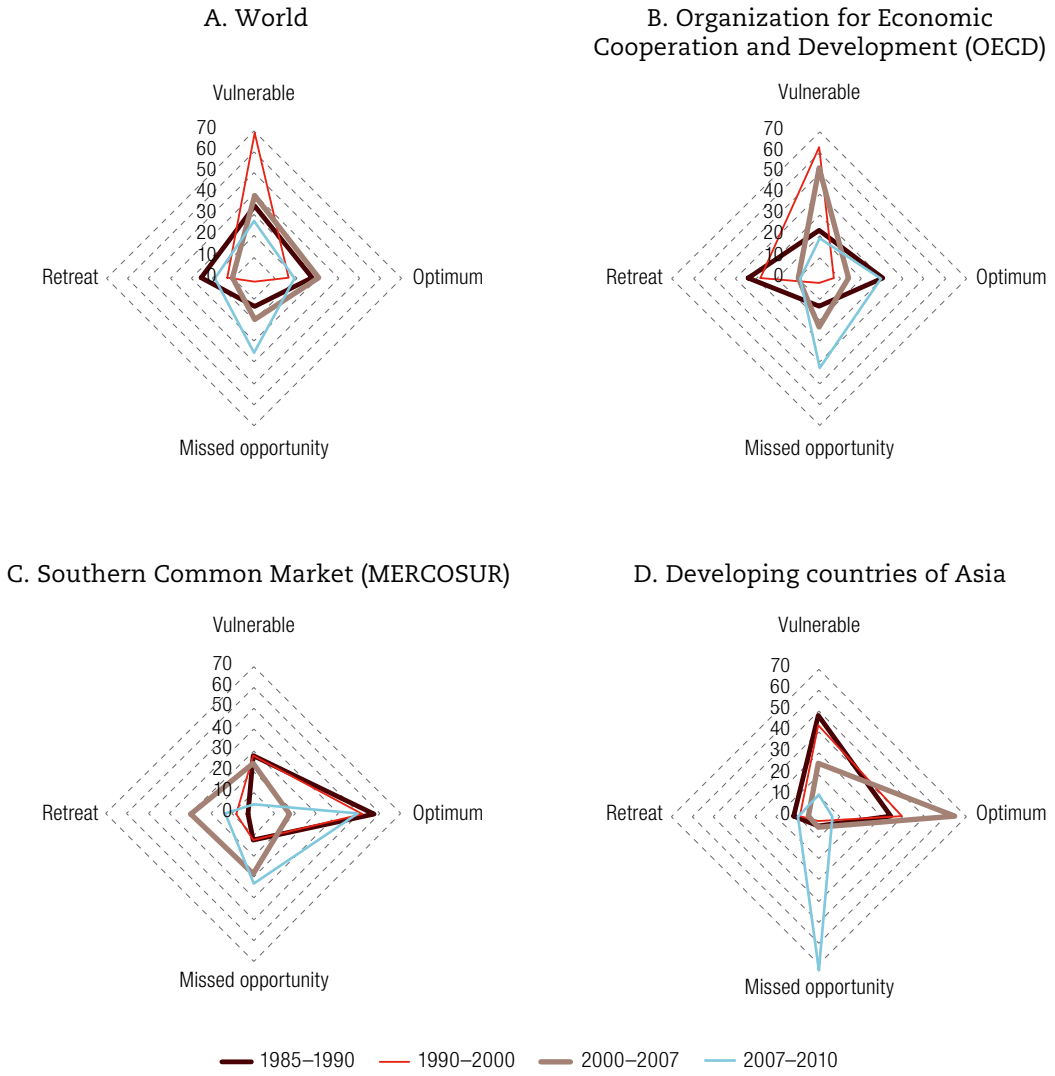
4. The Argentine competitiveness matrix

In the Argentine competitiveness matrix, as has been seen, the evolution of the country's trade pattern is related to the evolution of markets, so that radials can be used for each subperiod of analysis to visualize how exports are composed in terms of the fourfold classification, namely: optimum situation, situation of vulnerability, situation of missed opportunities and situation of retreat (see figure 2). The main results are as follows.

In exports to the world, the fact that the highest values are for groups that are vulnerable and in retreat shows that Argentina's export profile is dominated by groups for which demand is decreasing, i.e. a large proportion of exports (59%, 82%, 50% and 45% in each period, respectively) are from undynamic groups. Of the periods analysed, the worst was 1990–2000, when almost 70% of the country's exports were in vulnerable groups.

[12] See Castro (2011) for a historical analysis of the constitution, corporate organization and early internationalization of this multinational group.

Figure 2
Argentina: competitiveness matrix, by destination, 1985–2010
(Percentages)[a]



Source: Prepared by the authors, on the basis of Economic Commission for Latin America and the Caribbean (ECLAC), TradeCAN database.

[a] The percentages are for exports in the final year.

There was also an improvement from 1990–2000 to 2000–2007, when the share of exports in an optimum situation increased and the share of exports in a situation of vulnerability and retreat decreased. However, the increase in exports in a situation of missed opportunities shows that the country could have gained ground in some markets that were becoming more dynamic, but did not. This process is even more evident in the period 2007–2010, as exports in that situation amounted to more than a third of the total. Despite this, it is the only period in which dynamic exports exceeded undynamic ones.

The situation with exports to OECD was very bad, since they were concentrated in sectors where demand was decreasing, i.e. groups in a situation of vulnerability or retreat (56%, 90%, 63% and 28% in each period, respectively). And although dynamic exports gained significant ground in the period 1985–1990 and their share reached 43%, these exports became more important in the period 2007–2010, when they accounted for almost three quarters of the total.

The exports of vulnerable groups to OECD were very high in 1990 (63%) and in 2000, when they represented more than 50% of the total. This characterization is directly linked to the structure of exports to that market, with almost 75% being commodities (manufactured or otherwise).

The competitiveness matrix as it relates to OECD shows a radical shift from 2007 to 2010. In particular, exports in a missed opportunities situation accounted for almost 43% of the total and those in an optimum situation for 29%. However, this transformation in the matrix format did not derive from substantial changes in Argentina's export pattern, but from the fact that demand for commodities and food became dynamic in that subperiod. This is another example of OECD demand for natural resource-related goods not showing a declining trend. The worse results for OECD as a destination were also observed in the 1990s, highlighting the fragility of Argentina's international positioning during the Convertibility Plan.

With regard to MERCOSUR, the competitiveness matrix shows that about 50% of exports were in an optimum situation for most of the period under review, while almost three quarters were in dynamic groups (with a higher share for these groups from 2007 to 2010). The exception to the above is the subperiod 2000–2007, when exports in an optimum situation were just 17% of the total and dynamic ones 46%.

It is very likely that the sharp increase in MERCOSUR demand for non-natural resource-based manufactures between 2000 and 2007 was not absorbed by Argentina's supply, owing to the large increase in exports in a missed opportunities situation, which rose from 12% in 1990 to almost 29% in 2007. This reveals the difficulties the country experienced in adapting its industrial structure and exportable supply to growing demand from the world and MERCOSUR at the beginning of the twenty-first century. After a decade which was highly destructive of the country's industrial fabric, and in which almost all exports were in vulnerable groups, there was little in the way of production capacity to meet domestic and international demand. In that period, competitor countries gained ground in MERCOSUR at Argentina's expense. Brazil improved its position vis-à-vis Argentina, and China has been the main rival of both countries since 2000 (Fernández, 2014, p. 77).

Lastly, where the developing countries of Asia are concerned, the competitiveness matrix is characterized by large shares for exports in groups in which Argentina is competitive. Export composition remained almost identical in the first two periods analysed, when vulnerable groups outstripped those in an optimum situation, with the two groups together accounting for more than 80% of exports. Over 90% of Argentine exports were in these groups in 2000–2007, although the order was reversed. However, the subperiod 2007–2010 was characterized by a strong expansion of exports in a missed opportunities situation, offsetting a large reduction in exports in an optimum situation. Undynamic groups (vulnerable and retreat) were predominant until 2000, although they remained on a declining trend and ended up representing just 18% of exports by 2010.

IV. Final reflections

This article used Fajnzylber and Mandeng's competitiveness matrix to analyse the evolution of Argentina's export pattern from 1985 to 2010 and highlighted the importance of natural resources in the region's historical data. The markets analysed were the world, OECD, MERCOSUR and the developing countries of Asia.

The study concluded that the composition of world and OECD demand remained virtually unchanged. Indeed, it is remarkable that the OECD share should have declined without the similarities between import structures disappearing. The data are telling. OECD imports accounted for 83% of world imports in 1985 and more than 64% even 25 years later. In other words, world demand was and continues to be strongly driven by demand from industrialized countries, which is why Fajnzylber and Mandeng analysed OECD demand exclusively.

However, the developing countries of Asia have gained ground in the world as importers: they absorbed part of the OECD reduction and their share had more than doubled to 25% of world imports by 2010 (Fernández, 2014). This had not been suggested by those authors.

In this respect, it is remarkable that, although the demand structure of OECD and the developing countries of Asia has increasingly favoured non-natural resource-based manufactures since 1985, the structure of Argentine exports to these markets has not evolved in that direction. Paradoxically, the influence of the developing countries of Asia appears to have reinforced the shift towards commodities in Argentina's export pattern. And whereas until 1990 almost half of Argentina's exports to these countries consisted of high value added manufactured products, that position was not consolidated in the decades following the comprehensive implementation of the Washington Consensus and Convertibility Plan.

The opposite happened with exports to MERCOSUR. There was a clear and pronounced reduction in the share of natural resources and energy in the demand structure of that market. The same structural shift occurred in the matrix of exports to it: non-natural resource-based manufactures became very important. In other words, MERCOSUR demand for higher value added products has had a direct and positive impact on Argentine exports.

Although Argentina's international trade position has traditionally been tied to demand for natural resources and food in industrialized countries (where decreasing demand was observed by Fajnzylber in 1991), it could be said that today it is developing countries that are playing a determining role in reconfiguring international trade and hence Argentina's export pattern. The data show that demand from the developing countries of Asia accentuated the shift towards commodities in Argentina's international trade, and that demand from OECD was not conducive to the industrial development of the country's economy. Conversely, MERCOSUR was crucial in improving Argentina's trade pattern.

Bibliography

Balassa, B. (1965), "Trade liberalization and 'revealed' comparative advantage", *The Manchester School*, vol. 33, No. 2, Wiley.

Bielschowsky, R. (2016), "Fifty years of ECLAC thought: a review", *ECLAC Thinking: Selected Texts (1948–1998)* (LC/G.2699), Santiago, Fondo de Cultura Económica/Economic Commission for Latin America and the Caribbean (ECLAC).

Castro, C. (2011), "Cooperación, internacionalización temprana y organización empresarial en América Latina: el caso de la Organización Techint", *Investigaciones de Historia Económica*, vol. 7, No. 2, Madrid, Spanish Association of Economic History (AEHE).

Fajnzylber, F. (1991), "International insertion and institutional renewal", *CEPAL Review*, No. 44 (LC/G.1667-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

___(1988), "International competitiveness: agreed goal, hard task", *CEPAL Review*, No. 36 (LC/G.1537-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

___(1983), *La industrialización trunca de América Latina*, Mexico City, Editorial Nueva Imagen.

Fernández, V. (2014), "A inserção externa da Argentina: um estudo sobre a relevância dos recursos naturais no padrão de exportações, a competitividade e o comércio intra-industrial, no período de 1985 a 2010", thesis, Curitiba, Federal University of Paraná.

Ferrer, A. (1973), *La economía argentina: las etapas de su desarrollo y problemas actuales*, Mexico City, Fondo de Cultura Económica.

Furtado, C. (1964), *Development and Underdevelopment*, Berkeley, University of California Press.

___(1962), *Formação econômica do Brasil*, Rio de Janeiro, Editora Fundo de Cultura.

Latin American Perspectives (2015), vol. 42–6, No. 205 [online] http://latinamericanperspectives.com/2015/11/.

Magee, S. (ed.) (1975), "Prices, incomes, and foreign trade", *International Trade and Finance. Frontiers for Research*, P. B. Kenen (comp.), New York, Massachusetts, Cambridge University Press.

Mandeng, O. J. (1993), "Análisis de competitividad: Argentina. Estudio de caso basado en el programa computacional CAN", *Indicadores Econômicos FEE*, vol. 21, No. 2.

___(1991a), “International competitiveness and specialization”, *CEPAL Review*, No. 45 (LC/G.4687-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
___(1991b), “Metodología para un análisis de la competitividad internacional de los países”, *Industrialización y Desarrollo Tecnológico*, vol. 10, Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
Pinto, A. (1960), “Estabilidad y desarrollo: ¿metas incompatibles o complementarias?”, *El Trimestre Económico*, vol. 27, No. 106(2), Mexico City, Fondo de Cultura Económica.
Prebisch, R. (1951), *Theoretical and practical problems of economic growth* (E/CN.12/221), New York, United Nations.
___(1950), *The economic development of Latin America and its principal problems* (E/CN.12/89/Rev.1), New York, United Nations.

Trade misinvoicing in copper products: a case study of Chile and Peru[1]

Michael Hanni and Andrea Podestá

Abstract

This study examines the underinvoicing of exports of copper concentrates and refined copper cathodes from Chile and Peru. A novel methodology, which takes the industry's standard contractual terms and insurance and freight costs into account, is used to reveal the existence of below-market unit prices in copper trading. A sharp decline since 2011 in the extent of underinvoicing reflects improvements in the area of international taxation in the two countries; however, this progress represents no more than the first steps towards the establishment of a strong enough legal framework and institutional structure for the proper oversight of mining activity in its entirety. Given the complexity of evaluating and inspecting transactions of mining products, attention is drawn to the importance of strengthening tax and customs administrations.

Keywords

Copper, copper industry, exports, prices, invoices, illegality, taxation, tax administration, case studies, Chile, Peru

JEL classification

H26, H32, Q37

Authors

Michael Hanni is an Economic Affairs Officer with the Economic Development Division of the Economic Commission for Latin America and the Caribbean (ECLAC). Email: michael.hanni@cepal.org.

Andrea Podestá is a Consultant for the Economic Development Division of the Economic Commission for Latin America and the Caribbean (ECLAC). Email: apodestae@gmail.com.

[1] This article expands upon the final report of a joint project conducted by the Economic Commission for Latin America and the Caribbean (ECLAC) and *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) entitled Illicit Financial Flows, Tax Evasion and the Extractive Sector. The project was part of the cooperation programme on combating illicit financial flows funded by the Federal Ministry for Economic Cooperation and Development (BMZ) of Germany. The authors are grateful for the comments and suggestions made by an anonymous referee.

I. Introduction

The loss of tax revenues from the development and sale of raw materials is an issue of key importance for developing countries. The global economic slowdown and the drop in international commodity prices —and especially prices for crude oil and mineral and metals— from the levels seen during the commodity price boom have led to a steep reduction in public revenues. This situation has prompted many countries to address shortcomings in their systems for overseeing international trade in raw materials that could be costing them millions of dollars in foregone income.

Very little research on this problem has been done to date, but it is becoming of greater interest to governments and the wider public because the studies done so far have provided compelling evidence that the problem may be a very serious one indeed. For example, the Economic Commission for Africa (ECA) has found that the losses of capital occasioned by illicit financial outflows from the continent have increased significantly in the past few years and mainly take the form of misinvoiced transactions involving raw materials, especially crude oil, minerals and metals (ECA, 2015). A report by the United Nations Conference on Trade and Development (UNCTAD, 2016) suggests that some developing countries are losing up to 67% of the value of the raw materials they export owing to fraudulent international trade invoicing.

Reducing the tax losses occasioned by misinvoicing in international trade in raw materials represents a major challenge for developing countries. As noted by the Organization for Economic Cooperation and Development (OECD, 2015), there are large data gaps with regard to price-setting in the mining sector, and this makes it difficult for tax authorities to flag atypical transactions and check whether the quoted prices are fraudulent. This situation is compounded by the lack of international taxation expertise in the tax administrations of many developing countries (Readhead, 2016).

An analysis of the situation in specific cases in Latin America may therefore be of considerable interest. This study seeks to analyse the extent to which Chilean and Peruvian exports of copper products —copper concentrates and refined copper cathodes— are underinvoiced. Both of these countries play a significant role in the production and trade of these products globally, although the differences in the composition of their exports may influence the extent of underinvoicing in each country. According to the Chilean Copper Commission (COCHILCO, 2016), 44.8% of Chilean exports of fine copper, by volume, are refined products, versus 17.6% in the case of Peru. Conversely, copper concentrates represent 47.3% of copper exports from Chile and 82.0% from Peru.[2] In addition, copper-related economic activity is an important source of value added, investment, foreign exchange and public revenue in both countries. Accordingly, any trade misinvoicing could have major economic impacts.

In order to look into the possible manipulation of international mining commodity prices, this study draws on the wealth of data provided by the customs declarations filed by exporters with the customs administrations of these two countries. These declarations include information on the companies involved in the transactions and the export values and volumes concerned. In addition, and particularly in the case of Chile, they also provide information on the composition of the products that are being exported. This makes it possible to cross-check information on transactions conducted at an atypical price by a given exporter against information from the annual reports of that exporter, which detail the contractual terms applying to those sales.

A methodology based on the one developed by Hong, Pak and Pak (2014) is used to gauge the extent of underinvoicing by comparing the implicit unit price of a given raw material export with the observed price on the international market. This study contributes to the literature by introducing a number of novel methodological improvements. First of all, the method used to calculate the price filter incorporates a model of the typical approach used to set the price of each product. In addition,

[2] The remaining volume of fine copper exports in both countries corresponds to other smelting products, which represent 7.9% of the total in Chile and 0.4% in Peru.

rather than simply taking 10% off the market price to set the price floor, the market price f.o.b. (free on board) is calculated by applying the cost of freight and insurance (c.i.f.) shown on the Chilean customs declarations to each product in both countries.

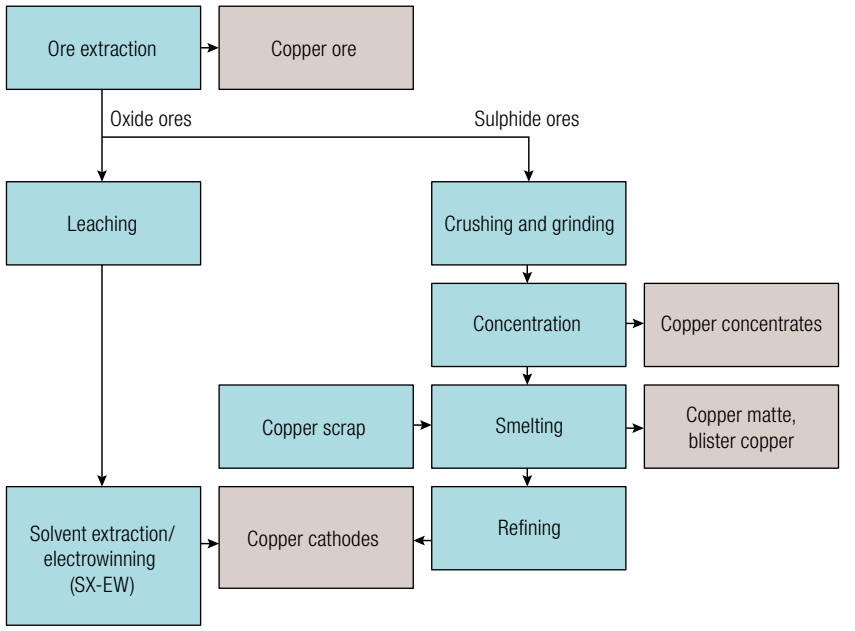
The results of this analysis confirm the existence of transactions in which the implicit unit price declared by the exporter differs substantially from the expected price based on the market price and the benchmark contract terms for each product. They also show, however, that the level of underinvoicing fell in both absolute and relative terms over the course of the study period. This may be attributable to the reinforcement of the two countries' international tax regulatory systems, since both Chile and Peru have refined their anti-evasion rules, particularly those applying to transfer pricing.

This study is structured as follows. Section II looks at how the copper industry is organized in Chile and Peru and how it is positioned globally. Section III offers a brief description of the main methodologies for estimating price manipulation in international trade. Section IV outlines the methodology used in this study and its findings with regard to trade in Chilean and Peruvian copper products. Section V sets out a number of conclusions and observations.

II. Copper production and marketing

Primary copper production begins with the extraction of copper-bearing ore by means of open-pit mining, underground mining or leaching (see diagram 1). Copper ore is not usually exported, since most of it is gangue, which has no commercial value (OECD, 2015). Ore is processed in one of two ways, depending on whether it is oxide or sulphide ore. Hydrometallurgical processes are generally used to treat oxide ores, with leaching and electrowinning processes being used to extract the copper and produce refined copper cathodes. It is estimated that about 18% of global refined copper output is obtained by this method (ICSG, 2015).

Diagram 1
Copper and copper product processing



Source: Prepared by the authors, on the basis of Organization for Economic Cooperation and Development (OECD), "Addressing information gaps on prices of mineral products: mineral product pricing practices case studies: copper, gold and iron ore", Paris, 2015; and International Copper Study Group (ICSG), *The World Copper Factbook 2014*, Lisbon, 2015.

Sulphide ores are crushed, ground and floated to obtain a concentrate with a copper content generally in the 20%–40% range, which is widely traded on the international market. The next stage is smelting, which produces copper matte (with a concentration of between 50% and 70%) or blister copper (with a concentration of between 98.5% and 99.5%). According to OECD (2015), these products are not heavily traded on the international market. Finally, smelted copper is refined by electrolysis or firing to produce refined copper cathodes with a purity of 99.99% or more. The refined copper produced by these methods is extensively exported and accounts for around 64% of world production (ICSG, 2015).

Scrap copper plays an important role in global copper production, as the secondary production of refined copper from recycled scrap accounts for about 18% of refined copper products worldwide (ICSG, 2015).

The available data can be used to analyse how copper production is distributed in Chile and Peru and how these countries' output stacks up against total production worldwide. According to statistics compiled by the United States Geological Survey (USGS), Chile is the world's largest copper producer, accounting for approximately 30% of global mining output as of 2015. As shown in table 1, of the 5.76 million metric tons (mt) of fine copper that Chile produced in that year, 3.99 million mt were copper concentrates and 1.78 million mt were refined cathodes produced by means of solvent extraction/electrowinning. Some of the concentrates were electrolytically refined to produce copper cathodes (910,000 mt) and other smelted products. In all, 66% of the cathodes produced by Chile were refined by means of solvent extraction/electrowinning (SX-EW) and the other 34% by electrolysis.

Table 1
Chile and Peru: fine copper production and exports, 2015
(Thousands of metric tons and percentages)

Product	Chile		Peru	
	Thousands of metric tons	Percentage of total	Thousands of metric tons	Percentage of total
A. Production				
Mine production of fine copper	5 764	...	1 705	...
SX-EW cathodes (end product)	1 778	30.9	73	4.3
Concentrates	3 986	69.1	1 632	95.7
Smelted products (end product)	586	10.2	48	2.8
ER cathodes (end product)	910	15.8	280	16.4
Concentrates (end product)	2 489	43.2	1 304	76.5
Cathodes (SX-EW + ER): total	2 688	46.6	353	20.7
B. Exports				
Exports of fine copper	5 737	...	1 628	...
Concentrates	2 714	47.3	1 335	82.0
Smelted products	455	7.9	7	0.4
Cathodes	2 568	44.8	286	17.6

Source: Prepared by the authors, on the basis of Chilean Copper Commission (COCHILCO), *1996-2015 Yearbook: Copper and other Mineral Statistics*, Santiago, 2016; and Ministry of Energy and Mines, *Anuario Minero, 2015*, Lima, 2016.
Note: SX-EW: solvent extraction/electrowinning refining; ER: electrolytic refining.

Of Chile's 5.74 million mt of fine copper exports, 2.57 million mt (44.8% of the total) were refined cathodes, 2.72 million mt (47.3%) were copper concentrates, and the rest (7.9%) were other smelted products.[3] Private companies accounted for most of the copper concentrate exports (87.9% of the total in 2015), while the State-owned producer, CODELCO, was a distant second with just 12.1%. This breakdown is also reflected in the composition of private enterprises' total exports, since copper concentrates represented 56.8% of their total international sales, whereas concentrates accounted for only 21.4% of the total exports of CODELCO.

[3] Production volumes and export volumes for any given year may not match due to production lags.

Peru was the world's third-largest copper producer in 2015, coming just slightly behind China. As shown in table 1, the country's fine copper mine output totalled 1.70 million mt (about 9% of the world total). The bulk of this was in the form of concentrates —1.63 million mt— as SX-EW cathodes amounted to only 73,000 mt (which was still 20% of total cathode output). Some of the copper concentrates were used to produce electrolytically refined (ER) cathodes (280,000 mt, or 80% of the total). The country's smelting and refining capacity is limited, which is why such a large percentage of its total production takes the form of concentrates (76.5% in the case of Peru, versus 43.2% for Chile). In 2015 it exported 1.63 million mt of fine copper: 1.34 million mt of concentrates (82.0%) and 286,000 mt of cathodes (17.6%).

Mining production is concentrated in a small group of companies in both of these countries. In Chile, the five largest producers accounted for 75% of the country's total output in 2015 (COCHILCO, 2016), while, in Peru, the five biggest mining enterprises accounted for 81% of total production (Ministry of Energy and Mines, 2016). The fact that most of these firms are subsidiaries or joint ventures of multinationals is of particular importance for this study. In Chile, multinational corporations have a controlling interest in three of the five leading producers and, in Peru, they control all five of the biggest producers.[4]

Table 2 shows just how important a part Chile and Peru play in world trade in copper products. In 2015, these two countries exported 50% of the world's total exports of copper ore and concentrates in terms of value. And Chile was by far the world's largest exporter of refined copper cathodes, with a market share of 34%. Peru's ninth-place showing in this category, with a market share of just 4%, is primarily a reflection of its limited smelting and refining capacity.

Table 2
Value of world exports of selected copper products and market shares of the main exporting countries, 2015
(Millions of dollars and percentages)

A. Copper ore and concentrates (HS6 260300)

Country	Value	Market share
Chile	13 891	34
Peru	6 568	16
Australia	3 659	9
United States	3 083	8
Canada	3 001	7
Mongolia	2 280	6
Brazil	1 984	5
Mexico	1 159	3
Spain	1 131	3
Philippines	700	2
Other countries	3 237	8
Total	40 693	100

B. Refined copper cathodes (HS6 740311)

Country	Value	Market share
Chile	14 357	34
Russian Federation	3 060	7
Japan	2 857	7
Australia	2 474	6
India	1 926	5
Poland	1 638	4
Republic of Korea	1 566	4
Kazakhstan	1 562	4
Peru	1 499	4
Canada	1 291	3
Other countries	8 663	21
Total	40 893	100

Source: Prepared by the authors, on the basis of figures from the United Nations International Trade Statistics Database (COMTRADE).

These two countries' leadership positions in the international copper trade also have a major impact on their economies. In Chile, exports of copper products represented, on average, 47% of total exports in value terms between 2011 and 2015. In Peru, copper accounted for a smaller share of the total in this period, but it was still around 23%. The difference between these two figures reflects

[4] In Chile, the producers in which multinationals have a controlling interest are Minera Escondida (BHP Billiton is the majority shareholder), Compañía Minera Doña Inés de Collahuasi (a joint venture of Anglo American PLC, Glencore and Japan Collahuasi Resources B.V.) and Anglo American Sur (Anglo American PLC is the majority shareholder). In Peru, the multinational-controlled producers are Minera Antamina (jointly owned by BHP Billiton, Glencore, Teck and Mitsubishi Corporation), Southern Peru Copper Corporation (Grupo México S.A.B. de C.V.), Minera Cerro Verde (Freeport-McMoRan is the majority shareholder), Minera Antapaccay (Glencore) and Minera Chinalco Peru (Aluminum Corporation of China).

the difference in these countries' production levels and Peru's more diversified production profile in the mining sector. Between 1995 and 2015, copper exports generated earnings of US$ 418 billion for Chile and US$ 96 billion for Peru.[5]

III. Overview of methodologies for detecting price manipulation in international trade

Historically, studies on price manipulation in international trade have employed the partner-country approach used by Bhagwati (1964 and 1974), which is based on the premise that country *A* imports from country *B* are also country *B* exports to country *A*. If, after adjusting for the cost of insurance and freight (among other variables), the value of the imports recorded in a given country exceeds the value that the rest of the world has recorded as exports to that country, then imports have been overinvoiced. By the same token, if the adjusted value of the exports registered for a given country is lower that the values declared by other countries as imports to that country, then the exports have been underinvoiced.

A series of recent studies based on this approach have contributed to a new line of research that focuses on quantifying the extent of fraudulent misinvoicing in international trade (the overinvoicing of imports and the underinvoicing of exports) as a key component of illicit financial outflows from developing countries. Notable studies in this connection include the reports of Global Financial Integrity (Kar and Spanjers, 2015; Hollingshead, 2010), the Economic Commission for Africa (ECA, 2015) and the Economic Commission for Latin America and the Caribbean (ECLAC, 2016) on illicit financial flows connected with price manipulation in international trade.

An implicit assumption that is made with this method is that the values declared by a trading partner correspond to fully competitive pricing. The advantage is that it is not necessary to determine the price under full competition for each transaction (as must be done when using the price filter method), but this may distort the extent of intentional misinvoicing if the price declared by the partner country is not a free-market price either. Estimates arrived at using this approach reflect only those capital outflows for which one of the trading partners declares a price, amount or quality for the goods in question that differs from the price, amount or quality registered by the other partner. The possibility exists, however, that in some cases both the exporter and importer may record the same relative price for a product but one which is very different from its market price.

Another reason why this method may yield underestimates is that the data are aggregated by country, trading partner or product. The problem here is that each pair of trading-partner records will include a number of operations that may offset each other, since some of the trades may be overinvoiced and others underinvoiced. Another difficulty has to do with the asymmetry of bilateral trade statistics in any of a number of areas, such as differences in the valuation of imports and exports (c.i.f. and f.o.b.), differences in product classifications or nomenclatures, and differences in the attribution to trading partners and/or in re-export records (Javorsek, 2016).

The price filter methodology espoused by Zdanowicz, Pak and Sullivan (1999) and by Pak, Zanakis and Zdanowicz (2003) is aimed at detecting international trade transactions that diverge from what is considered to be a normal price range (i.e. market price or freely competitive price) and then gauging the extent of that divergence. The normal price range can be determined on the basis of either an analysis of the interquartile range or the free market price.

In the first of these approaches, the import and export declarations submitted to customs authorities are used to identify abnormal prices. The implicit prices of the highest and lowest quartile are calculated for each product category, and the prices in the range between these two points are

[5] Figures from the United Nations International Trade Statistics Database (COMTRADE).

considered to be fully competitive prices. Price manipulation is detected by comparing each entry in the trade database with the interquartile range for the corresponding product classification. If the declared price falls within that range, then the transaction is regarded as having taken place under full competition and is thus classified as a normal transaction. If the price is higher than the price of the highest quartile, it is regarded as signalling an instance of overinvoicing, and if it is below the value for the lowest quartile, it is regarded as a case of underinvoicing.

A number of shortcomings and limitations of this method have been pointed out in the literature, however. One of these has to do with its endogeneity, since the quartile price points are estimated on the basis of all commercial transactions, which will invariably include some operations conducted at prices below the lowest quartile price and some at prices above the highest quartile price, even if all the trades have been conducted under full competition. Interquartile price filters are also influenced by related-party transactions that are entered into the trade database. Thus, if there is a large number of this type of transaction, the estimated price range may not be representative of competitive prices.

Another problem arises when dealing with very heterogeneous products, since this method may lead to the mistaken classification of legitimate transactions of high-quality products as instances of overinvoicing, legitimate transactions of low-quality products as cases of underinvoicing and transactions of mid-range products conducted at abnormal prices as legitimate trades. In addition, in the case of products whose prices are very volatile, if the interquartile price range is estimated from annual data rather than taking monthly price variations into account, the estimates will be less accurate.

As also occurs with the partner-country method, another difficulty arises when the records are grouped for a given product category rather than using separate records for each shipment that is cleared through customs, since the aggregated data may include overinvoiced and underinvoiced transactions that offset one another, in which case the extent of price manipulation will be underestimated. Misinvoicing may also be underestimated when dealing with large-volume trades of a product if the price is marginally different from the free competition price. In such situations, since the price used in the transaction falls within the interquartile range, it will be classified as normal even though the total value being misinvoiced may be very high.

With the price filter method based on market prices, on the other hand, over- or underinvoicing is detected by comparing the implicit unit prices from customs records with a price (or price range) that is considered to have been determined on the basis of free competition and that has been posted by various markets or institutions. When the import or export price diverges from the free market price, then the transaction is considered to be based on a fraudulent price level.

For most products, it is extremely difficult to determine the true market price (the arm's length price or free competition price). There are some raw materials, however, for which the market is liquid and transparent enough to make it possible to identify the free market price.[6]

According to Hong, Pak and Pak (2014), the free-market price filter method has some advantages. One of these is the fact that it is not necessary to estimate the free competition price because the free market price published by various institutions can be used instead. In addition, unlike the interquartile price filter, the free market price filter incorporates monthly variations in product prices and is separate from declared import values, so related-party trades do not skew the estimates. However, free market prices are not available for all products and, even in the cases of commodity markets where prices are easily identifiable, those prices may not be representative of the final price obtained by the exporter because of the terms of reference contained in the contracts used by each industry. This was true of the estimates calculated for this study, where, in addition to the international price for the good in question, standard contract terms and conditions were also taken into account.

[6] See, for example, Hong, Pak and Pak (2014), who calculated the extent of misinvoicing in trade in bananas by comparing the free market price with the price shown in United States import documentation.

IV. Estimation of the extent of misinvoicing in international trade in Chilean and Peruvian copper products

1. Methodology

The price filter methodology used by Hong, Pak and Pak (2014) and by Grondona and Burgos (2015) is used here to estimate the amount by which copper product exports may be underinvoiced. Unlike most of the studies that have been based on interquartile price filters, these authors compared the unit price of operations involving a specific product —bananas, in the first study, and soya products in the second— with the reference price for that product on the world market. This method is similar to the ones used to calculate transfer prices for related-party transactions, such as the so-called "sixth method" of transfer pricing valuation or a variant of the comparable uncontrolled price method. The contribution to the literature made by the research described here lies in the fact that, unlike the above studies, two adjustments were made that increase the estimates' accuracy. First, a pricing model was used that takes into account the contractual terms and conditions that the industry applies to copper products. Second, the calculation of the monthly market price f.o.b. incorporated the cost of insurance and freight as stated on customs declarations rather than assuming a flat 10% reduction.

The main data sources were the customs declarations for exports of copper products from Chile and Peru and the market prices for copper, gold and silver. The information on external sales of mining products was obtained from the Penta-Transaction database, which contains the customs declarations filed by the exporters that are registered with the customs authorities. These declarations generally include the name of the exporter, the shipment date, the f.o.b. value and the gross and net weights of the export. In the case of Chile, they also include information on the composition of the products and the cost of insurance and freight (i.e. the c.i.f. value).

Market prices have been taken from the database maintained by the United Nations Conference on Trade and Development (UNCTAD), which gives monthly values for the main commodity exports. For the most part, these prices are given in c.i.f. terms, represent the agreed prices on major markets (such as the London Metal Exchange) and are for a given product description. For example, in the case of copper, the quoted price is for refined copper cathodes with a minimum grade of 99.99% (grade A).

The price filter for exports of copper ore and copper concentrates was based on the market price and the typical contractual terms and conditions applying to sales of these products on the international market. As explained by Teck (2015) and Nyrstar (2016), contracts governing the sale of copper concentrates generally set out the standard terms established annually by the leading mining and smelting enterprises. The price obtained by the mining company is set using the following equations.

First, the price of the metal contained in the concentrate is calculated:

$$Price\ of\ the\ metal = ((M*D)*P_m) + ((O_m*D_{Om})*P_{Om}), \quad (1)$$

where M refers to the grade of the metal in the concentrate (usually between 20% and 30% for copper concentrates); D stands for the percentage of the value of the metal paid after applying a standard deduction that covers the metal lost during smelting (mining companies typically receive between 96.5% and 96.75% of the metal's value); and P_m stands for the going price of copper on the market. The contracts usually also provide for payment for the gold or silver content if the concentration of these metals exceeds a set threshold. In those cases, O_m stands for the other metal (gold or silver) contained

in the concentrate; D_{Om} refers to the percentage of that metal that is paid for (around 90%); and P_{Om} stands for the market price of the metal.

Next, the deductions made for the processing of the concentrate are calculated:

$$Deductions = TCRC + PP + RC_{Om} + Other \quad (2)$$

$TCRC$ stands for the basic treatment charge and the refinery charge (TC and RC, respectively), which, in theory, represent the cost of converting the concentrate into refined metal. PP stands for the smelter's participation in the movement of the market price in the form of escalators and de-escalators. That share is calculated on a monthly basis as a set amount per ton which is then added to the per-dollar treatment charge if the market price is above the base price. On the other hand, if the market price is below the base price, then a fixed amount per ton is deducted from the treatment charge. (Since 2005–2006, however, the leading mining enterprises have not agreed to include this component in the reference contracts.) RC_{Om} stands for the refinery charge for the non-copper metal (silver or gold) content of the concentrate. The "other" entry includes charges such as penalties for overly high levels of contaminants in the concentrate, but since precise information on the level of contaminants is not available, this component could not be included in the analysis.

The net market price c.i.f. is then calculated as the price of the metal in the concentrate minus the deductions provided for in the contract:

$$Net\ market\ price = price\ of\ the\ metal\ content - deductions \quad (3)$$

Next, the underinvoiced amount in trade in copper concentrates is estimated using the following equation:

$$Underinvoiced\ amount = volume * MAX(0, P_* - P) \quad (4)$$

In this case, P is the implicit unit price obtained from the customs declaration based on the concentrate's weight, net of its moisture content.[7] P_* is equal to the *net market price* (obtained using equation (3)), expressed in dry metric tons less the cost of freight and insurance. These costs are calculated on a monthly basis from the Chilean customs declarations, which include information on the exports' c.i.f. value. The same values are used for Peru on the assumption that the prices are similar for the two countries.

Unfortunately, not all the customs declarations include detailed information on the composition of the export product. This occurs mainly in the case of Peru and makes the calculations more difficult to perform, since mining companies are paid based on the product's metal content. For both countries, three price filters corresponding to different grades are therefore used in order to cover the values usually employed in the industry. In Chile's case, since the customs declarations provide more information, an estimate is also given that takes the stated composition into account.

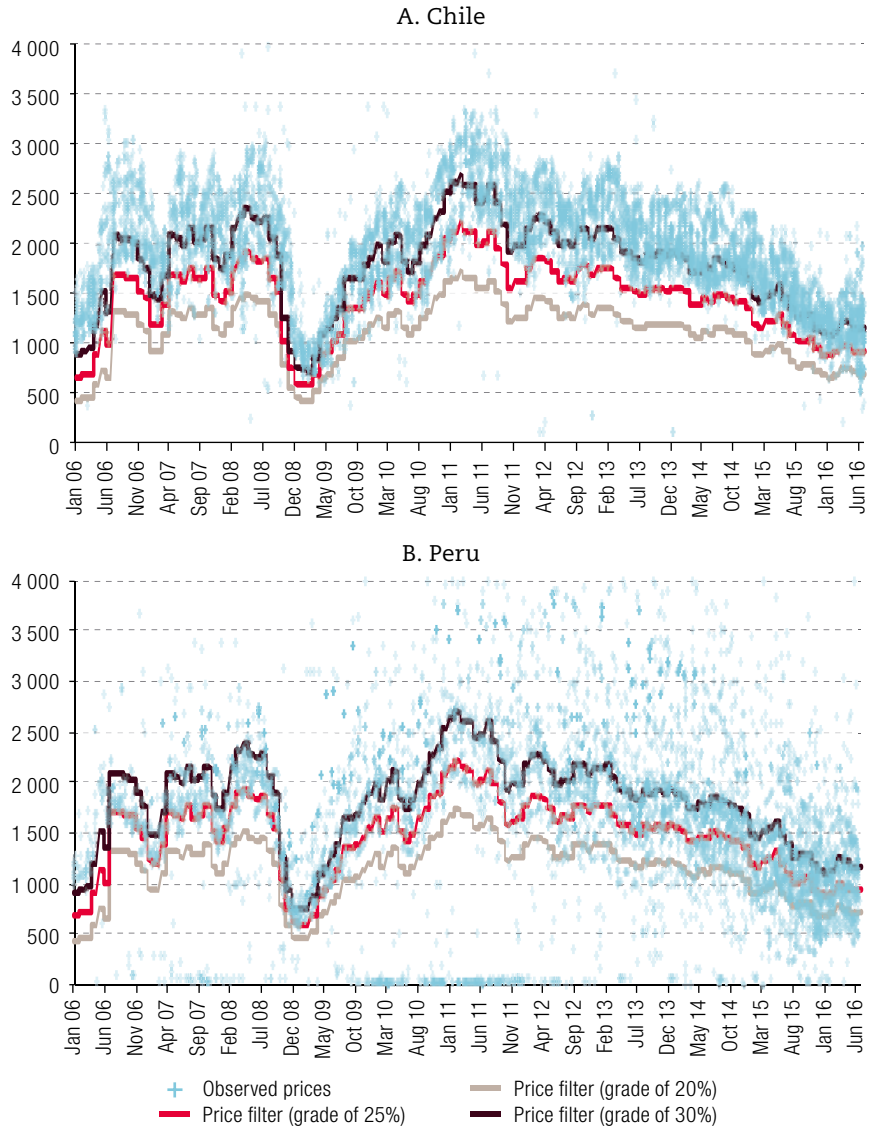
For refined copper cathode exports, the underinvoiced amount is calculated using an equation similar to the one proposed by Hong, Pak and Pak (2014), since the composition of the export product is assumed to be close to the composition used as a basis for the international reference price. In a departure from the approach used by those authors, however, the monthly market price is estimated in f.o.b. terms using the cost of insurance and freight reported on the Chilean customs declarations. These same values are then used for Peru as well.

[7] In both countries, if the net weight was equal to the gross weight, the recorded weight was adjusted downward by 10% to arrive at an estimate of the weight in terms of dry metric tons.

2. Findings regarding copper ore and concentrates

As shown in figure 1, the three price filters correlate with the movements in the implicit unit prices obtained from customs declarations. This indicates that most copper concentrate sales are made on the basis of the benchmark reference terms used by the industry. In the period between 2006 and the first half of 2016, the 7,872 customs declarations submitted in Chile corresponded to 72.10 million net metric tons having an f.o.b. value of US$ 140.273 billion. In Peru, the 9,142 customs declarations submitted during that period corresponded to 35.11 million net metric tons having an f.o.b. value of US$ 61.9 million. The implicit unit prices obtained from the declarations are US$ 1.95/kg for Chile and US$ 1.76/kg for Peru.

Figure 1
Chile and Peru: implicit unit prices obtained from customs declarations for exports of copper ore and concentrates (HS6 260300) and three different price filters, 2006–2016[a]
(Dollars per net metric ton)



Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

Some transactions take place at price points above —and even, in some cases, far above— the upper bounds of the price filters. In such cases, it is highly likely that the exported concentrate contains an amount of silver or gold that raises the product's unit price. (As noted earlier, the contracts governing the sale of copper concentrates typically provide for an additional payment for these metals if their concentration exceeds a specified level.) Although Peruvian customs declarations do not usually provide information on the composition of the exported good, most Chilean ones do, and that information indicates that the average silver and gold content of these concentrates is substantial (around 2 grams of gold per metric ton and approximately 98 grams of silver per metric ton).

The observations for the two countries differ significantly, however. In the case of Chile, observed prices tend to remain within a more or less stable range over time; most transactions take place at prices above the upper bounds of the price filters for all of the grades covered in this study, which points to a degree of product homogeneity in terms of copper and precious metal content. In contrast, the unit prices derived from Peruvian customs declarations cover a wide range, which points to a considerable degree of product heterogeneity. Moreover, in Peru's case, a significant number of transactions involve price points below the lower bounds of all the price filters.

In Peru, a number of transactions have been registered at unit prices close to US$ 0 per ton. A review of these declarations indicates that the vast majority of them concern exports that are transported by truck to the Chilean border. Although the composition of the products is not specified in the customs declarations, it is very probable that these products are copper ore rather than copper concentrate. In that case, the expected value of the products would be far below the lower bound of the price filter and thus would not necessarily be an instance of price manipulation. The volumes involved in these transactions are relatively small, especially in the case of shipments bound for China, and the part they play in the estimates of underinvoicing is therefore virtually nil.

The exports conducted by Peru in 2015–2016 are worthy of closer examination, particularly in the case of the customs declarations of Minera Chinalco Peru S. A., which began to export copper concentrates from its new Toromocho mine in 2014. These declarations give unit values below the lower bound of the price filter for copper with a grade of 20%. Although the copper concentration of the product is not stated on most of these customs declarations, the few that do specify it indicate that the concentrates generally have a grade of between 20% and 22%. However, the copper-bearing ore from this new mine contains excessive amounts of arsenic (CHINALCO-CMC, 2016), and the concentrates may therefore be bringing a lower price on the market. Consequently, the company may be selling these concentrates for less and, in that case, the transactions would not necessarily be reflecting price manipulation. The lack of the necessary information makes it unfeasible to adjust the estimates, however.

Table 3 gives the estimated amounts of copper concentrate exports from Chile and Peru that have been underinvoiced. In the case of Chile, the estimated value of underinvoiced exports amounted to US$ 3.035 billion during the study period, which was equivalent to an estimated 2.2% of the total f.o.b. value of its exports of copper concentrates based on the composition of the concentrates as stated in the declarations (the "registered" entry). Most of this corresponds to the years between 2006 and 2010, when the underinvoiced value represented, on average, 4.0% of the total value of these exports. The amount of underinvoicing fell thereafter in both absolute and relative terms, accounting for an average of 0.9% of the value of exports in the years between 2011 and 2015.

In the case of Peru, using the intermediate 25%-grade price filter, the underinvoiced value amounts to US$ 1.083 billion in 2006–2016, or 1.8% of the f.o.b. value of these exports. The underinvoiced amounts trend upward and spike in 2015 in both absolute and relative terms, due in part to the exports from the new mine mentioned earlier (for which underinvoicing totalled US$ 96.3 million in 2015). However, of the total amount of underinvoicing for the study period, around half (US$ 538 million) corresponds to sales which may have involved concentrates with a copper content of less than 25%, since mining operations

in Peru are reportedly yielding concentrations of copper of between 20% and 30%. Unfortunately, this supposition cannot be confirmed based solely on the information provided by customs declarations. If, nevertheless, the 20%-grade price filter is applied instead, then this firm's level of underinvoicing during the study period is close to zero.

Table 3
Chile and Peru: f.o.b. values and underinvoiced amounts of exports of copper concentrates (HS6 260300) based on three price filters, 2006–2016[a]
(Millions of dollars and percentages)

A. Chile

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Millions of dollars												
20% grade	0	0	0	0	0	0	0	0	0	0	0	0
25% grade	7	53	62	106	104	33	49	6	4	17	61	504
30% grade	157	326	496	522	746	271	560	305	285	229	331	4 229
Registered	389	553	549	383	401	111	254	85	137	74	98	3 035
f.o.b. value	11 376	13 476	12 866	7 629	12 375	14 462	15 912	17 190	16 475	12 949	5 564	140 273
Percentages of f.o.b. value of exports												
20% grade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25% grade	0.1	0.4	0.5	1.4	0.8	0.2	0.3	0.0	0.0	0.1	1.1	0.4
30% grade	1.4	2.4	3.9	6.8	6.0	1.9	3.5	1.8	1.7	1.8	5.9	3.0
Registered	3.4	4.1	4.3	5.0	3.2	0.8	1.6	0.5	0.8	0.6	1.8	2.2

B. Peru

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Millions of dollars												
20% grade	1	4	11	1	6	7	5	12	11	35	24	118
25% grade	25	38	63	36	100	98	123	99	113	263	124	1 083
30% grade	278	518	523	311	590	582	683	536	601	848	467	5 936
f.o.b. value	2 794	4 348	4 666	3 842	6 248	7 814	8 044	7 112	6 934	6 570	3 535	61 906
Percentages of f.o.b. value of exports												
20% grade	0.0	0.1	0.2	0.0	0.1	0.1	0.1	0.2	0.2	0.5	0.7	0.2
25% grade	0.9	0.9	1.4	0.9	1.6	1.3	1.5	1.4	1.6	4.0	3.5	1.8
30% grade	9.9	11.9	11.2	8.1	9.4	7.5	8.5	7.5	8.7	12.9	13.2	9.6

Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

As is to be expected, the amount of underinvoicing is greatest in trade with the largest buyers of copper concentrates from these two countries (see table 4). Chile's exports to its five biggest trading partners represent nearly 85% of its total exports of this product, and these countries account for 78.2% of the estimated underinvoicing. In most of these cases, the percentage of underinvoicing was quite similar, ranging from 1.9% to 2.1%; the exceptions were the Republic of Korea (1.4%) and India (2.5%).

In the case of Peru, using the 25%-grade price filter, the country's five main trading partners accounted for 77.2% of the underinvoiced value and 76.5% of the total value of these exports. However, the figures for the individual countries vary quite a bit. The relative level of underinvoicing is the highest for Japan (3.2%) and the Republic of Korea (2.5%), in a middling range (1.6% and 1.4% of the corresponding f.o.b. values, respectively) for Chile[8] and for China (the biggest buyer) and very low for Germany (0.3%).

[8] Because Peru's copper smelting and refining capacity limited, a portion of its output of copper ore and copper concentrates is exported to Chile and refined there.

Table 4
Chile and Peru: underinvoicing of exports of copper concentrates (HS6 260300), by trading partner, 2006–2016[a]
(Millions of dollars and percentages)

A. Chile (registered values)

Country	Amount underinvoiced	f.o.b. value	Percentage of f.o.b. value underinvoiced
Japan	821	41 713	2.0
China	767	39 764	1.9
India	456	18 087	2.5
Republic of Korea	165	11 613	1.4
Brazil	163	7 940	2.1
Other countries	661	21 156	3.1
Total	3 035	140 273	2.2

B. Peru (25%-grade price filter)

Country	Amount underinvoiced	f.o.b. value	Percentage of f.o.b. value underinvoiced
China	358	25 020	1.4
Japan	332	10 329	3.2
Germany	20	5 991	0.3
Republic of Korea	82	3 291	2.5
Chile	45	2 726	1.6
Other countries	247	14 549	1.7
Total	1 083	61 906	1.8

Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

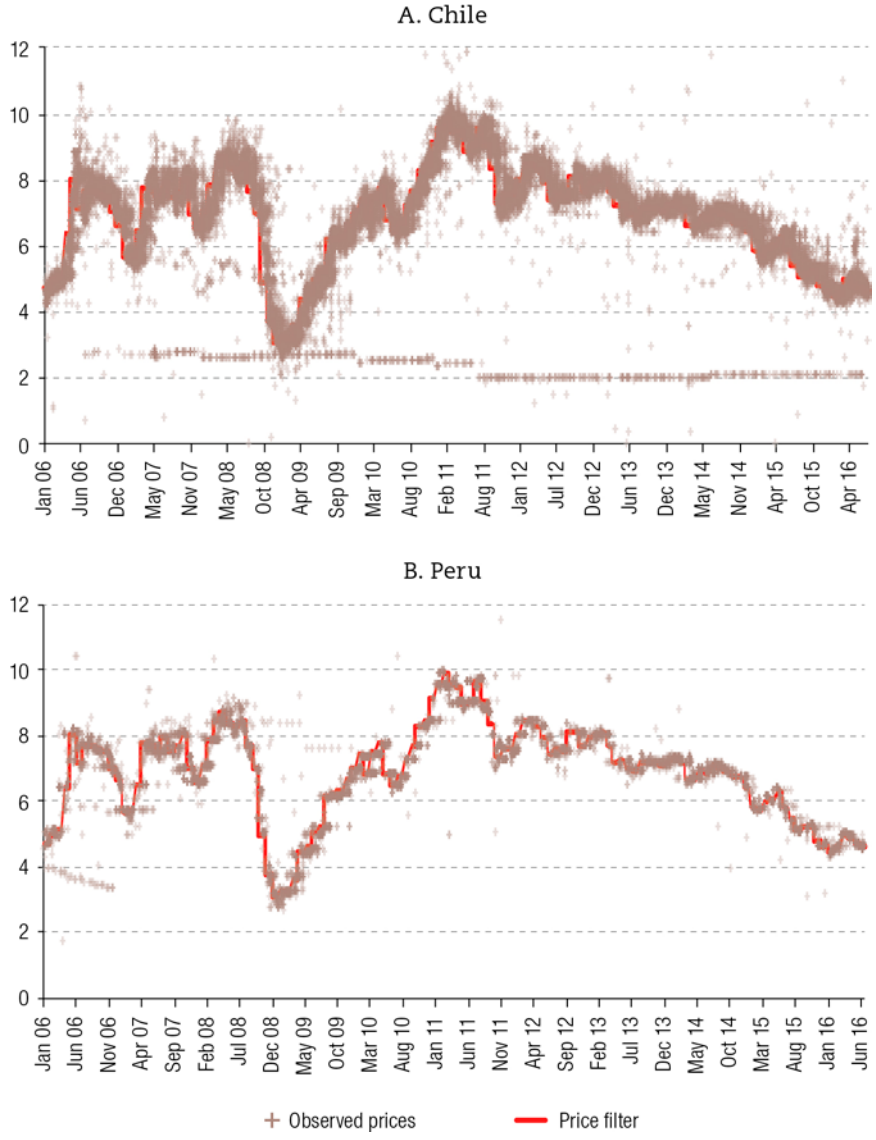
3. Findings regarding refined copper cathodes

As shown in figure 2, most of the observed prices obtained from customs declarations for exports of refined copper cathodes from Chile and Peru are in line with the price filter. Between 2006 and the first half of 2016, a total of 83,767 customs declarations for refined copper exports were filed in Chile and 12,172 were filed in Peru. The value of Chile's 29.29 million metric tons of exports totalled US$ 199.585 billion, while the value of Peru's 3.32 million metric tons of exports amounted to US$ 22.713 billion. On average, the implicit unit price was US$ 6.8/kg for both countries.

Some of each country's export transactions were atypical, however, as they diverged from the market price trend. In the case of Chile, there is a long series of transactions spanning the entire period that run in nearly a straight line situated substantially below the market price. A closer inspection shows that these trades are sales made by CODELCO to Chinese buyers. This is accounted for by the fact that, in May 2005, CODELCO signed a contract with China Minmetals Corporation for the sale of 836,250 tons of cathodes over a period of 15 years (180 months). The contract stipulated that the sale price would be computed on the basis of one fixed readjustable component plus a variable component that would be determined in line with the market price at the time of shipment. Exports under this contract began in June 2006 and were channelled through Copper Partners Investment Company Ltd. of Bermuda, with CODELCO and that company holding equal equity interests. In 2016, CODELCO withdrew from that joint venture and terminated its contract with Minmetals after Chile's tax authorities questioned the joint venture's tax structure and ordered CODELCO to pay US$ 149 million in back taxes in 2015 (CODELCO, 2016).

For Peru, especially at the beginning of the study period, transactions are noted in which the observed price remains below the market price for several months at a time (see figure 2). Between January and November 2006, the observed prices for one group of operations, in particular, trended steeply downward. These trades involved sales of copper cathodes by a subsidiary of a United States firm to customers in that country. Unfortunately, the customs declarations do not provide information on the buyer, so it cannot be determined whether these were related-party sales or not. What is striking about these trades is that the unit prices trended downward while the market price was rising sharply (by 61% between January and May 2006).

Figure 2
Chile and Peru: implicit unit prices derived from customs declarations for exports of refined copper (HS6 740311) and the corresponding price filter, 2006–2016[a]
(Dollars per net kg)



Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

In contrast, most of the other atypical clusters of transactions were conducted at a set price, i.e. they follow a horizontal line on the graph. For example, in 2007, some of the exports from Southern Peru Copper Corporation were made at similar prices throughout the year even though the market price was quite unstable during that period. In this case, the firm's audit report for that year states that the company used to sell copper on the basis of annual contracts, which could explain why sales during the same year were made at the same price (Southern Peru Copper Corporation, 2008).

Table 5 shows the underinvoiced amounts, by value, of exports of refined copper cathodes from Chile and Peru. For Chile, they are estimated at US$ 6.348 billion between 2006 and the first half of 2016, or 3.2% of the total value of those exports. Of that amount, US$ 2.516 billion (40%) corresponds

to transactions governed by the long-term contract concluded by CODELCO and Minmetals. In the case of the rest of these transactions (US$ 3.833 billion, or 1.9% of the total value of those exports), a definite downward trend is apparent, with the underinvoiced amounts dropping from an average of US$ 567 million per year between 2006 and 2010 to an average of US$ 182 million between 2011 and 2015. As a result, the share of the total export value that appears to have been underinvoiced fell from an average of 3.1% in 2006–2010 to 0.9% in 2011–2015. In the case of Peru, the underinvoiced amount totalled US$ 369 million between 2006 and the first half of 2016, or 1.6% of the total. As is also true of Chile, both the value of underinvoiced shipments and their relative size in terms of total export values declined considerably during the study period.

Table 5
Chile and Peru: underinvoiced amounts of exports of refined copper (HS6 740311), 2006–2016[a]
(Millions of dollars and percentages)

A. Chile

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Millions of dollars												
Refined copper	564	862	767	771	935	645	628	424	334	291	127	6 348
CODELCO/ Minmetals	75	319	253	130	285	347	329	300	253	186	39	2 516
Other	489	543	514	642	651	298	299	124	81	105	88	3 833
f.o.b. value	16 114	19 544	20 307	15 054	22 646	25 727	22 066	19 655	17 087	14 651	6 738	199 590
Percentages of f.o.b. value of exports												
Refined copper	3.5	4.4	3.8	5.1	4.1	2.5	2.8	2.2	2.0	2.0	1.9	3.2
CODELCO/ Minmetals	0.5	1.6	1.2	0.9	1.3	1.3	1.5	1.5	1.5	1.3	0.6	1.3
Other	3.0	2.8	2.5	4.3	2.9	1.2	1.4	0.6	0.5	0.7	1.3	1.9

B. Peru

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Millions of dollars												
Refined copper	73	48	49	54	71	33	22	6	3	7	2	369
f.o.b. value	3 005	2 372	2 571	1 817	2 495	2 790	1 846	1 834	1 838	1 511	635	22 713
Percentages of f.o.b. value of exports												
Refined copper	2.4	2.0	1.9	3.0	2.8	1.2	1.2	0.3	0.2	0.5	0.2	1.6

Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

As in the case of trade in copper concentrates, the biggest buyers account for the bulk of the underinvoiced sales. Table 6 shows that, in Chile, the five leading trading partners account for 72.0% of the exported value and 82.2% of the underinvoiced value. Sales to China represented a majority of the underinvoiced amount (59.4%), largely as a result of the terms of the contract concluded between CODELCO and Minmetals. Consequently, the underinvoicing of sales to China equalled 5.3% of the value of exports during the period in question. In contrast, the percentage of total exports, by f.o.b. value, that were underinvoiced and were not governed by that contract equalled 1.8%, which is in line with the figures for other trading partners (ranging between 1.6% and 2.4%).

Peru's five biggest trading partners accounted for 88.3% both of its exports of this product by value and of the underinvoiced portion of those exports. In absolute terms, its exports to the United States entailed the most underinvoicing during the study period (US$ 108 million), and this was also true in relative terms (2.3% of the f.o.b. value compared to between 0.9% and 1.8% for the country's other trading partners). The bulk (54%) of the underinvoicing in sales to the United States occurred during the early years of the study period (2006 and 2007), which is in line with the observations made in connection with the data shown in figure 2.

Table 6
Chile and Peru: underinvoicing of exports of refined copper (HS6 740311), by trading partner, 2006–2016[a]
(Millions of dollars and percentages)

A. Chile

Country	Amount underinvoiced	f.o.b. value	Percentage of f.o.b. value underinvoiced
China	3 768	71 616	5.3
excluding CODELCO/ Minmetals	1 252	70 350	1.8
United States	418	26 174	1.6
Italy	415	16 993	2.4
Republic of Korea	295	14 807	2.0
Taiwan Province of China	324	14 065	2.3
Other countries	1 128	55 934	2.0
Total	6 348	199 590	3.2

B. Peru

Country	Amount underinvoiced	f.o.b. value	Percentage of f.o.b. value underinvoiced
China	46	5 251	0.9
Italy	77	4 873	1.6
United States	108	4 608	2.3
Brazil	61	3 306	1.8
Taiwan Province of China	34	2 015	1.7
Other countries	43	2 659	1.6
Total	369	22 713	1.6

Source: Prepared by the authors, on the basis of figures from Penta-Transaction.
[a] As of the first half of 2016.

V. Conclusions

The findings arrived at in this study using a new methodology that has been adapted to local conditions in Chile and Peru show that some exports of copper concentrates and refined copper have been conducted at below-market unit prices (with market prices being determined on the basis of the industry's typical contractual terms and the costs of insurance and freight). These operations warrant scrutiny on the part of the proper authorities in order to determine if they have involved fraudulent misinvoicing or not. This would pave the way for the type of oversight that would assist the authorities in designing and implementing measures for reducing the loss of tax revenues associated with such operations. An additional consideration has to do with the fact that, since the copper industry is such an important one for both Chile and Peru, a widespread public perception that tax revenues are being lost due to the actions of this industry could have serious repercussions in terms of public confidence in the tax system in these countries.

It is estimated that the potential value of exports of copper concentrates that may have been underinvoiced in the period between 2006 and the first half of 2016 totalled US$ 3.035 billion in Chile (2.2% of the value exported) and US$ 1.083 billion (1.8% of the value exported, assuming a grade of 25%) in Peru. The potentially underinvoiced amounts in sales of refined copper cathodes were US$ 3.833 billion in Chile (3.2% of the value exported) and US$ 369 million in Peru (1.6% of the value exported).[9]

The level of underinvoicing decreased in both absolute and relative terms over the course of the study period. The amount of underinvoicing in the case of Chilean exports of copper concentrates dropped from an average of 4.0% of the total export value in 2006–2010 to an average of 0.9% in

[9] These are conservative estimates, since other ways of undervaluing exports on customs documentation may exist which have not been captured for lack of the necessary data. For example, a study conducted by the Journalism Research Centre (CIPER) of Chile found that, for decades, exports of copper concentrates from that country had not been inspected or checked, with the authorities simply accepting the information supplied by the mining companies on the concentrates' grade and weight at face value. Castillo (2015) also asserts that the patchy or faulty inspection of mining exports is the greatest failing of the customs administration of that country. In the same vein, an investigative committee of the Chamber of Deputies of Chile has concluded that the country lacks a suitable institutional structure for maintaining the type of effective, rigorous oversight needed to ensure product traceability in the copper industry. That committee stated that oversight agencies are underfunded and have not been given sufficient authority (Chamber of Deputies Chile, 2015).

2011–2015. For those same subperiods, the underinvoicing of refined copper exports fell from an average of 3.1% in Chile and 2.4% in Peru to averages of 0.9% and 0.7%, respectively. This may be attributable to the reinforcement of the two countries' international tax regulatory systems, since both Chile and Peru have refined their anti-evasion and anti-avoidance rules, particularly those applying to transfer pricing. Nevertheless, the progress made in this connection is only a first step towards building a strong enough institutional and legal framework to tightly police all the different stages involved in this activity, starting with mining operations themselves and continuing on to the sale of these products on the international market.

A number of difficulties were encountered when attempting to estimate the amount of these exports, by value, that has been underinvoiced. Although exporters' customs declarations were used as a data source because they make a much more detailed analysis possible, in most cases they still do not provide all the information needed to accurately calculate all the payments and deductions involved in each transaction. The financial reports of a number of the firms involved in undervalued transactions were also available, but they generally do not provide complete, detailed information on the terms and conditions of the contracts that these companies sign with their buyers. All of this serves to underscore the challenges faced by the relevant countries' tax and customs authorities in seeking to verify the sworn statements submitted by mining companies. This also points up the importance of having customs records that provide more detailed and complete information on the concentration, composition and characteristics of each product and on the buyers (especially the type of information needed to determine whether it is a related-party transaction or not) so that the authorities can keep a close watch over them.

Future work in this field should focus on identifying other ways in which mining firms illegally divert profits and send them abroad. Although the evidence suggests that an increasing percentage of the international copper trade is being conducted under market conditions, these producer countries could still be losing tax revenues as a result of other strategies, such as, in particular, transactions between subsidiaries —which play an important role in the mining sector in both of these countries— and their parent companies abroad. Even though related-party operations are governed by the rules on transfer pricing, they usually include payments for services whose market value is very difficult to ascertain. Mining companies' financial structures should therefore also be examined in order to determine whether they have been intentionally designed to artificially reduce those firms' tax obligations. The possible abuse of financial derivatives as a vehicle for transferring profits out of the region should also be investigated more thoroughly (PWYP Norway, 2011).

A promising development in this field is the deployment by the OECD/G-20 Base Erosion and Profit Shifting (BEPS) Project of a broad package of consensus-based measures for combating these types of practices. In particular, the BEPS provision for country-by-country reporting will provide tax authorities with an overall picture of the operations of multinational corporations, since these reports will state where these enterprises report their profits, taxes and economic activities. This information will enable tax authorities to assess the risks involved in transfer pricing and other BEPS practices so that they can focus their inspection and oversight resources on the most critical areas.

Bibliography

Bhagwati, J. (1974), "Fiscal policies, the faking foreign trade declarations, and the balance of payments", *Illegal Transactions in International Trade*, J. N. Bhagwati (ed.), Amsterdam, North Holland.

___(1964), "On the underinvoicing of imports", *Bulletin of the Oxford University Institute of Economics and Statistics*, vol. 26, No. 4 Oxford, University of Oxford.

Castillo, R. (2015), *El cobre: anatomía del mayor fraude minero en Chile*, Santiago, Andros Impresores.

Chamber of Deputies of Chile (2015), "Informe de la Comisión Especial Investigadora encargada de analizar las eventuales responsabilidades de CODELCO y de ENAMI, con ocasión de la sustracción de concentrados de cobre", 3 March [online] https://www.camara.cl/pdf.aspx?prmID=14119&prmTIPO=INFORMECOMISION.

CHINALCO-CMC (CHINALCO Mining Corporation International) (2016), *Annual Report, 2015* [online] http://www.hkexnews.hk/listedco/listconews/sehk/2016/0428/LTN20160428325.pdf.

COCHILCO (Chilean Copper Commission) (2016), *1996–2015 Yearbook: Copper and other Mineral Statistics*, Santiago.

CODELCO (Corporación Nacional del Cobre de Chile) (2016), *Memoria Anual, 2015*, Santiago.

ECA (Economic Commission for Africa) (2015), *Illicit Financial Flow. Report of the High Level Panel on Illicit Financial Flows from Africa*, Addis Ababa.

ECLAC (Economic Commission for Latin America and the Caribbean) (2016), *Economic Survey of Latin America and the Caribbean, 2016* (LC/G.2684-P), Santiago.

Grondona, V. and M. Burgos (2015), "Estimación de los precios de transferencia: el caso del complejo sojero", *Working Paper*, No. 71, Buenos Aires, Center of Economics and Finance for the Development of Argentina (CEFID-AR).

Hollingshead, A. (2010), *The Implied Tax Revenue Loss from Trade Mispricing*, Washington, D.C., Global Financial Integrity.

Hong, K., C. Pak and S. Pak (2014), "Measuring abnormal pricing – an alternative approach: the case of US banana trade with Latin American and Caribbean countries", *Journal of Money Laundering Control*, vol. 17, No. 2, Bingley, Emerald.

ICSG (International Copper Study Group) (2015), *The World Copper Factbook 2014*, Lisbon.

Javorsek, M. (2016), "Asymmetries in international merchandise trade statistics: a case study of selected countries in Asia-Pacific", *Working Paper Series*, No. SD/WP/02, Bangkok, Economic and Social Commission for Asia and the Pacific (ESCAP) [online] http://www.unescap.org/sites/default/files/SD_Working_Paper_April2016_Asymmetries_in_International_Trade_Statistics.pdf.

Kar, D. and J. Spanjers (2015), *Illicit Financial Flows from Developing Countries: 2004-2013*, Washington, D.C., Global Financial Integrity.

Ministry of Energy and Mines (2016), *Anuario Minero*, 2015, Lima.

Nyrstar (2016), "Modeling Nyrstar", August [online] http://www.nyrstar.com/investors/en/Investors%20Materials/English/Modeling%20Nyrstar.pdf.

OECD (Organization for Economic Cooperation and Development) (2015), "Addressing information gaps on prices of mineral products: mineral product pricing practices case studies: copper, gold and iron ore", Paris.

Pak, S. J., S. H. Zanakis and S. J. Zdanowicz (2003), "Detecting abnormal pricing in international trade: the Greece-USA case", *Interfaces*, vol. 33, No. 2, Catonsville, INFORMS.

PWYP Norway (Publish What You Pay Norway) (2011), "Protection from derivative abuse", December [online] https://www.publishwhatyoupay.no/sites/all/files/1006a-PWYP_DerivativesReport_ENG_DOWNLOAD_0.pdf.

Readhead, A. (2016), *Preventing Tax Base Erosion in Africa: a Regional Study of Transfer Pricing Challenges in the Mining Sector*, Natural Resource Governance Institute.

Southern Peru Copper Corporation (2008), "Estados financieros, 31 de diciembre de 2007 y 31 de diciembre de 2006", Lima.

Teck (2015), "Modelling Workshop", November [online] http://www.teck.com/media/Investors-Presentations-Webcasts-20151104-modelling-workshop.pdf.

UNCTAD (United Nations Conference on Trade and Development) (2016), *Trade Misinvoicing in Primary Commodities in Developing Countries: The Cases of Chile, Cote d'Ivoire, Nigeria, South Africa and Zambia* (UNCTAD/SUC/2016/2), Geneva.

Zdanowicz, J., S. Pak and M. Sullivan (1999), "Brazil-United States trade: capital flight through abnormal pricing", *The International Trade Journal*, vol. 13, No. 4, Abingdon, Taylor & Francis.

Labour market fluidity and employment outcomes in Colombia: evidence from employer-employee linked data[1]

Leonardo Fabio Morales and Daniel Medina

Abstract

Labour market flexibility has been a traditional subject of study in labour economics; recent literature has focused on the related concept of fluidity, broadly understood as the mobility of workers and jobs in the labour market. Here, we compute standard measures of fluidity for the Colombian urban labour market, finding evidence of increased fluidity, especially after 2010. Recent developments in equilibrium unemployment models predict, in general settings, a negative relationship between some fluidity measures and the equilibrium rate of unemployment. Recent literature on worker and job flows has identified benign aspects of fluidity, in that fluid labour markets are expected to have shorter average unemployment duration. We find evidence for a positive effect of fluidity on different employment and occupation indices using instrumental variable regression models that exploit variations in labour market outcomes and fluidity measures over time.

Keywords

Employment, labour market, human resources, labour mobility, measurement, employment statistics, Colombia

JEL classification

J60, J63, J11

Authors

Leonardo Fabio Morales is a researcher with the Labour Market Analysis Group of Banco de la República (central bank) of Colombia. Email: lmoralzu@banrep.gov.co.

Daniel Medina is a trainee professor with the Department of Economics of EAFIT University, Colombia. Email: dmedin17@eafit.edu.co.

[1] The authors are grateful for comments from Christian Posso, Carlos Medina, Lina Cardona and the members of the Labour Market Analysis Group of Banco de la República of Colombia (http://investiga.banrep.gov.co/es/grupos-de-investigacion/grupo-de-analisis-del-mercado-laboral-gamla). An earlier version of this article in included as a working document in Morales and Medina (2016).

I. Introduction

A recent body of labour economics literature has dealt with the degree of dynamism in developed countries' labour markets. The loss of dynamism in the United States labour market during the last three decades has been particularly well documented (Bjelland and others, 2011; Molloy and others, 2016; Davis and Haltiwanger 2014; Hyatt and Spletzer 2013). The concept of fluidity has been used in this literature to capture the ability of an economy to mobilize workers and jobs across firms, economic sectors and labour markets. Fluidity has become an important topic in the study of the labour market recently because there is evidence for the adverse consequences of a reduction in dynamism (Davis and Haltiwanger, 2014; Molloy and others, 2016). Despite the importance of this topic, very little is known about labour market fluidity in developing economies and its consequences for labour market outcomes.

In this study, we compute worker reallocation rates (WR), job reallocation rates (JR) and churning rates (CR), which are the most standard fluidity measures used in the literature; these three rates are relative measures of what the literature on labour market fluidity calls worker, job and churning flows, respectively. Worker flows are movements of workers through firms and economic sectors and are measured by aggregating hires and separations at individual firms. Job flows are movements of jobs and are measured by aggregating the absolute value of net changes in firms' payrolls. Lastly, churning flows are the excess of worker flows over job flows. We use data from the formal labour market in Colombia, a middle-income developing economy, for the period between October 2008 and December 2014. We aggregate these measures for the 23 main metropolitan areas in Colombia. Our definition of a firm is broad: in this paper, a firm is a single or multi-establishment business in a city, with at least two employees in total. These must be formal establishments, defined as those that account for payroll taxes and employee social security contributions.

One of the strengths of this paper is that we use a unique data set generated from the administrative records of the Colombian Social Security Bureau. We use these records to assemble longitudinal employer-employee data for all formal firms in the country, enabling us to compute fluidity measures for all economic sectors. Most papers in the literature on job and worker flows use plant-level data, which at best are samples for specific economic sectors, usually manufacturing. Some studies use information for all formal firms in all sectors, but restricted to a specific geographical area in a country, such as a particular state in the United States (Burgess, Lane and Stevens, 2000). Most of what we can learn from the literature on worker and job flows concerns the manufacturing sector and uses rotating panels (Davis, Haltiwanger and Schuh, 1996).[2]

The effect of fluidity on labour market performance may be positive if an increase in fluidity is associated with a reduction in the cost of transitioning in the market, which is likely to affect the aggregate productivity of the economy positively (Molloy and others, 2016). In addition, there are empirical and theoretical grounds for considering the effect of fluidity on labour market performance to be favourable. First, empirical studies find that the reallocation of workers across different firms and sectors is procyclical, especially when there is an excess of worker reallocation over job reallocation (churning) (Akerlof and others, 1988; Davis, Haltiwanger and Schuh, 1996). Second, search models of equilibrium unemployment, allowing for job-to-job transitions, predict that factors which reduce search costs and therefore increase worker reallocation will lower the equilibrium rate of unemployment.

Our findings include evidence that the formal labour market in Colombia became more fluid after the last quarter of 2010 and that this coincided with a substantial decrease in the unemployment rate.[3]

[2] Examples of these information sources are the Longitudinal Research Database (Davis, Haltiwanger and Schuh, 1997) and the Job Openings and Labor Turnover Survey (Davis and Haltiwanger, 2014). In the case of rotating panels, corrections have to be made to prevent overestimation of the fluidity measures; our fluidity measure is valid without need of correction because we observe the whole universe of formal firms.

[3] This evidence has been corroborated by recent studies on Colombia, such as Morales and Lobo (2017).

In addition, we estimate econometric models to capture the causal relationship between the measures of fluidity and some labour market outcomes. The results we analyse in this paper are outcomes in the salaried-formal labour market, mainly because the fluidity measures we are able to generate from our data are exclusively for salaried-formal workers and jobs. Specifically, the dependent variables of the models in this paper are formal employment rates (the formal wage-earning employed population as a proportion of labour market participants) and formal occupation rates (the formal wage-earning employed population as a proportion of the working-age population).

We find a benign and sizeable effect of the WR, JR and CR on several of our labour market outcomes. In general, we present evidence that increases in labour market fluidity yield growth in formal employment and formal occupation levels for the working-age population. Davis and Haltiwanger (2014) reach a similar conclusion for the United States labour market; nevertheless, to the best of our knowledge, no other study in the literature offers an empirical assessment of the hypothesis that fluidity benefits formal labour markets in developing economies. In Colombia, like many other developing countries, informality is a major problem, but the formal labour market is still sizeable and significant. In the 23 largest cities of Colombia, formal employees were nearly 51% of all employees in 2016, while in the Latin American region as a whole, the formal labour market represented 54% of the total in 2015. For developing countries, therefore, it is also crucial to reach a deeper understanding of the causal effects of fluidity on the performance of the formal labour market, especially since there is an ongoing debate in many of them about the undesirable consequences of economic policies that make labour markets more rigid and sclerotic.[4]

The next section of this paper begins by describing the fluidity measures employed, something that is crucial for understanding the rest of it. The third section carries out an empirical and theoretical review of the literature on the relationship between worker and job dynamics and labour market performance. The fourth section describes the data sources and the fifth comments on the recent dynamics of fluidity measures in Colombia. The sixth section presents the empirical model and the seventh the results of the estimations. The last section concludes and sets out some general policy implications.

II. Fluidity measures

For the purpose of calculating worker and job flows, a job is defined as a position filled by a worker (Davis, Haltiwanger and Schuh 1996). All our measures are therefore based on observations of the size of a firm and the flow of workers entering and exiting it. We measure these flows on a monthly basis for all firms defined as formal in Colombia from October 2008 to December 2014.[5] A firm j_t is a set of business establishments in the same city with at least two employees, and the firm belongs to the formal sector if it accounts for payroll taxes. An individual i_{jt} is an employee on the payroll of firm j in period t.

Administrative records are used to generate a linked employer-employee longitudinal data set by observing the payroll of a given firm on a monthly basis. This data structure is used to compute hires (h_{jt}= {i: $i_t \in j_t$ and $i_t \notin j_{t-1}$}) as the set of employees who are observed in a given period and were not observed before. Similarly, separations (s_{jt}= {i: $i_t \notin j_t$ and $i_t \in j_{t-1}$}) are computed from employees who were observed in the previous period and are not observed in the current one. Lastly, stayers (k_{jt}= {i: $i_t \in j_t$ and $i_t \in j_{t-1}$}) are the set of employees observed in both periods.

[4] Sclerotic labour markets are characterized in Blanchard and Portugal (2001) as rigid and static markets. They present low rates of entry into and exit from unemployment and high mean unemployment duration.

[5] The electronic Unified Social Security Contributions Form (PILA) was rolled out in 2008, but use of data from its first six months of operation is unadvisable because some firms started reporting somewhere between January and June 2008. As a precaution, information from that system is only used from a trimester later, by which time all firms then operating were reporting to PILA. Our estimates are checked for robustness by changing the first month from which the fluidity variables are measured; the results do not change significantly. This robustness check is discussed in footnote 23.

The payroll of the firm in a given period is denoted as $e_{jt}=k_{jt}+h_{jt}$. The number of jobs created and destroyed is approximated from the changes in the payroll from one period to the next. Therefore, job creation c_{jt} and job destruction d_{jt} at firm j in period t are denoted as $c_{jt}=1_{\{\Delta e_{jt}>0\}}\Delta e_{jt}$ and $d_{jt}=-1_{\{\Delta e_{jt}<0\}}\Delta e_{jt}$, respectively. Summations of all these sets are used to generate aggregate measures of fluidity in a local labour market A (a metropolitan area). Therefore, the aggregate flows of hires ($H_{A,t}$), separations ($S_{A,t}$), job creation ($C_{A,t}$) and job destruction ($D_{A,t}$) in local labour market A can be represented as $H_{A,t}=\sum_{j\in A}h_{jt}$, $S_{A,t}=\sum_{j\in A}s_{jt}$, $C_{A,t}=\sum_{j\in A}c_{jt}$ and $D_{A,t}=\sum_{j\in A}d_{jt}$, respectively.[6]

We follow the previous literature on the subject (Davis, Haltiwanger and Schuh, 1996; Davis and Haltiwanger, 1992), defining firm size as the moving average of order two of the firm's employment, as represented by the following equation: $x_{jt}=(e_{jt}+e_{jt-1})/2$. Total firm size in a metropolitan area is defined as $X_{A,t}=\sum_{j\in A}x_{jt}$. We express worker flows (hires and separations) and job flows (job creation and destruction) as the total labour market employment rate $X_{A,t}$. The fluidity measures used in this paper are thus defined as follows:

Worker reallocation rate[7] **(WR)** [$WR_{A,t}=(H_{A,t}+S_{A,t})/X_{A,t}$]: This is the sum of monthly rates of hires and separations. Worker reallocation reflects the number of people changing either their employer or their employment status (employed/unemployed) from one period to the next (Davis, Haltiwanger and Schuh, 1996). It measures the number of workers entering or exiting firms.

Job reallocation rate (JR) [$JR_{A,t}=(C_{A,t}+D_{A,t})/X_{A,t}$]: This is the sum of the monthly job creation and destruction rates. Job reallocation is the amount of employment gained and lost from one period to the next (Davis, Haltiwanger and Schuh, 1996). It measures opportunities for moving from shrinking to expanding firms.

Churn rate (CR) [$CR_{A,t}=(H_{A,t}-C_{A,t}+S_{A,t}-D_{A,t})/X_{A,t}$]: This is the difference between the WR and the JR, usually characterized as an excess of worker flows over and above the amount required to accommodate job flows (Davis and Haltiwanger, 2014). The churn rate captures the number of hires that are not jobs created and the number of separations that are not jobs destroyed. Churning jobs are those that arise from replacing workers who were separated from their jobs either because they resigned or because they were dismissed as their firms sought to better match their staffing to their needs.

III. The relationship between labour market fluidity and outcomes

We present evidence in a later section of this paper that labour market fluidity has increased in Colombia in recent years. The literature has identified several good and several undesirable aspects of more fluid labour markets. A positive relationship between some fluidity measures and the economic cycle has been documented in several papers, but only for developed economies. There are also some standard theoretical frameworks that predict a negative relationship between certain fluidity measures and the equilibrium unemployment rate. In this section, we delve into the empirical and theoretical relationship between fluidity and economic performance, placing emphasis on equilibrium unemployment.

The literature has identified undesirable aspects of labour market fluidity associated with the reallocation of jobs. Some of these will now be discussed. Increases in the JR will increase unemployment if they are the result of job destruction exceeding job creation. A reduction in the JR may also be

[6] $H_{A,t}(S_{A,t})$ represents all hires (separations) in metropolitan area A in period t. $C_{A,t}(D_{A,t})$ represents all employments gains (losses) at new (exiting) and expanding (shrinking) establishments. $X_{A,t}$ measures the volume of employment in local market A.

[7] This is sometimes referred to as worker turnover in the literature.

associated with greater job security and a lower incidence of unemployment, which are desirable labour market characteristics for many reasons. For example, the loss of a job can mean lower earnings for many years after the episode of unemployment (Davis and Haltiwanger, 2014).[8] Lastly, there is an empirical regularity in the literature on labour market flows: the inverse relationship between firm size and the pace of job reallocation (Davis and Haltiwanger, 1999). On this evidence, a reduction in the JR can be associated with higher productivity. The argument for this association is that the decline in the JR may be driven by growth in firm size, as bigger firms evince lower reallocation measures while also having higher productivity.

Benign aspects of labour market fluidity have also been identified in the literature. An increase in the JR may be due to more new jobs being created than existing ones destroyed. In addition, a more fluid labour market will decrease the average duration of unemployment because it implies an increase in the frequency of job offers. There is the expectation of a direct relationship between fluidity and job mobility, with more fluid markets being associated with greater potential for employees to change careers or move into better positions, which is a desirable characteristic in labour markets. Regarding the employer-employee matching process, the quality of this may be better in markets that are more fluid. Akerlof and others (1988) argue that job-to-job mobility is highly procyclical and improves matching between workers and jobs, creating an additional welfare benefit from reductions in unemployment.

An additional argument for the benefits of fluid markets is that fluidity may be the result of a less rigid labour market. Several papers find that employment protection laws reduce labour market fluidity (Blanchard and Portugal, 2001; Gómez-Salvador, Messina and Vallanti, 2004; Boeri and Jimeno, 2005; Decker and others, 2014). There is extensive evidence that a less rigid labour market produces better aggregate results, such as lower unemployment rates and higher productivity in the economy. For the specific case of the North American economy, Autor, Donohue III and Schawb (2006) and Autor, Kerr and Kugler (2007) present evidence for the adverse effects of labour protection laws on employment and total factor productivity.

There is a substantial body of literature on labour market flows, focusing on data from the United States manufacturing sector. This empirical literature has questioned the ability of standard views of the real business cycle to explain movements of workers and jobs in the economy. According to the prevailing macroeconomic framework of real business cycle models, worker and job flows should be neutral to the economic cycle. The data do not well support these predictions; instead, what is observed from the United States manufacturing sector can be roughly summarized as follows. The JR is negatively correlated with net changes in employment; in other words, the economy restructures the organization of jobs in recessions (Davis, Haltiwanger and Schuh, 1996). Nevertheless, according to Akerlof and others (1988), the WR is mildly procyclical. Since the portion of the WR that corresponds to the JR is countercyclical, then, it must be the case that the excess of worker reallocation over job reallocation (the churn rate) is highly procyclical. It should be pointed out that most of the literature cited computes simple unconditional correlations between a measure of the economic cycle and the labour reallocation rate.

Some quite recently developed theoretical frameworks are helpful for understanding the influence of worker and job flows on labour market performance. The best model for this purpose is Pissarides' equilibrium unemployment theory (Pissarides, 2000). In a fairly general version of the influential Pissarides search model, a theoretical prediction is that increases in worker flows will reduce equilibrium unemployment. A search model with endogenous job destruction and on-the-job search unambiguously predicts that an increase in worker flows (job-to-job transitions) originating from reductions in on-the-job

[8] Several studies have evaluated the impact of an episode of unemployment on a variety of outcomes, from health to psychological well-being, finding substantial negative effects. For a review of this literature, the reader may refer to Davis and Von Wachter (2011).

search costs will reduce job destruction, increase job creation and lower equilibrium unemployment.[9] This effect will be enhanced if the increase in worker flows somehow induces a quality enhancement in job-worker matching that in turn increases labour productivity. There is not much literature providing evidence for this conjecture; nevertheless, Akerlof and others (1988) show that fluid labour markets yield better job-worker matching.

In this paper, we test what Davis and Haltiwanger (2014) call the "fluid market hypothesis". This hypothesis establishes that fluid labour markets promote higher levels of employment. The first study to assess a causal relationship between fluidity and employment was Shimer (2001). This paper finds the proportion of young people in the working-age population to have a positive effect on employment. In the model proposed there, this happens mainly because the larger the proportion of young people in the working-age population, the cheaper it is for firms to recruit new workers. Under these circumstances, firms will find it more profitable to create employment for younger jobseekers, thus boosting job creation and reducing unemployment (Shimer, 2001).

Davis and Haltiwanger (2014) propose an additional mechanism through which fluidity may boost employment: fluid labour markets imply workers receiving more frequent job offers, which in turn has the effect of shortening jobless spells. From the worker's point of view, shorter jobless spells avoid loss of human capital, increasing the incentives to work in the future. In addition, firms may discriminate against persons who have been out of work for longer, and shorter average unemployment spells in the economy should reduce the adverse effects of this. Research on worker/job flows in labour markets is highly focused on developed economies.[10] Furthermore, papers on labour market fluidity and its effects on employment have appeared only fairly recently and are not numerous. Our paper contributes to the literature in at least two ways. First, it is one of the few papers to have found effects of fluidity on employment and labour demand, and to the best of our knowledge there is no other study of the effect of fluidity on labour market outcomes for a developing economy. Second, our data are unique in covering all formal firms in the Colombian economy, which means that our conclusions are not restricted to the manufacturing sector, as they are in most studies on worker/job flows and fluidity.

Studying the consequences of fluidity for formal employment and formal labour demand in developing economies is crucial in countries like Colombia where nearly half of all employees have formal jobs; identifying the consequences of greater labour market fluidity for formal job creation is a key factor in understanding these markets. For various reasons, especially the lack of data, there have been very few attempts to understand flows of workers and jobs in developing countries and their consequences, and this is a gap in the literature that this paper seeks to fill.

IV. The data

The data used in this paper come from two different sources. The fluidity measures are generated from the administrative records of the Unified Social Security Contributions Form (PILA).[11] PILA is a unique source of longitudinal information, covering wages, contributions to retirement funds and health

[9] Technically, in a traditional diagram showing the Beveridge curve and the job creation line in a vacancies-unemployment space, an increase in the population searching on the job shifts and steepens the slope of the job creation line, reducing all possible unemployment equilibrium rates regardless of what happens with the Beveridge curve. Nevertheless, under the most standard assumptions, the Beveridge curve shifts to the left, increasing the reduction in the equilibrium unemployment rate.

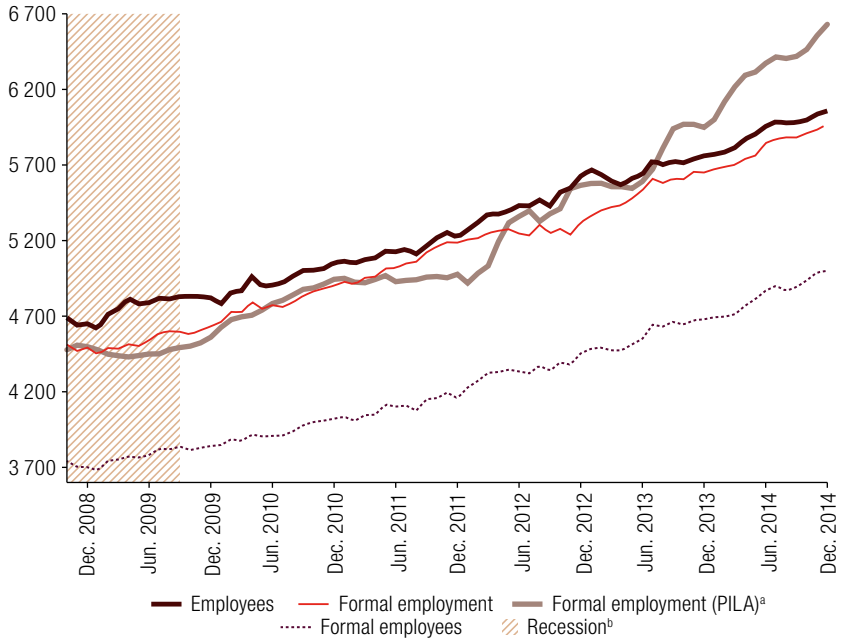
[10] There has recently been increasing interest in this topic as it affects the Latin American region, especially where job flows are concerned. The most comprehensive description of job creation in the Latin American region can be found in Pagés, Pierre and Scarpetta (2009). Previous work on labour market flows in Colombia has focused on measures of job creation and job destruction for the manufacturing sector (Melo and Ballesteros, 2013 and 2014).

[11] The Ministry of Social Security in Colombia designed and implemented an integrated system for collecting all social security-related payments that employers are required to make. When making these payments, employers must fill in a form with information on each employee on their payroll.

insurance, some basic demographic characteristics and some basic features of the firms concerned. We used this information source to construct a linked employer-employee longitudinal data set with firms observed at least once during the period from October 2008 to December 2014. For the same period, we generated labour market outcomes and additional control variables by using Colombia's official Large Integrated Household Survey (GEIH).[12] To summarize, our data include fluidity measures, labour market outcomes and controls for the 23 main metropolitan areas in Colombia on a monthly basis from October 2008 to December 2014.

The focus of this paper is on wage employees working in formal firms, defined as those that account for payroll taxes and contributions to the social security system. Figure 1 represents formal wage employment of different kinds. The solid line is employment at formal firms with more than five employees as reported via PILA. The solid dark and dashed lines are formal employment and total wage employees, with figures provided by the GEIH.[13] All measures of employment show it to have increased substantially, especially since 2009. This increase in the number of employees has gone together with a period of remarkable economic growth in Colombia.

Figure 1
Total formal employment, quarterly moving averages, seasonally adjusted monthly series, October 2008 to December 2014
(Thousands)



Source: Prepared by the authors.
[a] Firms with more than five employees reporting via the Unified Social Security Contributions Form (PILA), without data imputation.
[b] A recession is defined as a period with two consecutive contractions in GDP.

[12] The GEIH is applied on a monthly basis by Colombia's National Administrative Department of Statistics (DANE) and is representative of the country's 23 largest metropolitan areas.

[13] The definition of a formal worker used by the National Administrative Department of Statistics (DANE) is "a wage employee in a firm with more than five employees or a professional self-employed worker".

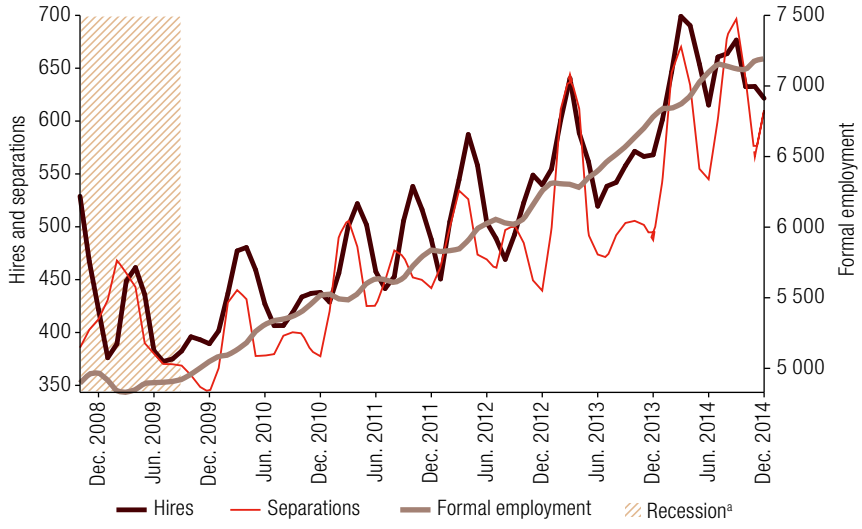
V. The recent dynamics of fluidity measures in Colombia

Figure 2 shows the flows that are the basis of traditional fluidity measures in the literature: hires, separations, job creation and job destruction during the period between October 2008 and December 2014. Figure 2.A presents flows in moving averages of order three. The first thing to note is that during the period studied in this paper all flows show remarkable increases, especially after the last period of economic recession (June 2008 to December 2009). Flows of hires (separations) rose from 410,400 (389,100) workers in the period from January 2009 to June 2010 to nearly 632,800 (594,200) workers in the period from January 2013 to December 2014. Similarly, the number of jobs created (destroyed) increased from 193,100 (201,200) in the period from January 2009 to June 2010 to 307,000 (333,700) in the period from January 2013 to December 2014. This period of expanding flows coincided with a good performance in the Colombian economy: the annual growth rate was at least 4% in every year after 2009. Before this, Colombia's economic growth was slowing, and real GDP grew by just 1.65% in 2009, a low figure in comparison with subsequent rates.

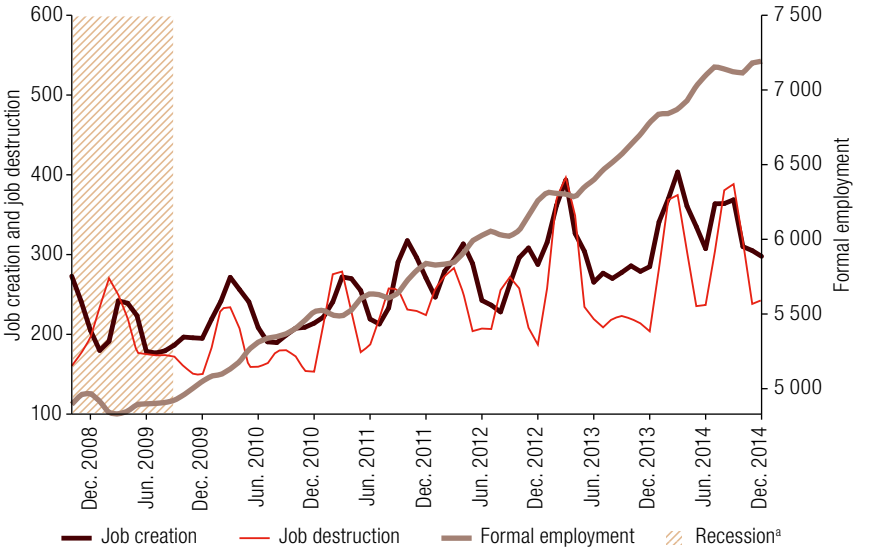
The relationship between worker and job flows can be characterized from the information in figure 2. From October 2008 to December 2014, the average seasonally adjusted flow of workers hired by all formal firms in Colombia was 507,000, while an average of 265,000 new jobs were created in the same period. Roughly 52% of all hires were replacements for existing workers and not new jobs. Similarly, the average seasonally adjusted flow of workers separated from formal firms in Colombia was 477,000, while 234,000 jobs were destroyed. Roughly 49% of all separations were because workers were replaced rather than jobs destroyed. In addition, it can be noted that the change in employment is positive (negative) when creation is greater (less) than destruction. It is also true that the net change in employment must be equal to hires minus separations, whence the change in employment is likewise positive (negative) when there are more (less) hires than separations.

Figure 2
Hires, separations and job creation and destruction in 23 metropolitan areas, quarterly moving averages, October 2008 to December 2014
(Thousands)

A. Monthly gross formal employment, hires and separations



B. Monthly gross formal employment, job creation and job destruction



Source: Prepared by the authors.
[a] A recession is defined as a period with two consecutive contractions in GDP.

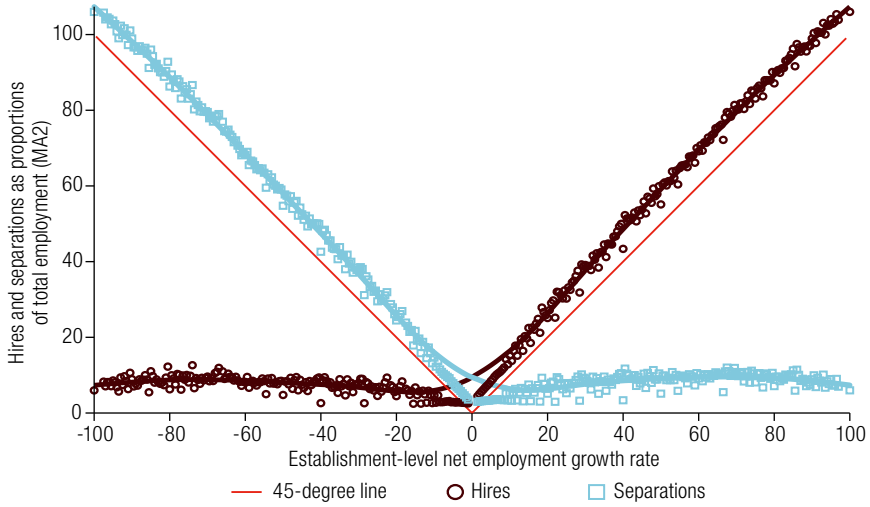
Figure 3 illustrates the relationship between net changes in employment and hiring and separation flows, showing how job creation and destruction rates are related to separation and hiring rates. It presents a scatter plot of net employment growth rates[14] and hiring and separation rates (median) observed from establishment-level data, describing the close relationship between worker flows and employment growth and showing that growth is positive when the hiring rate is above the separation rate. On the one hand, separation rates for shrinking firms are extremely high, while hiring rates are low and flat; on the other hand, hiring rates for expanding firms are extremely high and separation rates are low and flat.

The behaviour of firms is symmetrical in expansions and contractions. The relationship between net growth and hiring or separation rates has what the literature usually refers to as hockey stick shapes. In both cases, the pairs of hiring (separation) rates and net growth rates are above a 45-degree line. This is to be expected, since a small but non-zero level of hiring is observed in contractions, while a modest but non-zero level of separations is observed in expansions.[15] In expansions, for example, the hiring rate has to be greater than the growth rate to compensate for separations. Interestingly, in significant expansions and contractions, the lines corresponding to hires and separations in figure 3 are even farther away from the 45-degree line. Thus, for example, there are rapid expansions with a noticeably higher rate of separations. This makes sense because rapid expansion requires a higher level of separations to maintain the quality of the employer-employee match.

[14] Net employment growth rates are defined as the ratio between changes in employment and firm size defined as $x_{jt}=(e_{jt}+e_{jt-1})/2$.

[15] The relationship between hires, separations and employment growth rates follows similar patterns across different economies. A version of figure 3 presented by Davis, Faberman and Haltiwanger (2012) for the United States economy is similar to what is presented in this paper. This is because of the close relationship between worker flows and employment growth; as any economic model of labour demand would predict, firms should expand as a result of increases in hiring and contract as a result of increases in separations.

Figure 3
Cross-sectional relationship between worker flows and net employment growth at the establishment level, 23 metropolitan areas, October 2008 to December 2014
(Percentages)

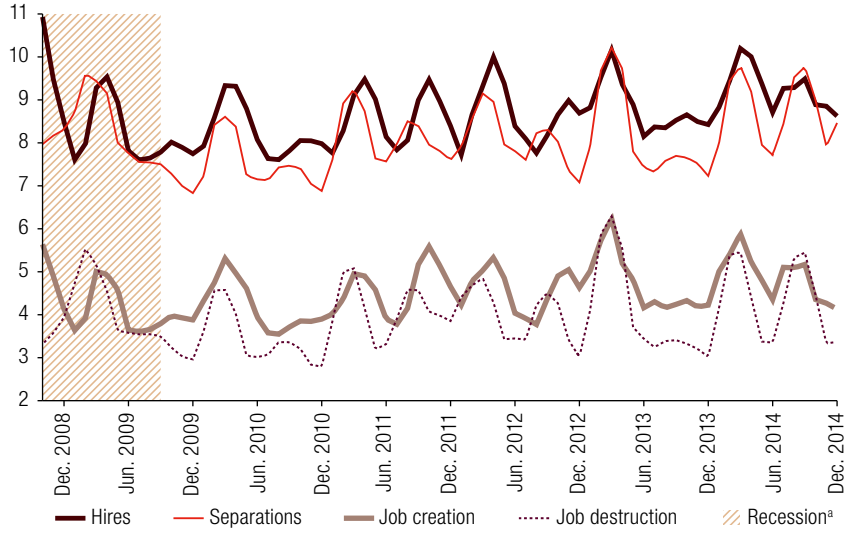


Source: Prepared by the authors, on the basis of S. J. Davis, J. Faberman and J. C. Haltiwanger, "Labor market flows in the cross section and over time", *Journal of Monetary Economics*, vol. 59, No. 1, Amsterdam, Elsevier, 2012.
Note: Estimates are the employment-weighted average of the establishment-level growth rates within intervals (0.5 percentage points). MA2 is a moving average sthocastic process with two temporary lags.

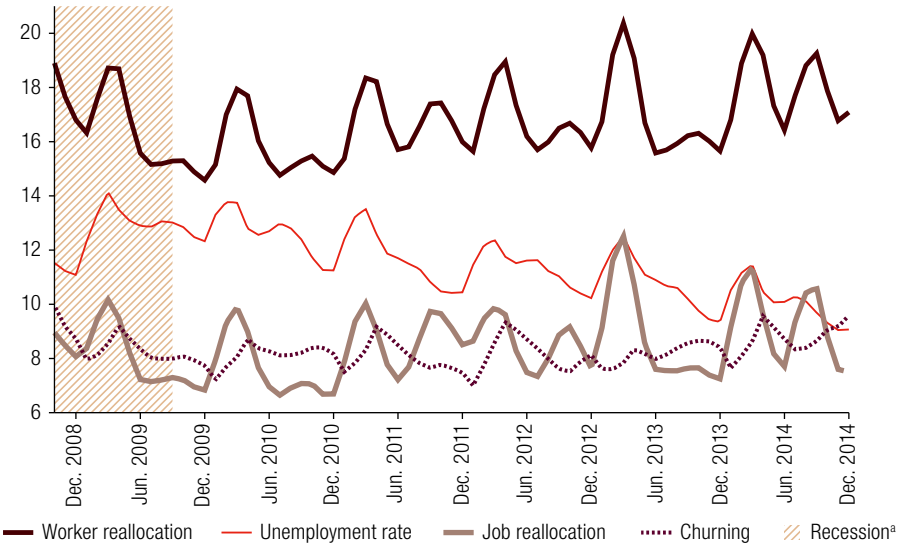
Figure 4.A shows flows of workers and jobs presented as percentages of employment levels in the metropolitan areas. Figure 4.B shows worker reallocation rates (WR) and job reallocation rates (JR) and the combination of the two, the churn rate (CR). Figure 4.A shows that rates of hires and separations were between 6.6% and 12.0% during the period studied. The average hiring rate was 8.9%, while the average separation rate was 8.4%. At times when the hiring rate is above the separation rate, a large reduction in the level of unemployment is observed (figure 4.B).

Figure 4
Fluidity measures, 23 metropolitan areas, quarterly moving averages, October 2008 to December 2014
(Percentages of employment)

A. Monthly rates of hires, separations and job creation and destruction



B. Monthly rates of job reallocation, worker reallocation and churning



Source: Prepared by the authors.
[a] A recession is defined as a period with two consecutive contractions in GDP.

As mentioned earlier, job creation and destruction rates are just proportions of hiring and separation rates, respectively. On average, the job creation rate is 60% of the hiring rate and the destruction rate is 57% of the separation rate. Thus, destruction represents a greater percentage of total separations than creation of total hires, which is consistent with the reduction in unemployment observed during the period. Figure 4.B shows that both the WR and the JR present a noticeable increase in magnitude and volatility after the last trimester of 2010. The combination of the two yields the churn rate (CR), which also increased after 2011.

Figure 4.B compares the evolution of unemployment and our three measures of labour market fluidity, the churn rate (CR), the worker reallocation rate (WR) and the job reallocation rate (JR). In all three cases, there seems to be a negative relationship between unemployment and all three measures after 2009. When unemployment shows a decreasing trend, the fluidity measures seem to increase.

In this study, unlike most of the literature, labour flows are measured for all formal sectors of the Colombian economy, not only manufacturing. It is not the intention of this paper to characterize the heterogeneity of labour market fluidity across different economic sectors; nevertheless, mention may be made of some of the evidence collected in Flórez and others (2018), which carries out an in-depth analysis of the heterogeneity of labour flows in the Colombian formal market. One of the most salient conclusions of that study[16] is that manufacturing, the most studied sector in the international literature, is one of the least dynamic sectors in the labour market: the WR, JR and CR were lower for the manufacturing sector than for any other during the period 2009–2016. In general, all other economic sectors have fairly similar reallocation rates, but there is one that stands out for its high rates, namely construction. The causes and consequences of this heterogeneity in labour dynamics are still an unexplored issue in the literature.

[16] The monthly WR rates estimated for the Colombian formal labour market in Flórez and others (2018) show WR rates of 11.84% for the manufacturing sector and 18% for the labour market as a whole during the period 2009–2016. The construction sector had a WR rate of 36% for the same period.

VI. The empirical model

The purpose of this paper is to identify the role that labour market fluidity plays in employment and occupation rates. The definition of "labour market" is a metropolitan area. There are 23 main metropolitan areas in Colombia. We compute standard fluidity measures and control variables for each metropolitan area in each period (month) from October 2008 to December 2014. The equation that we estimate can be represented as:

$$y_{it} = x_{it}'\beta + \delta_i + \tau_{i,t} + \alpha f_{it} + \varepsilon_{it} \quad (1)$$

where y_{it} is the labour market outcome (employment and occupation rates defined for formal wage workers) in metropolitan area i at period t, δ_i is the fixed effect by metropolitan area, the vector x_{it} contains a series of control variables that vary by metropolitan area, and $\tau_{i,t}$ denotes a series of fixed effects over time. The coefficient of interest is α, which captures how the labour market outcome y_{it} changes when the fluidity measure f_{it} increases by 1 percentage point. The control variables we include in vector x_{it} are the following: the hourly wage deflated by the implicit GDP deflator; the proportion of the working-age population with tertiary education; the proportion of private sector firms; employees' average age; the proportion of males in wage employment; department-level labour demand;[17] GDP per person employed; employers' costs; the Hodrick-Prescott filter for quarterly GDP; and state annual GDP growth.

There are a number of reasons why α can be affected by endogeneity bias. There may be time-varying unobserved factors in the metropolitan area that determine the labour market outcome y_{it} whilst being correlated with the fluidity measure f_{it}. In addition, given that we construct fluidity measures from administrative records, these measures may be subject to measurement errors; for example, firms may misreport their payroll information for some periods. These imperfections in the linked employer-employee longitudinal data set lead to the fluidity measures being miss-estimated, and it may be that the measurement error in fluidity measures is not random. For all these reasons, we estimate instrumental variable models.

1. Instrumental variables

Drawing on the previous literature, we construct plausible valid instruments for each of our endogenous variables. We use two types of instruments. First, we use local labour market characteristics that, depending on the control variables included in the regressions, are assumed to be exogenous. Second, following Davis and Haltiwanger (2014), we construct instruments based on national-level measures of fluidity intensity by economic sectors; these instruments map changes in national labour market fluidity on to metropolitan area fluidity intensity.

Instruments based on the characteristics of local markets: We use a series of instruments based on the idea that low-skilled young workers have the greatest labour market mobility (Shimer, 2001; Davis and Haltiwanger, 2014). First, we take the population aged between 18 and 24 with less than secondary education and at most complete secondary education, both as a share of the working-age population. Second, we take the minimum wage, on the basis that it necessarily applies to low-skilled young workers. A condition for using these instruments is that the median hourly wage in each local labour market is controlled for. The minimum wage is an exogenous factor frequently imposed on the market by the government.[18] Furthermore, workers and firms, acting individually, have virtually no

[17] Section VI.1 explains in detail how this control was constructed.

[18] In five of the seven years from 2008 to 2014, the government imposed the minimum wage because negotiation between unions and firms did not accomplish any agreement.

opportunity to influence it. Therefore, by controlling for the average wage per metropolitan area, we can assume that the minimum wage is uncorrelated with the error in equation (1).

Instruments based on the reallocation intensity of economic sectors: In this case, we follow the literature on local labour demand measures. Bartik (1991) designs a measure for changes in local labour demand unrelated to local labour supply. The idea is to map "national" employment changes on to local employment changes (by "national" we mean total minus local employment). This is done by averaging national employment changes across industries using local industry employment shares as weights. In this paper, we use Bartik's original index of changes in local labour demand as a control variable, constructed as follows:

$$B_{at} = \sum_{k=1}^{K} \gamma_{kat-1} \bullet \Delta_{kt}^{-} \tag{2}$$

$$\text{where } \Delta_{kt}^{-} = \frac{\Delta E_{kt}^{-}}{1/2\left(E_{kt}^{-} + E_{kt-1}^{-}\right)}$$

with γ_{kat-1} being the employment share of local market a in economic sector k and Δ_{kt}^{-} the change in employment in economic sector k at time t, E_{kt}^{-}, as a percentage of our measure of firm size (excluding local labour market a). This special growth rate is often used in the literature on worker/job flows and is known as Davis, Haltiwanger and Schuh (DHS) net employment growth (Davis, Haltiwanger and Schuh, 1996). The variable B_{at} predicts what the net employment change in local labour market a would have been given the net employment growth in other labour markets and its own industrial composition.

Several papers have constructed instruments following Bartik's original idea. Good examples of these are Blanchard and Katz (1992), Bound and Holzer (2000) and Autor and Duggan (2003). For the specific study of labour market fluidity, Haltiwanger and Davis (2014) propose a series of instruments that result from the interaction between Bartik-like local labour demand indices and job reallocation rates. In this paper, we draw on the whole of this earlier literature to design our reallocation intensity instrument as follows:

$$BI_{at} = \sum_{k=1}^{K} \gamma_{kat-1} \bullet f_{kt}^{-} \tag{3}$$

where f_{kt}^{-} is a fluidity measure (WR, JR, CR) for sector k computed nationally, but excluding local market a. In addition, $\gamma_{kat\text{-}1}$ is the employment share of local market a in economic sector k in the previous period. This instrument captures the interaction of the fluidity measures for different industries in other labour markets given the previous industrial composition in the local labour market. The instrument BI_{at} uses national fluidity measures (excluding the local level) for different economic sectors to predict local fluidity measures. In the construction of these instruments, the "national" fluidity measures are weighted by the lagged share of a sector's employment in the local industrial composition.

Comments on the validity of the instruments: Regarding the first set of instruments, we assume they are exogenous given the set of controls that we use in the structural equation. Let us consider the real minimum wage, this could be correlated with the business cycle and other relevant factors affecting the performance of the labour market even though it is usually imposed by the government. We therefore include GDP per person employed, a Hodrick-Prescott filter of quarterly GDP and annual departmental GDP growth as control variables in our structural equation. In addition, we control for the average wage in the MA. Given that we are controlling for the economic cycle and the effect of average wages on labour market outcomes, we assume that minimum wages are uncorrelated with the error term in equation (1). In the case of the shares of the population aged between 18 and 24 with different levels of education, these variables are usually assumed to be exogenous in the literature because they

are heavily influenced by demographic trends; they are therefore unlikely to correlated with economic cycles or time-varying unobserved heterogeneity.[19]

With regard to Bartik-like instruments, we include B_{at} as a control variable in our structural equation; we assume that the BI_{at} instruments are uncorrelated with the error term in equation (1) on condition that this variable is included in the regression. This may be the case for the following reasons. First, these instruments isolate changes in reallocation intensities that derive from changes in industry-level reallocation intensity. They are computed using other metropolitan area reallocation measures and the lagged employment composition of a particular metropolitan area (Davis and Haltiwanger, 2014). Second, we control for several measures of the economic cycle and predicted changes in labour demand using other metropolitan area changes in labour demand. Since we control for B_{at}, Bartik-like instruments are not correlated with time-varying shocks that affect labour demand at the industry level; therefore, the only way reallocation at the industry level could plausibly affect labour market outcomes is through its effect on local reallocation.

We use overidentified models in all our instrumental variable regressions, employing several of the instruments proposed in the previous paragraphs. We use the statistics of the joint significance test (F-test) in the first stage to test the strength of our instruments. We use the standard test for overidentifying restrictions to test the validity or exogeneity of additional exclusion restrictions.[20] F-statistics from the first stage are greater than 13 in all cases, and in no case do we reject the hypothesis that the instrument is valid in terms of identification restrictions.

VII. Results

In this section, we show the estimation results of equation (1). Given that we can only generate our fluidity measures for formal wage employees,[21] the outcomes that we study relate to formal wage-paying labour markets. The inability to observe the informal market is a limitation of this study.[22] Nevertheless, it is a step forward in the literature because, to the best of our knowledge, the relationship between fluidity and labour market performance has not been studied before in the context of the Latin American region or even developing economies in general. We focus on two labour market outcomes in particular: on the one hand, the share of salaried-formal workers as a proportion of the total labour force; on the other hand, the proportion of salaried-formal workers as a proportion of the total working-age population. The first variable is a component of the employment rate and will be referred to as the formal employment rate. The second the other variable is the formal-salaried occupation rate (formal wage workers as a proportion of the working-age population).

Table 1 shows summary statistics for controls, dependent variables and fluidity measures. The period studied was characterized by a reduction in unemployment and substantial economic growth, so it is not surprising that the average hiring rate (9.22%) was greater than the average separation rate (8.47%), or that the average job creation rate (5.57%) was greater than the average job destruction rate (4.81%). We can characterize the average ratio between worker and job flows from these numbers. As can be seen, around 60% of all hiring was accounted for by new jobs and around 57% of all separations by jobs destroyed. The data from which we compute our fluidity measures contain information on more

[19] In the specific case dealt with here, these demographic instruments are unlikely to be correlated with the measurement error of fluidity measures because the two variables come from different sources.

[20] The statistic for the overidentifying restriction test is computed as $N \times R_u^2$, where N and R_u come from an auxiliary regression of $\hat{\varepsilon}_{it}$ on [X Z]. In this auxiliary regression, X stands for the matrix of exogenous covariates and Z stands for the matrix of instruments; $N \times R_u^2$ is distributed χ^2 with degrees of freedom equal to the number of overidentifying restrictions. The null hypothesis of this test is the exogeneity of the instruments, mathematically, H_0: $E(Z'u)=0$.

[21] Formal in the sense of working in firms that pay payroll taxes. This is not the latest official definition of informality from the International Labour Organization (ILO), but it is a traditional institutionalist definition of informality, and is the most attractive one given the nature of our data.

[22] This segment of the market is large, and furthermore some of the job creation observed in PILA may result from the formalization of previously informal jobs.

than 186,000 firms with at least two employees, giving an average total of nearly 6.1 million formal workers observed on a monthly basis over the study period, equivalent to 57% of all employment. The annex presents some characteristics of firms. For example, the average firm has 33 employees, of whom 60% are male and around 61% earn the minimum wage; 61% of firms are small, with less than 20 employees; and nearly 14% of firms are medium-sized, with more than 20 and fewer than 100 employees.

Table 1
Summary statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Formal workers / working population[a]	1 725	0.48	0.08	0.27	0.59
Salaried formal workers / working population[a]	1 725	0.40	0.07	0.20	0.51
Salaried formal workers / labour force[a]	1 725	35.13	6.66	17.28	45.51
Salaried formal workers / working-age population[a]	1 725	23.39	5.24	10.52	31.41
Hiring rate	1 725	9.22	2.57	3.02	24.47
Separation rate	1 725	8.47	2.44	2.18	23.13
Job creation rate	1 725	5.57	2.08	2.11	23.16
Job destruction rate	1 725	4.81	1.9	1.4	21.74
Worker reallocation rate	1 725	17.68	4.48	6.48	33.96
Job reallocation rate	1 725	10.37	3.32	3.82	27.66
Churn rate	1 725	7.31	2.59	0.67	15.98
Real hourly wage rate (pesos)	1 725	4221	638	2771	8162
Proportion of working-age population with tertiary education	1 725	0.25	0.06	0.13	0.42
Proportion of private sector firms	1 725	0.97	0.02	0.88	0.99
Employees' average age	1 725	37.41	0.81	35.1	39.61
Employees' average age	1 725	1306	330	97	1569
Proportion of male employees	1 725	0.63	0.03	0.55	0.69
Department-level labour demand	1 725	0.01	0.02	-0.05	0.06
GDP per capita	1 725	5675	188	5313	6152
Employers' costs (firms) (proportion of mean wages)	1 725	0.53	0.05	0.42	0.56
HP filter quarterly GDP	1 725	-357	1112	-2815	1599
Departmental GDP growth	1 725	4.31	4.58	-6.37	25.18

Source: Prepared by the authors.
[a] Weighted averages, taking the contributions of each metropolitan area to total employment as weights.

During the period studied, the formal wage employment rate averaged 35%, this being the proportion of the labour force with a formal wage-paying job. The formal-salaried occupation rate, or proportion of the working-age population with a formal wage-paying job, was 23.4%. Overall, the proportion of the workforce with a formal job (formality rate) was 48%. The most select group in the working population are employees with a formal wage-paying job, who accounted for 40% of the total during the study period. It is worth mentioning some other characteristics of the estimation sample of our regression. For example, the average departmental growth rate during the period was 4.31%, the average employee age was 33.3 and the average hourly wage rate in metropolitan areas during the period studied was 4,221 thousands of Colombian pesos in 2008 values.

We analyse three fluidity measures, namely WR, JR and CR, and two different outcomes, the formal wage employment rate and the formal-salaried occupation rate. We estimate each of the equations using the ordinary least squares (OLS) and instrumental variables (IV) methodology (see table 2). In the case of IV, we use several instruments selected from those described in the previous section. For each regression, we choose the combination of instruments that has the strongest correlation with the endogenous variables; in addition, we run overidentifying restrictions tests with each set of instruments and make sure the hypothesis of the instrument being valid is not rejected. In general, the sets of instruments used are similar for all equations.

Table 2

The relationship between the employment rate, the occupation rate and labour market fluidity as measured by the worker reallocation rates (WR), job reallocation rates (JR) and churn rates (CR)

Variable	Salaried formal workers as proportion of the labour force						Salaried formal workers as proportion of the working-age population					
	OLS 1: WR	OLS 2: JR	OLS 3: CR	2SLS 1: WR	2SLS 2: JR	2SLS 3: CR	OLS 4: WR	OLS 5: JR	OLS 6: CR	2SLS 4: WR	2SLS 5: JR	2SLS 6: CR
Fluidity measure	0.030**	0.012	0.107***	0.265***	0.211**	0.360***	0.029***	0.016*	0.082***	0.244***	0.167**	0.239***
	(0.01)	(0.02)	(0.03)	(0.09)	(0.10)	-0.11	(0.01)	(0.01)	(0.02)	(0.07)	(0.07)	(0.07)
Real hourly wage	-0.084	-0.087	-0.103	-0.026	-0.015	-0.133*	0.035	0.034	0.019	0.088*	0.088*	0.001
	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)
Proportion of working-age population with tertiary education	0.229***	0.231***	0.226***	0.213***	0.226***	0.215***	0.165***	0.167***	0.164***	0.151***	0.163***	0.157***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Proportion of private sector firms	-0.640***	-0.656***	-0.652***	-0.455***	-0.522***	-0.622***	-0.289***	-0.301***	-0.302***	-0.119	-0.199**	-0.284***
	(0.10)	(0.10)	(0.10)	(0.12)	(0.11)	(0.10)	(0.06)	(0.06)	(0.06)	(0.09)	(0.08)	(0.06)
Employees' average age	0.082	0.082	0.074	0.090	0.102	0.058	0.061	0.062	0.055	0.069	0.077	0.045
	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.04)	(0.04)	(0.04)	(0.06)	(0.05)	(0.04)
Employees' average age squared	0.000	0.000	0.000	-0.001	-0.000	-0.000	-0.000	-0.000	-0.000	-0.001	-0.001	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Proportion of males in wage employment	0.093***	0.101***	0.088***	0.014	0.063*	0.050	0.022	0.028	0.019	-0.051	-0.000	-0.004
	(0.03)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)
Department-level labour demand	0.813	0.694	0.678	2.306	1.854	0.806	0.501	0.412	0.361	1.869	1.293	0.441
	(3.52)	(3.54)	(3.52)	(3.74)	(3.66)	(3.53)	(2.25)	(2.26)	(2.25)	(2.59)	(2.41)	(2.26)
GDP per capita	0.004***	0.004***	0.004***	0.003***	0.003***	0.003***	0.000	0.001	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Employers' costs (firms)	-0.088*	-0.081	-0.056	-0.212***	-0.215**	-0.018	-0.036	-0.031	-0.008	-0.149***	-0.133**	0.016
	(0.05)	(0.05)	(0.05)	(0.08)	(0.09)	(0.05)	(0.03)	(0.03)	(0.03)	(0.06)	(0.06)	(0.03)
HP filter quarterly GDP	-0.038	-0.036	-0.037	-0.065	-0.055	-0.041	-0.049	-0.047	-0.047	-0.074	-0.062	-0.050
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Departmental annual GDP growth	0.022**	0.020**	0.024**	0.037***	0.026**	0.033***	0.022***	0.021***	0.023***	0.036***	0.025***	0.029***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	72.235***	72.951***	72.033***	64.562***	68.655***	69.257***	46.077***	46.667***	46.113***	39.046***	43.405***	44.386***
	(11.81)	(11.82)	(11.78)	(13.23)	(12.39)	(11.88)	(7.23)	(7.22)	(7.16)	(9.42)	(8.09)	(7.19)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1 725	1 725	1 725	1 725	1 725	1 725	1 725	1 725	1 725	1 725	1 725	1 725
Adjusted R-squared	0.959	0.959	0.959	0.951	0.954	0.957	0.968	0.968	0.968	0.955	0.962	0.967
F-statistic				13.84	13.05	41.16				15.86	17.96	34
Overidentification test p-value				0.998	0.5672	0.407				0.999	0.722	0.1464

Source: Prepared by the authors.

Notes: The instruments used in the two-stage least squares (2SLS) regressions 2SLS1, 2SLS2, 2SLS4 and 2SLS5 are the real minimum wage, the Bartik-like WR or JR and workers aged between 18 and 24 with complete secondary education as a proportion of the labour force. The instruments used in the 2SLS3 and 2SLS6 regressions are the Bartik-like WR and JR and workers aged between 18 and 24 with complete secondary education as a proportion of the labour force. Standard errors are in parenthesis. * $p < 0.10$, ** $p < 0.05$ and *** $p < 0.01$. Bartik-like instruments are calculated as described in section VI.1. The real minimum wage is deflated by the consumer price index.

The unit of observation in all the models presented here are labour markets, which we define as Colombian metropolitan areas. We were able to collect all the information needed to estimate equation (1) for the main 23 Colombian metropolitan areas for the period between October 2008 and December 2014. In general, the fit of the regressions is high in all regressions with R-squared above 90%. We include metropolitan area fixed effects, month fixed effects and year fixed effects in all regressions. All these fixed effects explain a large portion of the variation of our dependent variables. The control variables have a consistent sign and significance throughout most of the specifications we estimate. For all our dependent variables, per capita GDP and the proportion of the working-age population with tertiary education correlate positively and significantly with each of these labour indices. As for employment rates, the percentage of private firms correlates negatively and significantly with this labour index. In other words, a labour market where the public sector represents a large share of overall employment has higher employment rates. For this same labour index, we observe a significant and positive correlation with the real GDP growth rate by department.

The worker reallocation rate (WR): The OLS estimations show that the WR has a positive effect on the formal wage employment and occupation rates. The magnitudes of these effects are quite small: an increase of 1 percentage point in the WR increases the formal-salaried employment rate and the formal-salaried occupation rate by 0.030 and 0.029 percentage points, respectively. Regarding the IV results, we find a positive and significant relationship between the WR and the two outcomes. The magnitudes of these relationships are substantially larger than with the OLS: an increase of 1 percentage point in the WR increases the salaried-formal employment and occupation rates by 0.26 and 0.24 percentage points, respectively. These results are in line with what is found for the United States labour market in Davis and Haltiwanger (2014), corroborating a plausible positive causal influence of WR on the employment rate.

The job reallocation rate (JR): The OLS estimations show a positive effect of the JR on formal-salaried employment and occupation rates, with small magnitudes in both cases and a significant effect only for the case of formal-salaried occupation rate. Regarding the IV results, we find a positive and significant plausible causal effect of the JR on both outcomes. The magnitudes of these effects are larger than the ones obtained with the OLS estimation. The effect of a 1 percentage point increase in the JR is an increase of 0.21 and 0.17 percentage points in the formal-salaried employment and occupation rates, respectively. This result contrasts with the negative correlations between the JR and net employment growth found in Davis, Haltiwanger and Schuh (1996). Nevertheless, the evidence for a countercyclical JR is based on unconditional correlations. Our results are in line with Davis and Haltiwanger (2014), who find a plausible positive causal influence of the JR on the employment rate; as in our findings, the JR has a smaller effect than the WR.

Churn Rate (CR): The OLS estimations show that the CR has a positive and significant relationship with both labour market indices. The magnitude of these correlations is small; nevertheless, it is larger than those estimated using OLS for the previous cases of the WR and the JR. With an increase of 1 percentage point in the CR, the formal wage employment and occupation rates rise by 0.11 and 0.08 percentage points, respectively. As regards the IV estimations, as before, the magnitudes of the plausible causal effects of the CR on our outcomes are substantially higher. With an increase of 1 percentage point in the CR, the formal-salaried employment and occupation rates rise by 0.36 and 0.24 percentage points, respectively.

General overview of the results: As explained in section III, from the point of view of equilibrium unemployment theory (Pissarides, 2000), increases in the WR and the CR would be expected to improve labour market performance. Furthermore, from the theoretical framework outlined in Shimer (2001) and Davis and Haltiwanger (2014), increases in all fluidity measures would be expected to improve both our labour market indices. These two studies propose theoretical channels through which fluidity might cause improvements in labour market performance. Shimer (2001) argues that firms find it profitable to create

jobs in more fluid and younger labour markets, where new employees are cheaper to recruit. Davis and Haltiwanger (2014) propose that workers receive more frequent job offers in fluid labour markets and spells of unemployment are shorter, preventing a costly loss of human capital. These channels also justify positive effects from the WR, CR and JR on the performance of labour markets (Davis and Haltiwanger, 2014).

Our OLS estimations show a positive and almost always significant correlation between all fluidity measures and the labour market indices. The IV estimations show a plausible significant causal effect for all fluidity measures on the labour market indices, and one that is substantially higher than that implied by the OLS regressions. The OLS coefficients are underestimated, then, because unobserved time-varying factors correlate negatively with fluidity measures. Our results are robust to modifications in the set of instruments and changes in the sample considered.[23]

The magnitudes of the effects that the WR, JR and CR have on the labour indices are quite similar; nevertheless, the JR has a smaller effect on formal wage employment and occupation than either the WR or the CR. The CR has the largest effect on employment. These patterns are in line with the theoretical framework of equilibrium unemployment theory, which emphasizes the role of worker flows (especially job-to-job transitions) on the reduction of the equilibrium rate of unemployment. In a general version of these search models, more dynamic job flows are a consequence of enhanced worker flow dynamics resulting from reductions in on-the-job search costs. Specifically, a given increase in worker flows (resulting from job-to-job transitions) will increase job creation and reduce job destruction; thus, the increase in job flows resulting from increased job creation will be partially offset by reduced job destruction. Theoretically, therefore, the effect of job flows on unemployment should be smaller because the greater job flows resulting from a given increase in worker flows are partially offset by lower job destruction. While the JR is expected to have a smaller effect than the WR, though, search models predict positive effects for the JR in reducing the equilibrium unemployment rate, for the simple reason that job flows are a component of worker flows.

The size of the informal urban labour market in Colombia is considerable. Nevertheless, formal workers were nearly 51% of the urban occupied population[24] and formal wage workers more than 43% of the urban occupied population in 2016. With our data, it is not possible to compute fluidity measures for informal workers. It seems likely that most worker and job dynamics arise in the formal labour market, since informal jobs and workers belong to small firms or are self-employed individuals.[25] Nevertheless, there is evidence for similar economies in the region which shows that own-account workers present high annual transition rates, especially from self-employed to employee status (Gluzmann, Jaume and Gasparini, 2012); these dynamics can only be partially captured by our fluidity measures, for instance via the creation of formal employment. That is a limitation of this study, since, as mentioned before, we can only compute fluidity measures for the formal labour market. Even though we do not observe informal labour markets flows, the indications are that informal worker and job dynamics are largely linked to job creation and hiring in the formal market, since the reduction in the Colombian informality rate observed in recent years is partly explained by the formalization of firms and jobs as a result of favourable labour market policies (Morales and Medina, 2017; Fernández and Villar, 2017). To summarize, even though we cannot observe the job and worker dynamics of informal workers, we are confident that we can say something meaningful about a large part of the labour market.

[23] As a robustness check, we estimated all IV regressions with the minimum wage excluded from the set of instruments. For formal wage employment, a 1 percentage point increase in the WR, JR and CR increases this rate by 0.271, 0.188 and 0.360 percentage points, respectively. For the formal wage occupation rate, a 1 percentage point increase in the WR, JR and CR increases this rate by 0.24, 0.10 and 0.24 percentage points, respectively. In all cases, the coefficients are statistically significant. As an additional robustness check, the starting point of the sample used for all the regressions was moved backwards and forward by one and two months, without any major change in the results.

[24] This rate is computed using the International Labour Organization (ILO) definition of informality, which covers non-professional informal workers in firms with five employees or fewer.

[25] The proportion of all fluidity explained by very small firms is tiny. Firms with two to five employees represent only 1.09% of total job flows, 5.87% of total worker flows and 3.57% of churn flows.

In a recent paper, Flórez and others (2018) compare fluidity measures between the United States and Colombia. Their analysis reveals differences between the two labour markets; for instance, they find that the quarterly churn rate of the formal labour market is almost twice as great in the United States as in Colombia.[26] This comparison should be treated with caution given the differences in the composition of the two economies' formal and informal markets and the fact that measurements of labour flows in the United States change depending upon the source (Flórez and others, 2017). Nevertheless, given the characteristics of the two labour markets, there are many reasons to expect that of the United States to be more fluid than Colombia's. The previous literature shows that employment protection and rigid labour market institutions play an important role in reducing labour market dynamism (Blanchard and Portugal, 2001). Colombia has high levels of employment protection, with 4.5 weeks' maternity leave and a number of laws governing wrongful dismissal and termination costs (Cardona-Sosa and others, 2018).[27] In addition, before the tax reform of 2013, Colombia had one of the highest levels of payroll taxes in the Latin American region, with employer and employee payroll taxes accounting for 60% of wages. Some of these institutions may add rigidity to the market.

Recent policies have probably helped to increase fluidity and, as described in section V, the labour market became substantially more dynamic after 2010. Recently implemented policies include a sizeable reduction in payroll taxes in 2013 and a number of payroll tax subsidies for young employees and new formal firms (the First Job Act, implemented in 2010). There is evidence that these policies have helped to boost formal employment (Morales and Medina, 2017; Fernández and Villar, 2017).

Lastly, we provide evidence of a plausible causal relationship between fluidity and enhanced labour market performance in terms of employment and occupation. This evidence should be interpreted with caution, however, as we only analyse two of many possible outcomes which might be influenced by labour market fluidity. As mentioned in section III, the literature has identified unwelcome aspects of labour market fluidity, many of them related to job instability. From the evidence in the literature, it seems that job instability is bad for workers and for firms, with the suggestion that there might be a positive relationship between seniority and a firm's productivity (Auer, Berg and Coulibaly, 2005); larger worker and job flows are expected to reduce average employment tenure in the economy.

VIII. Conclusions

This paper analyses the fluidity of the Colombian formal labour market and the relationship between measures of fluidity and some formal labour market outcomes, particularly employment rates and occupation rates for salaried-formal workers. Recent empirical work focusing on the United States economy suggests that fluidity has a positive influence on labour market performance (Davis and Haltiwanger, 2014; Molloy and others, 2016; Shimer, 2001). In addition, recent theoretical developments (search models of equilibrium unemployment) predict that factors which reduce search costs and therefore increase fluidity will lower the equilibrium rate of unemployment. Our work contributes to the empirical literature by estimating the effects of fluidity on formal labour market performance using information on all economic sectors, not only manufacturing. In addition, to the best of our knowledge, there is no other study of the impact of fluidity on labour market performance in a developing economy.

[26] They reach this conclusion using quarterly churn rates computed from PILA in the case of Colombia, while in the case of the United States they use the quarterly churn rate derived by the Census Bureau from the Longitudinal Employer-Household Dynamics survey. The comparison period was from 2009 to 2016.

[27] Unjustified layoffs are expensive in Colombia, with firms having to pay 20 days' wages per year worked. This policy is similar to that of Portugal, one of the countries with the highest termination costs. In 2015, Colombia ranked 29, Portugal 13 and the United States 69 in the Organization for Economic Cooperation and Development (OECD) index of protection for permanent workers, out of 71 countries for which the index could be calculated.

We analyse the standard fluidity measures from October 2008 to December 2014. We find a strong upward trend from 2009 in all three fluidity measures studied in this paper. This is a period in which unemployment fell remarkably. By using econometric models, we show evidence of a consistent, sizeable and plausible causal effect of fluidity measures on both our labour market outcomes. Using simple OLS models, we find almost all fluidity measures to have a positive and significant correlation with formal-salaried employment and occupation rates; nevertheless, the magnitudes of these correlations are small. When an instrumental variable regression approach is used, all the fluidity measures are found to have a positive and significant effect on labour market outcomes, and the magnitudes of the coefficients are substantially higher.

We find that an increase in all our fluidity measures causes increases in salaried-formal employment rates and occupation rates. The magnitudes of the effects are relatively similar for each outcome. An increase of 1 percentage point in any of the fluidity measures causes an increase in formal-employment rates of between 0.21 and 0.36 percentage points in formal employment rates, while an increase of 1 percentage point in the JR, WR or CR causes an increase in formal occupation rates of between 0.17 and 0.24 percentage points. The JR is the variable with the smallest impact, while the CR is the one with the highest impact when it comes to employment rates; this is in line with the predictions of the theoretical framework for equilibrium unemployment.

According to our findings, more fluid labour markets have been beneficial for the Colombian formal labour market during recent years, with the good labour market performance observed between 2009 and 2014 being at least partially the result of greater fluidity. The literature on labour flows usually argues for a positive relationship between fluidity and labour market flexibility (Davis and Haltiwanger, 2014; Molloy and others, 2016). The evidence we present in this paper sheds light on the plausible beneficial effects of policies pursuing greater flexibility. Our conclusions are relevant for a broader understanding of the formal labour market in developing countries; we provide evidence that policies pursuing greater fluidity and flexibility are likely to boost formal employment. Nevertheless, this statement needs to be treated with caution in the light of previous literature on the effects of labour policies in developing countries. The conclusion from a meta-analysis of the subject presented in a 2012 World Bank report (World Bank, 2012) is that both overregulation and underregulation in labour markets reduce firms' productivity and job creation. The report argues that the negative effects of most standard labour regulations are subtle or unknown.

Our findings are relevant to the analysis of current labour markets in the Latin American region and likewise in other developing economies where changes in labour policies have been implemented recently. Some of these policy changes are expected to increase flexibility. In Mexico, for instance, the labour policy reform implemented in 2012 introduced innovative and more flexible labour contracts. In Colombia, the 2012 tax reform reduced payroll taxes, which has promoted the creation of formal jobs (Morales and Medina, 2016). In Ecuador, the labour reform implemented in 2016 introduced new subsidized contracts for young workers, a more flexible conception of working shifts and unpaid leave of absence for childcare to supplement normal maternity leave. Some other labour reforms, such as Chile's, which grants rights to unions, are expected to reduce flexibility. In this paper, we identify a plausible causal relationship between fluidity and formal labour market performance that can be used as a yardstick for predicting the possible consequences of all these policies implemented in developing economies. We cannot say much about informal labour markets, and that is a limitation of this study, considering that the informal sector of the Colombian economy is substantial. Further research on the construction of proxy measures of labour flows for the informal market is needed; to the best of our knowledge, not a single study has been able to analyse the labour market fluidity of the informal sector in any country. This lack of knowledge about labour market dynamics is due to the impossibility of observing the informal market by means of traditional data sources.

Bibliography

Akerlof, G. A. and others (1988), "Job switching and job satisfaction in the U.S. labor market", *Brookings Papers on Economic Activity*, No. 2, Washington, D.C., Brookings Institution Press.

Auer, P., J. Berg and I. Coulibaly (2005), "¿El trabajo estable mejora la productividad?", *International Labour Revie*w, vol. 124, No. 3, Geneva, International Labour Organization (ILO).

Autor, D. H., J. J. Donohue III and S. J. Schwab (2006), "The costs of wrongful-discharge laws", *The Review of Economics and Statistics*, vol. 88, No. 2, Cambridge, The MIT Press.

Autor, D. H. and M. G. Duggan (2003), "The rise in the disability rolls and the decline in unemployment", *The Quarterly Journal of Economics*, vol. 118, No. 1, Oxford, Oxford University Press.

Autor, D. H., W. R. Kerr and A. D. Kugler (2007), "Does employment protection reduce productivity? Evidence form US states", *The Economic Journal*, vol. 117, No. 521, Wiley.

Bartik, T. J. (1991), *Who Benefits from State and Local Economic Development Policies?*, Kalamazoo, Upjohn Press.

Bjelland, M. and others (2011), "Employer-to-employer flows in the United States: estimates using linked employer-employee data", *Journal of Business & Economic Statistics*, vol. 29, No. 4, Abingdon, Taylor & Francis.

Blanchard, O. and L. Katz (1992), "Regional evolutions", *Brookings Papers on Economic Activity*, No. 1, Washington, D.C., The Brookings Institution.

Blanchard, O. and P. Portugal (2001), "What hides behind an unemployment rate: comparing Portuguese and U.S. labor markets", *The American Economic Review*, vol. 91, No. 1, Nashville, American Economic Association.

Boeri, T. and J. F. Jimeno (2005), "The effects of employment protection: learning from variable enforcement", *European Economic Review*, vol. 49, No. 8, Amsterdam, Elsevier.

Bound, J. and H. J. Holzer (2000), "Demand shifts, population adjustments, and labor market outcomes during the 1980s", *Journal of Labor Economics*, vol. 18, No. 1, Chicago, The University of Chicago Press.

Burgess, S., J. Lane and D. Stevens (2000), "Job flows, worker flows, and churning", *Journal of Labor Economics*, vol. 18, No. 3, Chicago, The University of Chicago Press.

Cardona-Sosa, L., Flórez, L. A., Morales, L. F., and Banco de la República (2018), "How does the Household Labour Supply Respond to the Unemployment of the Household Head?", *LABOUR*, vol. 32, No. 4.

Davis, S. J., J. Faberman and J. C. Haltiwanger (2012), "Labor market flows in the cross section and over time", *Journal of Monetary Economics*, vol. 59, No. 1, Amsterdam, Elsevier.

Davis, S. J. and J. Haltiwanger (2014), "Labor market fluidity and economic performance", *NBER Working Paper*, No. 20479, Cambridge, National Bureau of Economic Research.

___(1999), "Gross job flows", *Handbook of Labor Economics*, O. Ashenfelter and D. Card (eds.), vol. 3, Amsterdam, Elsevier.

___(1992), "Gross job creation, gross job destruction, and employment reallocation", *The Quarterly Journal of Economics*, vol. 107, No. 3, Oxford, Oxford University Press.

Davis, S. J., J. C. Haltiwanger and S. Schuh (1996), *Job Creation and Destruction*, Cambridge, The MIT Press.

Davis, S. J. and T. M. Von Wachter (2011), "Recessions and the cost of job loss", *NBER Working Paper*, No. 17638, Cambridge, National Bureau of Economic Research (NBER).

Decker, R. and others (2014), "The role of entrepreneurship in US job creation and economic dynamism", *The Journal of Economic Perspectives*, vol. 28, No. 3, Nashville, American Economic Association.

Fernández, C. and L. Villar (2017), "The impact of lowering the payroll tax on informality in Colombia", *Economia*, vol. 18, No. 1, Washington, D.C., Brookings Institution Press.

Flórez, L. A. and others (2018), "Labour flows across firm's size, economic sectors and wages: evidence from employer-employee linked panel", *Borradores de Economía*, No. 1013, Bogotá, Bank of the Republic.

Gluzmann, P., D. Jaume and L. Gasparini (2012), "Decisiones laborales en América Latina: el caso de los emprendedores. Un estudio sobre la base de encuestas de hogares", *Working Paper*, No. 137, Center for Distributive, Labor, and Social Studies (CEDLAS).

Gómez-Salvador, R., J. Messina and G. Vallanti (2004), "Gross job flows and institutions in Europe", *Labour Economics*, vol. 11, No. 4, Amsterdam, Elsevier.

Hyatt, H. R. and J. R. Spletzer (2013), "The recent decline in employment dynamics", *IZA Journal of Labor Economics*, vol. 2, No. 1, Springer.

Morales, L. F., and D. Medina (2016), "Labor fluidity and performance of labor outcomes in Colombia: evidence from employer-employee linked panel", *Borradores de Economía*, No. 926, Bogotá, Bank of the Republic.

Melo, L. and C. Ballesteros (2014), "Impacto de los factores externos sobre la creación y destrucción de empleo en el sector manufacturero colombiano", *Lecturas de Economía*, No. 81, Medellín, University of Antioquia.
___(2013), "Creación, destrucción y reasignación del empleo en el sector manufacturero", *Revista de Economía Institucional*, vol. 15, No. 28, Bogotá, Externado University of Colombia.
Molloy, R. and others (2016), "Understanding declining fluidity in the US labor market", *Brookings Papers on Economic Activity*, Washington, D.C., The Brookings Institution.
Morales, L. F. and J. Lobo (2017), "Estimating Vacancies from Firms' Hiring Behavior: The Case of a Developing Economy", *Borradores de Economía*, No. 1017, Bogotá, Bank of the Republic.
Morales, L. F. and C. Medina (2017), "Assessing the effect of payroll taxes on formal employment: the case of the 2012 tax reform in Colombia", *Economia*, vol. 18, No. 1, Washington, D.C., Brookings Institution Press.
___(2016), "Assessing the effect of payroll taxes on formal employment: the case of the 2012 tax reform in Colombia", *Borradores de Economía*, No. 971, Bogotá, Bank of the Republic.
Pagés, C., G. Pierre and S. Scarpetta (2009), *Job Creation in Latin America and the Caribbean. Recent Trends and Policy Challenges*, Washington, D.C., World Bank/Palgrave Macmillan.
Pissarides, C. (2000), *Equilibrium Unemployment Theory*, Cambridge, The MIT Press.
Shimer, R. (2001), "The impact of young workers on the aggregate labor market", *The Quarterly Journal of Economics*, vol. 116, No. 3, Oxford, Oxford University Press.
World Bank (2012), *World Development Report 2013: Jobs*, Washington, D.C.

Annex A1

Table A1.1
Summary statistics on firms

Variable	Observations	Mean	Standard deviation
Employment	13 977 725	32.65387	263.3392
Private firms	13 977 725	0.972648	0.163108
Average wage as proportion of minimum wage	13 958 019	1.554001	1.199409
Proportion of wages less than or equal to the minimum wage	13 977 725	60.98038	39.64137
Proportion of men	13 977 725	59.72614	31.84601
Proportion of firms with 20 employees or fewer	13 977 725	0.815355	0.3880093
Proportion of firms with more than 20 and fewer than 100 employees	13 977 725	0.138829	0.3457676
Proportion of firms with more than 100 employees	13 977 725	0.045816	0.2090867

Sourced: Prepared by the authors.

Analysis of Brazilian industry's dependency on imported inputs between 2000 and 2014

Valéria Silva Mortari and Maria Aparecida Silva Oliveira

Abstract

The aim of this paper is to analyse the extent to which different sectors of Brazilian industry were dependent on imported inputs between 2000 and 2014. The methodology of input-output analysis was used for this purpose, and the sectors were classified according to their direct and indirect demand for imported inputs. Sectors with relatively little demand for imported inputs are those related to the food, timber, wood and cork product industries and the repair and installation of machinery and equipment. The other industrial sectors relied on imported inputs to carry out their productive activities. The increasing use of imported inputs in Brazilian production processes means that the benefits of sector growth are partly appropriated by other economies.

Keywords

Industry, imports, input-output analysis, industrial production, industrial statistics, Brazil

JEL classification

L60, L160, O14

Authors

Valéria Silva Mortari is a master's degree student at the Institute of Economics and International Relations of the Federal University of Uberlândia (UFU), Brazil. Email: valeriasmortari@gmail.com.

Maria Aparecida Silva Oliveira is a professor in the Economics Department of the Federal University of São Carlos (UFSCar). Email: aparecidaoliveira@ufscar.br.

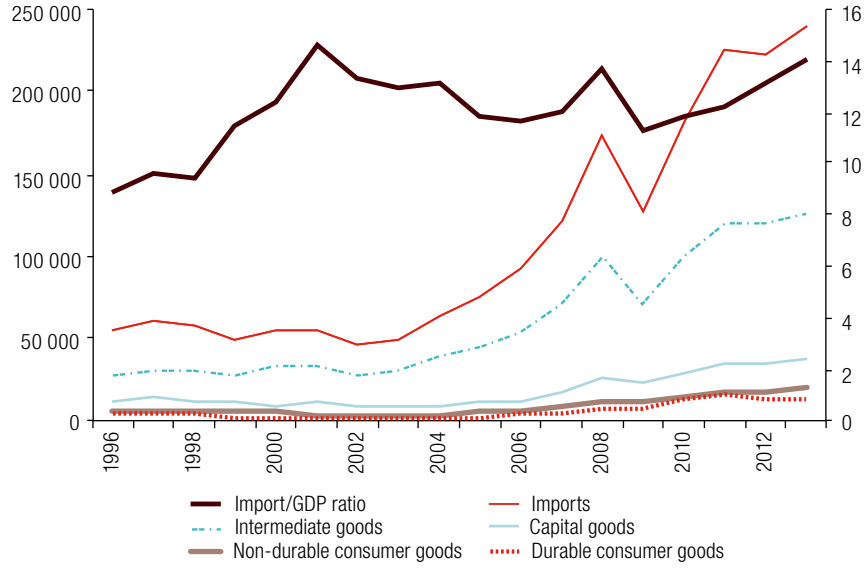
I. Introduction

Industry is hugely important for a country's economic performance, given its capacity to produce indirect intersectoral effects in terms of employment, income and technology, by establishing integrated national production chains. As a result, a stimulus to production in a given sector of industry is not confined to that sector alone, but spreads to other economic activities that are directly or indirectly linked to it (Hirschman, 1958; Kaldor, 1957). A country's industrial production structure is crucial for generating dynamic growth and economic development in both the short and the long run (Prebisch, 1950; Furtado, 1964).[1]

The Brazilian economy underwent profound structural changes in the 1990s, not only because of the economic policy measures that were adopted to stabilize prices, but also because of the way those policies were implemented, which was prejudicial to Brazilian industry. Key measures in the rapid process of opening up the economy entailed liberalizing imports without at the same time implementing an industrial policy to protect the various sectors of industry from increasing competition (Kon and Coan, 2009, p. 13). This opening-up process involved successive cuts in import quotas, followed by an appreciation of the real; and it marked the transition of Brazilian industry towards a new trade regime, coming after at least four decades of vigorous import protection (Moreira, 1999, p. 295).[2]

These measures fuelled a continuous and generalized growth of imports into Brazil. The data reveal the gathering pace of inflows, mainly of intermediate goods, which have been gaining an increasing share of Brazilian imports and presage a rising trend for the years to come, as shown in figure 1. The import share in gross domestic product (GDP) grew significantly in the late 1990s and remained at a high level throughout the 2000 decade.

Figure 1
Brazil: imports, current values and share of gross domestic product (GDP), 1996–2013
(Thousands of reais and percentages)



Source: Prepared by the authors, on the basis of data from Ipeadata and the System of National Accounts.

[1] See also Nakabashi, Scatolin and da Cruz (2010).

[2] According to Cardoso (2001), the Real Plan —which was designed to combat chronic inflation— went through three stages: measures to balance the government accounts, establishment of monetary reform, and use of the exchange rate as a nominal anchor. The combination of these economic policies triggered a sharp rise in the real interest rate, which attracted a large influx of capital into Brazil and caused the exchange rate to appreciate. This, in conjunction with trade liberalization policies, damaged the industrial sector and fuelled higher unemployment (Cardoso, 2001, p. 12).

In view of the lengthy process of trade liberalization that accompanied the exchange-rate appreciation, industrial activity in Brazil has gradually become more externally dependent, with more and more imported components and products being used in production processes.[3]

According to Morceiro, Gomes and Magacho (2014), imported inputs grew across the board between 2003 and 2008, to account for at least 60% of tradable inputs used in production. This detracts from industry's contribution to GDP growth and job creation; and it also weakens production linkages (Marconi and Barbi, 2010; Fonseca, 2010; Morceiro, 2012; Magacho, 2010 and 2013; Morceiro, Gomes and Magacho, 2014), resulting in a lower degree of sectoral interdependence in the economy. The aforementioned authors also show that the largest share of imported inputs is used in the production of high-technology goods, so the value added by these industries leaks out to the external sector.

In view of the external dependency that has developed in Brazilian industry in recent decades, in which the import content of domestically produced goods is steadily increasing, and given the adverse effects of this process on income and employment, this article sets out to quantify the extent to which Brazilian industry is reliant on imported inputs. The aim is then to identify which products are most needed (those most widely used in domestic industry) and where they are used —in other words, the sectors that generate the heaviest demand for imports.

The study uses input-output analysis to quantitatively identify the sectors that increase the economy's external dependency when their output grows, considering their direct and indirect needs for imported inputs and the substitution of domestic suppliers by foreign ones.

II. Industrial production linkages and imports of intermediate goods

According to Hirschman (1958), it is important to study industry linkages because of their capacity to boost economic growth through the intersectoral relations that are forged between different production chains. The effects of a demand stimulus in one sector are not confined to that sector alone, but are also felt in others, through forward and backward linkages involving relations of buying and selling between productive activities. Hirschman explains this in terms of the complementary capacities of industry —when one industry increases its output, it stimulates joint expansion in other sectors.

In this connection, it is interesting to note the different points of view that exist on the use of imported inputs in the industrial production process, in other words how an industry's deficiencies can be overcome by importing intermediate goods.

Ishikawa (1992) argues that the use of imported inputs in the production process should benefit industry, because it represents a major source of technology transfer, especially in developing countries (Aurea and Galvão, 1998; Lastres and Cassiolato, 2000). The import process thus represents the transfer of knowledge and technology between nations (Veeramani, 2009), which can generate significant productivity increases in industrial activity, as reported in the work of Bonelli and Fonseca (1998), Rossi Júnior and Ferreira (1999) and Carvalho and Feijó (2000).

In a context of global value chains, which has been a recent focus of the literature, it is clear that the act of exportation requires a counterpart act of importation.[4] This can be inferred from the fact

[3] See Fonseca, Carvalho and Pourchet (1998); Levy and Serra (2002); Feijó, Carvalho and Almeida (2005); and Fonseca (2010).

[4] The global value chains phenomenon entails the fragmentation of production processes worldwide. The movement gained force in the 1970s, but achieved greater prominence in the 2000 decade (UNCTAD, 2013). In the global value chains framework, firms no longer operate in all stages of the production of a final good, but spread them across different countries, while themselves concentrating on higher value added activities. This strategy enabled large firms to reduce their costs, based on the greater incorporation of imported parts, parts and components, without losing control of the main areas of the business (Gereffi, Humphrey and Sturgeon, 2005).

that the consumption of intermediate goods in production accounts for 51% of all international trade (Thorstensen, Ferraz and Gutierre, 2014). Accordingly, policies that restrict the importation of inputs would have direct and indirect effects on a country's capacity to increase the technological complexity of its industrial production destined for the domestic or external market. It would, therefore, also hinder its differentiated integration into global value chains (Thorstensen, Ferraz and Gutierre, 2014). In the current context, the importation of intermediate goods is an inherent part of the production process and represents competitiveness gains based on a strategic and differentiated form of international engagement by the country in question.[5]

The counterargument is based on the importance of a country's production structure for its economic development, and how the domestic sourcing intermediate goods supports the diversification of production and growth of per capita income, as noted by Marconi and Rocha (2012) drawing on Chenery, Robinson and Syrquin (1986). The reason for this is that intermediate goods are also produced from other intermediate goods, thereby structuring a good's production chain or value chain (Marconi and Rocha, 2012, p. 859). In view of this and following Marconi and Rocha (2012), it is argued that the continuous substitution of domestic inputs in the production process by imported ones hinders indirect inter-industry effects and frustrates the industrialization process.

Authors such as Coutinho (1997), Morceiro (2012), Magacho (2010 and 2013) and Morceiro, Gomes and Magacho (2014) also stress that importing inputs can break pre-existing industrial linkages and impede the formation of new ones. This view sees the substitution of domestic suppliers by foreign ones as leading to a reduction in the capacity of industry to generate indirect productive effects in terms of income, employment and technology.

As noted in the studies by Marconi and Barbi (2010) and Marconi and Rocha (2012), the process of substituting domestic inputs with imported ones is also considered to be one of the causes of the de-industrialization process. Lastly, a number of studies highlight the harmful effects of this process on the capacity of industry to create jobs (Soares, Servo and Arbache, 2001; Maia, 2001, Moreira and Najberg, 1998), and how the use of imported inputs in production can undermine the capacity of industry to endogenously generate the factors needed for economic growth (Magacho, 2013).[6]

III. Methodology

1. Input-output table

Input-output analysis is used to achieve the proposed aim of analysing the degree to which the Brazilian economy depends on imported inputs. This model was developed in the 1930s by Leontief, who managed to portray the economy in a given period, by capturing contemporary relationships between sectors as if they were parts of a single organism (Guilhoto, 2004). The economic relations thus synthesized constitute the input-output table.

The input-output table describes the economy in terms of circulation, as an integrated system of flows and transfers of inputs and outputs between sectors. It is formed by calculating global production and is divided into three parts. The first reflects intermediate demand, in other words purchase and sale transactions between the different sectors of production. The second consists of value added —which includes factor remunerations, and production taxes and subsidies— and imports. The third, which corresponds to final demand, comprises household and government consumption, gross capital formation and exports.

[5] See Sá Porto, Canuto and Mota (2017).

[6] The papers cited here are studies of the Brazilian case.

To ease understanding of the methodology, table 1 presents an illustrative input-product matrix, in which X_1 and X_2 are sectors of production, Y is final demand, VA is value added, M represents the share of intermediate consumption that is sourced abroad, T is total taxes net of subsidies paid, and X represents the gross value of production (GVP). The x_{ij} variables represent the intermediate consumption of input i in the production of good j. The columns of the matrix represent the costs of input purchases; and the rows show the income obtained by the sector from the sale of the good for intermediate consumption by other sectors and for final demand.

Table 1
Representative input-output table

Input/Output	Sectors		Y	GVP
(Costs↓/ Income→)	X_1	X_2		
X_1	x_{11}	x_{21}	y_1	X_1
X_2	x_{12}	x_{22}	y_2	X_2
M_1	m_{11}	m_{21}		
M_2	m_{12}	m_{22}		
VA	va_1	va_2		
T	t_1	t_2		
VBP	X_1	X_2		

Source: Prepared by the authors, on the basis of R. E. Miller and P. D. Blair, *Input-Output Analysis: Foundations and Extensions,* New York, Cambridge University Press, 2009.

The technical coefficients matrix can be obtained from the intermediate consumption matrix, which is given by:

$$A = \left[a_{ij}\right] \text{ in which } a_{ij} = \frac{x_{ij}}{x_j} \text{ or } x_{ij} = a_{ij}x_j \quad (1)$$

For each row of the input-output table:

$$\sum_{j=1}^{n} x_{ij} + y_i = X_i = \sum_{j=1}^{n} \alpha_{ij} X_j + y_i \quad (2)$$

in which n is the number of sectors in the economy.

In matrix terms, $AX+Y=X$, which can be rearranged to give:

or
$$X = \left(I - A\right)^{-1} Y \text{ or } X = LY \quad (3)$$

where I is an identity matrix and $\left(I-A\right)^{-1} = L = \left[lij\right]$ is the Leontief inverse matrix, in which, according to Guilhoto (2004), each lij element represents the direct and indirect input requirements of sector i per unit of final demand in the production of sector j. Equation (3) describes the basic Leontief model.

The intermediate consumption of the n sectors of the economy can also be satisfied through imports; and here it is important to observe the relationship between the domestic and external sectors. This is represented by the matrix M, in which each element m_{ij} indicates the value of intermediate goods imported from (external) sector i that are used in the production process of (domestic) sector j. The matrix M is at the heart of the analysis of this article; and its components are used to achieve the proposed aim of the study, as shown in the next section.

2. Degree of dependence on imported inputs

Dependency on imported inputs is analysed using the method proposed by Schuschny (2005), which consists initially of calculating the sector's direct requirements for imported inputs. Let A^m be the matrix of imported technical coefficients given by:

$$A^m = \left[a_{ij}^m\right] \text{ in which } a_{ij}^m = \frac{x_{ij}^m}{X_j} \tag{4}$$

x_{ij}^m is the value of input i imported by sector j and aij^m is the coefficient that measures the value of imported inputs i used by sector j for each monetary unit produced by this sector. Thus, the total imports matrix is obtained by post-multiplying the matrix of import coefficients by the Leontief inverse, as follows:

$$Q = A^m L \text{ or } Q = \left[qij\right] \tag{5}$$

Each qij element indicates the direct and indirect imports of input i needed to generate one monetary unit of production in sector j. The sum of the elements of column j of the matrix $Q\left(Q_j = \sum_{i=1}^{n} q_{ij}\right)$ reports the total import content needed to produce one monetary unit of sector j domestically. According to Schuschny (2005), this calculation provides very useful structural information, since it can be used to identify activities that rely heavily on imports from the rest of the world —in other words they depend on external resources to increase their level of production. Similarly, the sum of the elements of row i of the matrix $Q\left(Q_i = \sum_{j=1}^{n} q_{ij}\right)$ indicates the value of imports of input i needed for all sectors to increase production by one monetary unit. This indicator identifies the foreign sectors on which the domestic economy as a whole relies most, in other words those that do most to fuel the flow of imports when domestic production expands.

Comparing the indicators described above makes it possible to classify sectors in groups according to their behaviour as demanding or demanded of imported intermediate inputs, as shown in table 2.

Table 2
Sectoral classification according to the demand for imported intermediate inputs

	Demanding $\left(Q_j > \sum_{j}^{n} Q_j / n\right)$	Relatively undemanding $\left(Q_j \leq \sum_{j}^{n} Q_j / n\right)$
Demanded $\left(Q_i > \sum_{i}^{n} Q_i / n\right)$	Type II	Type I
Relatively undemanded $\left(Q_i \leq \sum_{i}^{n} Q_j / n\right)$	Type III	Type IV

Source: Prepared by the authors, on the basis of A. R. Schuschny, "Tópicos sobre el modelo de insumo-producto: teoría y aplicaciones", *Statistical and Prospective Studies series*, No. 37 (LC/L.2444-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2005.

The sectoral characteristic of the typology presented in table 2 can be described as follows:

- Type I: when the production of the economy expands, direct and indirect demand for imported inputs from these sectors increases by more than average; but, when the production of these sectors themselves increases, their own demand for imported inputs is relatively small.

- Type II: to increase their production by one monetary unit these sectors depend directly and indirectly on imported inputs, to a greater extent than the economy-wide average; and, when the other sectors of the economy increase their production, the direct and indirect importation of inputs from these sectors also increases by more than average. Consequently, these are sectors that need imported inputs for their own production and which supply the domestic demand for inputs by less than the average for the economy as a whole. For that reason, these sectors are unlikely to create many linkages in the domestic production system.
- Type III: although these sectors have direct and indirect demand for imported inputs above the average of the economy at large, when the other sectors increase their production, the direct and indirect demand for imported inputs from these sectors is below average.
- Type IV: these sectors depend little on imported inputs to increase their production, so any incentives to industry sectors in this category are appropriated by the domestic sector. They are also sectors that are relatively undemanded, so when the economy as a whole grows, the direct and indirect demand for imported inputs from these sectors is less than the average across all sectors.

The sectors classified as type II or type III tend to increase the country's external dependency, because their production directly and indirectly fuels imports through their intermediate demand. As these sectors rely on imported inputs to increase their production, they generate less value added domestically, which has negative repercussions on the national production chain.

3. Database

This study makes use of the input-output tables for 2000–2014 that are available in the World Input-Output Database (WIOD). The input-output tables and tables of imports of intermediate inputs are broken down into 56 sectors, 20 of which are industrial. This enables a detailed analysis to be made of the external dependency of national industrial production. The data contained in the tables are measured in millions of dollars at current prices.

IV. Discussion of the results

This section discusses the results obtained by applying the methodology explained above. To improve understanding, the classification of Pavitt (1984) and the Organization for Economic Cooperation and Development (OECD) (2005) is used, which groups sectors by type of industry or technology. As the groups contain sectors with similar industrial characteristics, the discussion is subdivided as follows: natural-resource-intensive industry, scale-intensive industry, science-based industry, labour-intensive industry and industry with differentiated technology.

1. Natural-resource-intensive industry

A recent discussion in the scientific literature noted a structural change in Brazilian industry, which has intensified since the economic liberalization measures of the 1990s. Some authors, such as Nassif (2008) and Oreiro and Feijó (2010), have shown that industrial production in Brazil has shifted towards natural-resource-intensive industry, which has come to play a key role in the performance of the national economy. Thus, the analysis of reliance on imported inputs is relevant for identifying the sectors that directly and indirectly stimulate imports when their production increases and, thus, establish whether the stimuli generated in this industry are appropriated abroad.

The sectors that comprise natural-resource-intensive industry are listed in table 3, classified by their degree of external dependency. Firstly, although this industry has played a crucial role in the economy through its export performance, when natural-resource-intensive sectors increase their production they generally demand imported inputs, directly and indirectly, to a greater extent than the average of the economy as a whole.

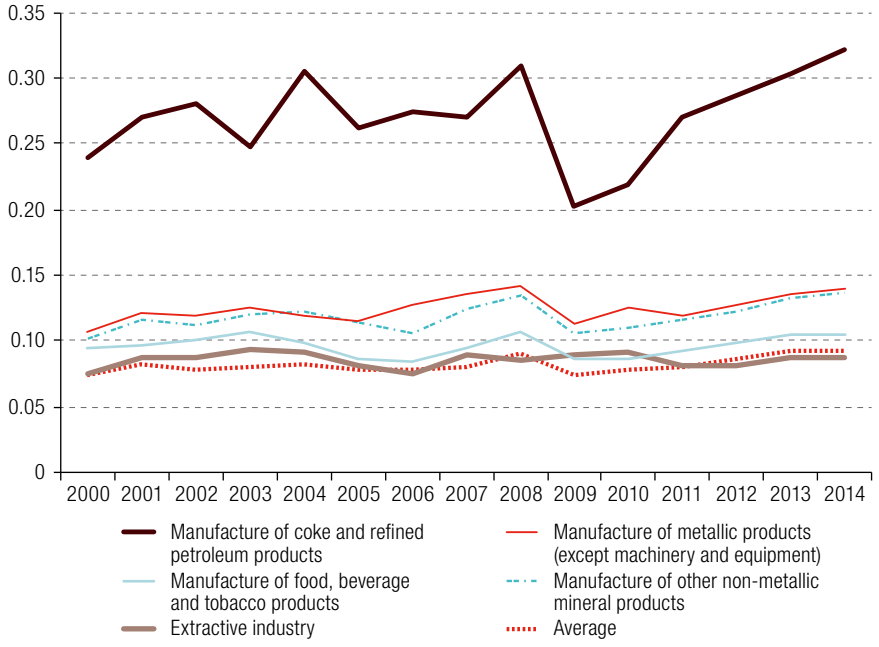
Table 3
Brazil: classification of the degree of dependency on imported inputs, natural-resource-intensive industry

Sectors / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Extractive industry	II	II	II	II	II	II	I	II	I	II	II	II	I	I	I
Food products, beverages and tobacco	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
Coke and refined petroleum products	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Other non-metallic mineral products	III	III	III	III	III	III	III	III	III	III	II	III	III	III	III
Metal products (except machinery and equipment)	II	III	II	II	II	III	III	III	III	III	III	III	III	II	II

Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Table 3 shows that, between 2000 and 2011, extractive industry was generally classified as type II, since its production generates more than average demand for imported inputs; and the economy at large is also more than averagely reliant on imported inputs from this sector to increase its production. Since 2012, however, this industry has been classified as type I, so its external dependency was relatively small during this period. Figure 2 shows that the extractive industry's direct and indirect demand for imported inputs has dropped slightly below the economy-wide average in the last three years.

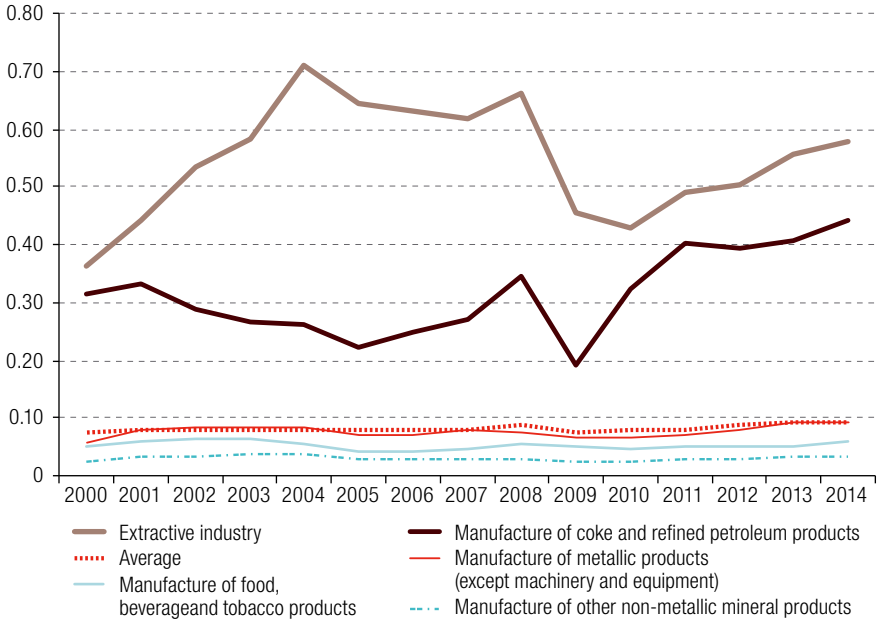
Figure 2
Brazil: direct and indirect demand for imported inputs per dollar of output generated by the sectors, natural resource-intensive industry, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Nonetheless, figure 3 shows that the economy at large relies heavily on imported inputs from extractive industry and that this dependency has remained high over the years. Whereas a one-monetary-unit increase in production in other sectors of the economy generated a direct and indirect import requirement from this sector of US$ 0.24 in 2000, the amount had increased to US$ 0.58 by 2014. In that year, the sectors most dependent on imports of this type of input were the following: manufacture of coke and refined petroleum products (responsible for 27% of the result reported in that year), manufacture of basic metals, manufacture of other non-metallic mineral products, and manufacture of chemicals and chemical products (manufacture of chemical substances and products).

Figure 3
Brazil: direct and indirect demand for imported inputs per dollar of production generated in the economy, natural resource-intensive industry, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Relative to the other sectors, the coke manufacturing and oil refining sector stood out for its high degree of external dependency. As shown in table 3, this sector was classified as type II, since its need for imported intermediate goods is above the average for the economy as a whole, and also represents inputs which economy as a whole must import to increase production.

When the coke and oil refining sector is analysed separately in the matrix Q, it can be seen that its main imported input throughout 2000–2014 comes from extractive industry itself, which on average accounts for 40% of its imports. Thus, the oil refining sector is dependent on an input that is closely related to its final product, since oil and gas production is a sector of extractive industry.

Figure 2 shows that, among the sectors analysed here, the coke and oil refining sector has the highest import requirements. In the period studied, that sector directly and indirectly imported an average of about US$ 0.27 for each dollar produced; and in 2014 the amount was US$ 0.32. Figure 3 also shows that, when the production of the other sectors of the economy increases by a dollar, the direct and indirect import demand linked to this sector averaged US$ 0.31 in the period analysed.

The sectors that relied most heavily on imported inputs from the coke and oil refining sector during 2000–2014 were, respectively: coke and oil refining, air transport, chemicals and chemical products, land transport and manufacture of rubber and plastic products.

The food, beverages and tobacco sector has maintained its type III classification. As shown in figure 2, the sector depends on inputs from abroad, importing US$ 0.10 per dollar produced in the period under review. Nonetheless, the direct and indirect demand for imported inputs from this sector by the economy as a whole was, in general, below average.

The other non-metallic mineral products sector was generally classified as type III, in other words as one in which production directly and indirectly requires imported inputs, to an extent that exceeds the average for the economy at large, as shown in figure 2. Nonetheless, when the other sectors of the economy increase their production, their external dependency on this sector is low, as can be seen in figure 3.

Lastly, the metal products manufacturing sector was classified as type II and type III during the period analysed, since its production depends on imports, and the economy as a whole relies on inputs from this sector for its productive activities. Thus, a stimulus to the manufacture of metallic products is associated, as a counterpart, with an increase in imports entering the country.

2. Scale-intensive industry

The sectors classified as scale-intensive industry are listed in table 4, which shows that production in this industry is highly dependent on imports of intermediate inputs. This is evident because in general this industry was classified as type II (demanding and demanded) and type III (demanding and relatively undemanded).

Table 4
Brazil: classification of the degree of dependency on imported inputs, scale-intensive industry

Sectors / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Paper and paper products	II	II	II	II	II	II	II	III	III	III	III	III	III	III	III
Printing and reproduction of media	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III
Chemicals and chemical products	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Rubber and plastic products	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Basic metals	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Vehicles and trailers	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Other transport equipment	III	II	III	III	III	II	II	II	II	II	II	II	II	II	II

Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

The classification of the paper and paper products manufacturing sector changed from type II to type III in 2007, as shown in table 4. This means that, in carrying on their production activities, the other sectors become less dependent on the paper and paper products manufacturing sector through time.

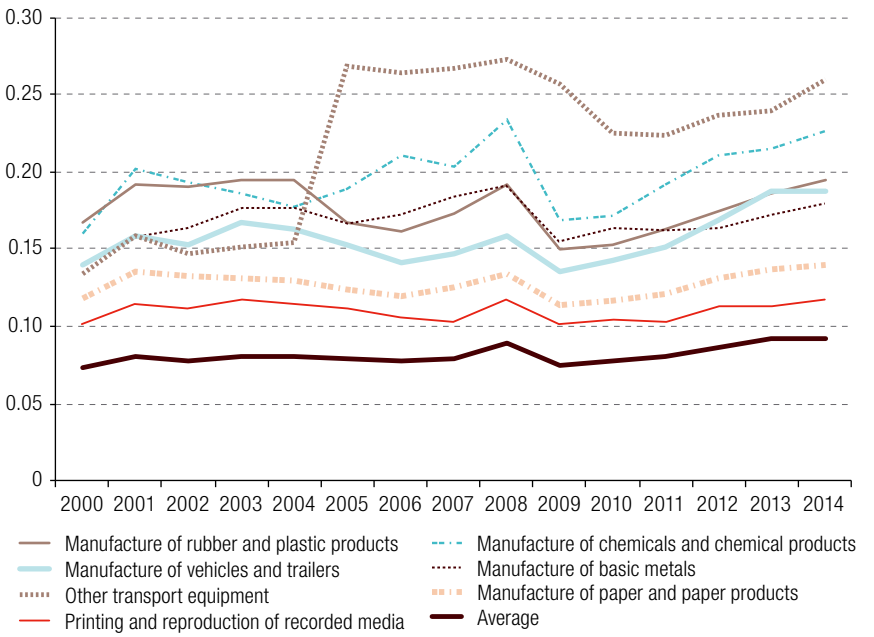
According to Montebello and Bacha (2011), firms in the Brazilian pulp and paper sector are vertically integrated and operate in various stages of the production process. Their main comparative advantage is in pulp production, exploiting the high level of production of wood from planted forests. These authors also note that production in the pulp sector has expanded significantly in recent years

to serve the external market. Interestingly, according to the authors, although the pulp sector is capital-intensive, for each direct job generated another five are created indirectly, based on activities that are interrelated with this sector. It is therefore worth noting that the change in this industry's classification is linked to its internal development in creating new firms related to this sector, which in turn enabled it to integrate into later stages of the national production chain and reduced the national economy's external dependency in relation to the pulp and paper sector.

In general, the printing and reproduction of recorded media sector was classified as type III; in other words, to increase its production, its demand for imported inputs exceeds the average for the economy as a whole. Although the sector reported average imported inputs of US$ 0.11 per dollar of production, figure 4 shows that its direct and indirect requirement for imported inputs stayed broadly constant in the period studied. In general, it did not replace domestic suppliers with foreign ones over time. Analysis shows that the Brazilian economy's external dependency in relation to this sector is close to zero (see figure 5).

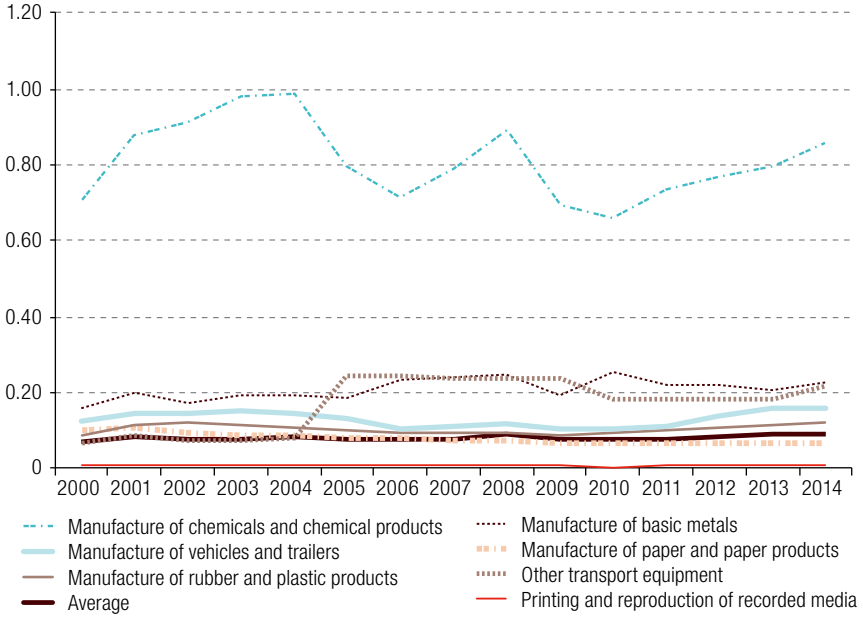
Among the sectors studied in this article, the chemicals and chemical products sector displays the Brazilian economy's highest degree of external dependency. When the production of the economy increases by one dollar, the direct and indirect need for imported inputs from the chemicals and chemical products sector averages US$ 0.81. The sectors displaying the highest level of external dependency in relation to imports of chemical and chemical product inputs were: manufacture of chemical substances and products, manufacture of rubber and plastic products, animal and plant production and related services activities, manufacture of paper and paper products and pharmaceutical products. This sector's production demands an average of US$ 0.20 of imported inputs per dollar produced; and nearly half of this amount is related to the chemicals and chemical products sector itself, so the indirect effects generated by this sector are mostly not appropriated by the national economy.

Figure 4
Brazil: direct and indirect demand for imported inputs per dollar of production generated by the sectors, scale-intensive industry, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Figure 5
Brazil: direct and indirect demand for imported inputs per dollar of production generated in the economy, scale-intensive industry, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Table 4 shows that the rubber and plastic products sector and the basic metals sector were classified as type II throughout the years studied, reporting average imported inputs of US$ 0.18 and US$ 0.17 per dollar of production, respectively. Thus, when these sectors increase their production, they draw imports into the country. The rubber and plastic products sector is mainly dependent on imports of chemical substances and products, which represents over 52% of their direct and indirect imports, while the basic metals sector mainly requires imports from extractive industry (35%).

In general, the manufacture of vehicles and trailers sector and that of other transport equipment were classified as type II in terms of their external dependency. This means that they themselves depend on imported inputs to produce, and that the economy as a whole also demands imported inputs from these sectors, as shown in figures 4 and 5. These figures reveal that both sectors have direct and indirect input requirements that exceed the average for the economy at large; and also, that when the economy as a whole grows, its demand for imported inputs from these sectors is above average. As shown in figure 4, the vehicle and trailer sector gradually increased its direct and indirect demand for imported inputs during the period analysed, to an average of US$ 0.16 per dollar produced. This amount rises to US$ 0.22 in the case of the other transport equipment sector. It is interesting to note that the main inputs demanded by these sectors come from external suppliers linked to the production of vehicles and trailers and other transport equipment, respectively.

An analysis of scale-intensive Brazilian industry shows that the indirect intersectoral effects generated by it are largely appropriated by the external sector. This is clear in the figures presented, which show that all sectors of this industry directly and indirectly demand imported inputs to an extent that exceeds the economy-wide average. In other words, an increase in the production of these sectors is inexorably linked to increased flows of imports entering the country.

3. Science-based industry

Science-based industry, characterized by its high technological content, consists only of the pharmaceutical industry and the manufacture of pharmaceutical products. Table 5 shows that this sector was generally classified as type III, in other words a sector that demands imported inputs. Consequently, an increase in the production of science-based industry stimulates imports both directly and indirectly.

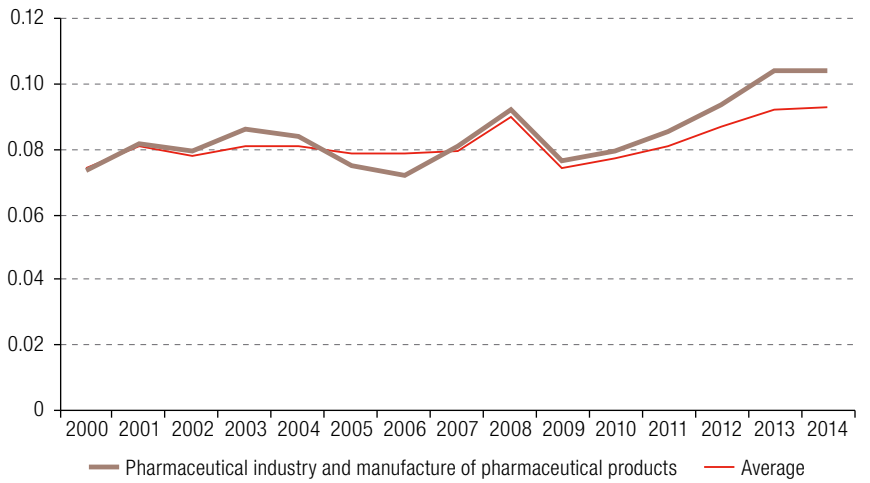
Table 5
Brazil: classification of degree of dependency on imported inputs, science-based industry

Sector / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pharmaceutical industry and manufacture of pharmaceutical products	IV	III	III	III	III	IV	IV	III	III	III	III	III	III	III	III

Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Figure 6 shows that science-based industry's direct and indirect demand for imported inputs generally exceeds the economy-wide average, and its external dependency increased gradually during the period under review. This suggests that domestic suppliers in this sector have probably been replaced over time. Between 2000 and 2014, the sector demanded an average of US$ 0.08 of imported inputs per dollar produced.

Figure 6
Brazil: direct and indirect demand for imported inputs per dollar of production generated by the sectors, science-based industry, 2000–2014
(Dollars)



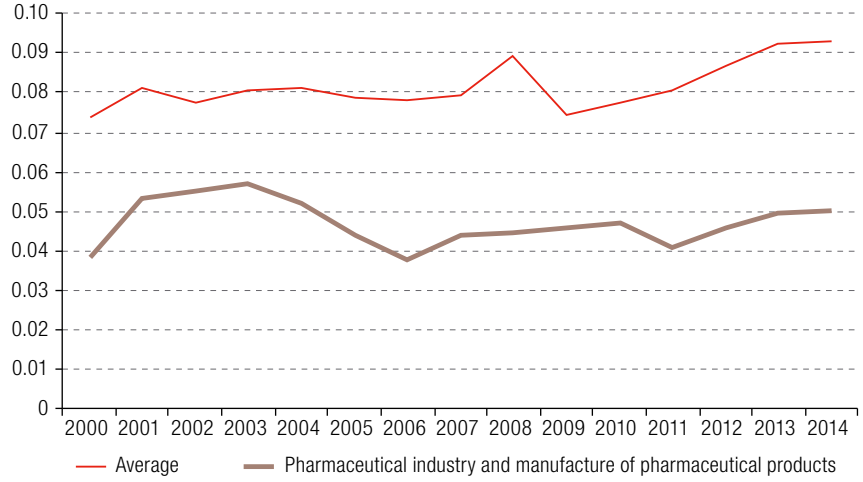
Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

As science-based industry was generally considered to be type III (a sector that is relatively undemanded by the economy at large), the value of direct and indirect demand for imported inputs is below average, as shown in figure 7. Thus, the economy has a low level of dependency on imported inputs from this sector; so an increase in its production does not generate a great demand for imports from the pharmaceutical industry and the manufacture of pharmaceutical products.

Brógio (2002) argues that Brazilian-owned pharmaceutical firms display fragilities, since foreign capital predominates in serving the domestic consumer market. The author notes that the firms that operate in Brazil display low levels of integration, probably because large firms keep the input-producing segment centralized in their countries of origin, which results in a heavy reliance on imports from those countries (Brógio, 2002, p. 115). Canchumani (2009) explains that the domestic and foreign-owned firms operating

in Brazil are engaged in the final stages of the production process —the formulation and marketing of medicines— and have a high degree of dependency in relation to the earlier stages that develop in the matrix. As a result, the pharmaceutical industry's production process is associated with import growth.

Figure 7
Brazil: direct and indirect demand for imported inputs per dollar of production generated in the economy, science-based industry, 2000–2014
(Dollars)

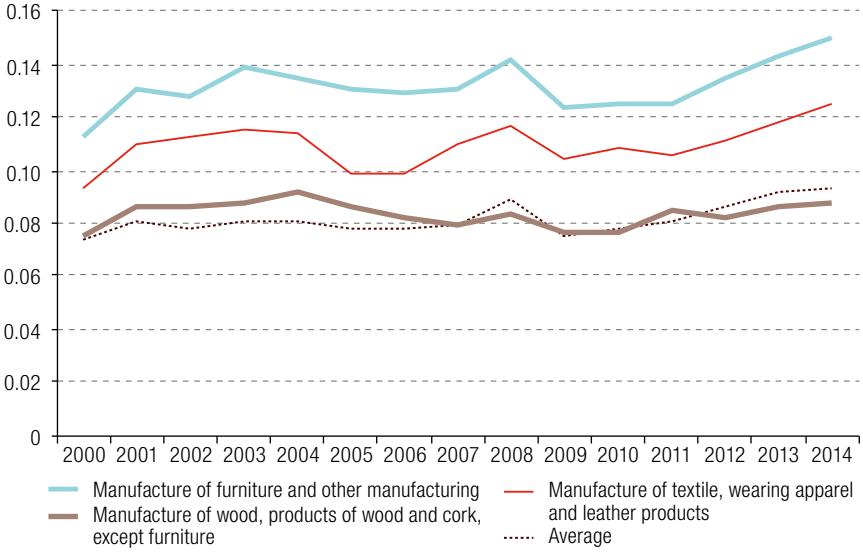


Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

4. Labour-intensive industry

The sectors that comprise labour-intensive industry in Brazil are listed in table 6. It can be seen that this industry in Brazil is not dependent on intermediate goods imports, because, when production in the economy grows, imports of inputs from these sectors do not increase significantly, as shown in figure 8. This is reflected in the classification of these sectors as type IV or III, as shown in table 6.

Figure 8
Brazil: direct and indirect demand for imported inputs per dollar of production generated by the sectors, labour-intensive industry 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

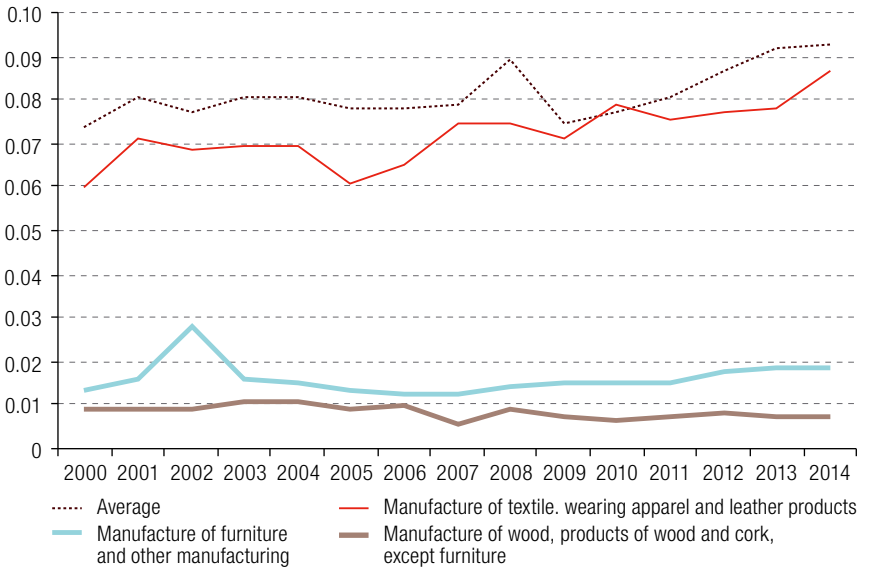
Table 6
Brazil: classification of degree of dependency on imported inputs, labour-intensive industry

Sectors/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Textile, wearing apparel and leather products	III	III	III	III	III	III	III	III	III	III	II	III	III	III	III
Wood, products of wood and cork, except furniture	IV	III	III	III	III	III	III	III	IV	III	IV	III	IV	IV	IV
Furniture and other manufacturing	III	III	III	III	III	III	III	III	III	III	III	III	III	III	III

Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

In general, the wood, wood products and cork (except furniture) sector was classified as type IV, in other words relatively undemanded. Consequently, its demand for imported inputs is lower than the average for the economy as a whole; moreover, intermediate imports from this sector were relatively undemanded by the other sectors, as shown in figure 9. Thus, production growth in this sector would have little impact on imports, so the indirect effects generated by this growth would be appropriated by the national production chain.

Figure 9
Brazil: direct and indirect demand for imported inputs per dollar of production generated in the economy, labour-intensive industry, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Table 6 shows that the textile, wearing apparel and leather products sector was classified as type III throughout the period, so an increase in its production generated higher-than-average direct and indirect demand for imported inputs. In the period under review, the average value of intermediate goods imports was around US$ 0.11 per dollar produced; and domestic suppliers were gradually replaced by external ones, as shown in figure 8.

According to Gorini and Siqueira (1997), the Brazilian textile sector trade balance was harmed by trade liberalization. This balance had been trending down since 1992; and in 1996 it posted a deficit of US$ 1,016,866, not so much because of a drop in exports but because of significant import growth, especially of products made from artificial or synthetic fibres (including non-woven textiles) and cotton (Gorini and Siqueira, 1997, p. 3). These authors listed various reasons for the increased share of cotton

in the textile industry's import structure, such as the reduction in import quotas, different payment terms between foreign and domestic suppliers, an increase in global supply and consequent fall in prices; and, lastly, the fact that in some countries, such as the United States, the product received subsidies.

According to Kon and Coan (2009), trade liberalization enabled and intensified the inflow of imports. This increased competition and, in turn, pushed many firms in the sector into bankruptcy. Nonetheless, following the impact of the policies implemented in the textile industry during the 1990s, steps were taken to restructure production to enable the sector to gain competitiveness and recover, with a view to serving both the domestic and the external markets. Innovation in the production process was very intensive in the textile industry, because it required modernization of the industry's technology stock involving the computerization of production (Kon and Coan, 2009, p. 21). According to these authors, in the 2000 decade, the Textile Sector Restructuring Program of the National Bank of Economic and Social Development (BNDES), made it possible to increase the sector's productivity and expand its productive capacity, through huge investments not only in the formation of physical capital but also in technology and innovation. Nonetheless, another challenge faced by this sector in the 2000 decade stemmed from the high level of China's international competitiveness, as described in Rangel, Silva and Costa (2010).

Lastly, during the period under study, the furniture and related manufacturing sector was considered as a demanding sector and, consequently, classified as type III. Figure 8 shows that, between 2000 and 2014, this sector substituted domestic suppliers with external ones, to the extent that the direct and indirect demand for imported inputs was US$ 0.11 per dollar produced at the start of the series, but had grown to US$ 0.15 by the last year of the series.

5. Industry with differentiated technology

The results of the classification of sectors belonging to industry with differentiated technology are shown in table 7. Except for the repair and installation of machinery and equipment sector, this industry is classified as type II: so, to increase their level of production, the sectors' direct and indirect requirements for imported inputs are above the economy-wide average; and, analogously, the production of the economy at large also depends on imported inputs from these sectors.

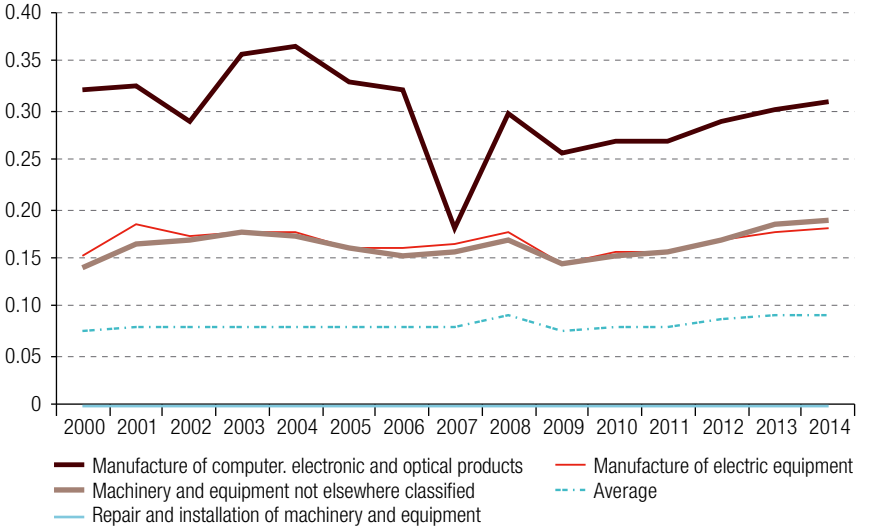
Table 7
Brazil: classification of degree of dependency on imported inputs, industry with differentiated technology

Sectors / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Computer, electronic and optical products	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Electric equipment	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Machinery and equipment not elsewhere classified	II	II	II	II	II	II	II	II	II	II	II	II	II	II	II
Repair and installation of machinery and equipment	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	I	I	I

Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Over the entire period studied, the manufacture of computer, electronic and optical products sector was classified as type II, that is, as both a demanding and a demanded sector. Figure 10 shows it has the highest demand for imported inputs among the sectors included in industry with differentiated technology, with direct and indirect imports averaging US$ 0.30 per dollar produced between 2000 and 2014. Although its direct and indirect demand for imported inputs fell sharply in 2007, the literature has not found an explanation for this; but as the values subsequently resumed their upward trend the inference is that the reduction reflects a conjunctural event.

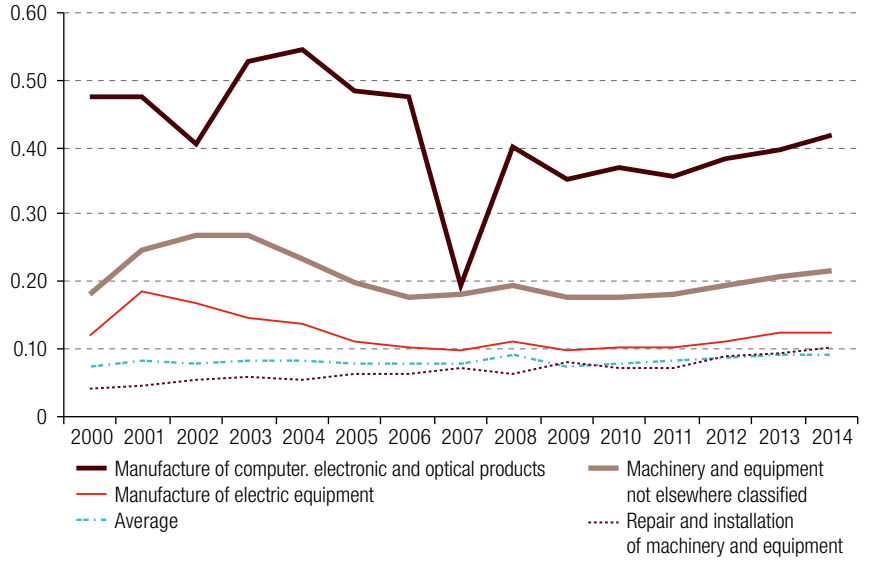
Figure 10
Brazil: direct and indirect demand for imported inputs per dollar of production generated by the sectors, industry with differentiated technology, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

The sector's main external dependency is linked to the importation of inputs from the manufacture of computer, electronic and optical products sector, which accounts for over half of its direct and indirect imported intermediate goods requirement. Nonetheless, figure 10 shows that the sector gradually replaced external suppliers with domestic ones during the period under review: while the direct and indirect importation of inputs amounted to US$ 0.36 per dollar produced in 2003, the figure had fallen to US$ 0.31 by 2014. The same occurs when analysing the overall economy's dependency on imported inputs from this sector, as can be seen in figure 11.

Figure 11
Brazil: direct and indirect demand for imported inputs per dollar of production generated in the economy, industry with differentiated technology, 2000–2014
(Dollars)



Source: Prepared by the authors, on the basis of data from the World Input-Output Database (WIOD).

Like the other sectors in this industry, the manufacture of electrical equipment sector was generally classified as type II. This means that the sector's production demands imported inputs in proportions that exceed the average of the economy at large, and that the economy as a whole depends on imported inputs from this sector to undertake its activities. The average demand for imported inputs from this sector during the period analysed was US$ 0.17 per dollar produced. Between 2000 and 2014, the demand for imported inputs from this sector and the machinery and equipment sector remained within a certain range, as can be seen in figure 10. The same is true of the overall economy's dependency on imported inputs from this sector, as shown in figure 11.

The sector that encompasses machinery and equipment not elsewhere classified was considered type II. In the period under review, this sector's imports averaged US$ 0.16 per dollar produced, with more than 39% of that amount corresponding to imported machinery and equipment; in other words, the sector draws in imports from the same sector. Analogously, the production of the economy as a whole demands inputs related to this sector in above-average proportions, as can be seen in figure 11; and the main demander is the machinery and equipment sector itself. Thus, when this sector's production increases, import demand is stimulated by more than average, thereby increasing the economy's external dependency. This is true for all of the sectors considered in this section.

Lastly, the repair and installation of machinery and equipment sector was classified as type IV during the period studied —that is, as a sector that is not very demanding and relatively undemanded. Nonetheless, figure 11 shows that between 2000 and 2014 the economy relied increasingly on imported inputs related to this sector to undertake its own productive activities, so the sector was reclassified as type I from 2012 onward.

V. Overview of Brazilian industry's dependency on imported inputs

To synthesize the findings of this research, table 8 presents the 20 industrial sectors studied, classified according to their direct and indirect demand for imported inputs.

Table 8
Brazil: classification of industrial sectors by dependency on imported inputs

Classification	Demanding	Relatively undemanding
Demanded	Extractive industry	
	Coke and petroleum refining	
	Manufacture of metal products (except machines and equipment)	
	Chemicals and chemical products	
	Rubber and plastic products	
	Basic metals	
	Vehicles and trailers	
	Other transport equipment	
	Computer, electronic and optical products	
	Electric equipment	
	Machines and equipment not classified elsewhere	
Relatively undemanded	Other non-metallic mineral products	Repair and installation of machinery and equipment
	Textile, wearing apparel and leather products	Wood, products of wood and cork, except furniture
	Furniture and other manufacturing	
	Paper and paper products	
	Printing and media reproduction	
	Food, beverage and tobacco products	
	Pharmaceuticals and pharmaceutical products	

Source: Prepared by the authors.

The table shows that most of Brazil's industrial sectors are both demanding and demanded; that is, sectors whose production directly and indirectly demands imported inputs in proportions above the economy-wide average. By stimulating industrial production, imports are also directly and indirectly stimulated. Similarly, when the production of the economy as a whole increases, imports from the sectors listed in the first quadrant of table 8 are stimulated by more than the economy-wide average. This reflects the fact that the structure of industrial production is heavily dependent on the external sector.

By contrast, the economy has low levels of dependency on imported inputs from the food industry. Sato (1997) argues that, after the Real Plan (which boosted workers' real incomes), the food sector made significant gains; and the period was also characterized by mergers and acquisitions that fuelled growth in the sector. Gouveia (2006) notes the importance of the food industry for the Brazilian economy, since it employs about 1 million workers, generated 15% of industrial sector sales in 2006 and plays a major part in generating trade surpluses. Thus, it can be stated that the indirect intersectoral effects generated by these sectors are mainly retained by the domestic sector.

An issue of concern, however, is that many of the most dynamic and technologically advanced industrial sectors —belonging to differentiated and scale-intensive industries, as well as the oil refining sector— display high levels of external dependency (they are shown in the first part of table 8). As a result, part of the growth generated by these sectors is no longer appropriated by the national economy. This is partly because of their large direct and indirect requirements for imported inputs, but also because other sectors of the economy themselves depend on imported imports from these industries to increase their production.

VI. Final remarks

The industrial sector is crucially important for a country's economic performance, given its capacity to produce indirect intersectoral effects in terms of employment, income and technology. Nonetheless, in recent decades, Brazilian industry has gradually increased its reliance on the external sector, by incorporating a large number of imported inputs into its production processes. This weakens pre-existing industrial linkages and hinders the formation of new ones, limiting their capacity to form production chains and intensifying the country's external dependency.

The aim of this study has been to analyse the extent to which different sectors of Brazilian industry were dependent on imported inputs between 2000 and 2014. The results made it possible to identify the activities that depend significantly on imports from the rest of the world; in other words, they draw on resources from external economies to increase their level of production. They also make it possible to identify the external sectors on which the economy relies most —that is, those with the largest share in the increased flow of imports when domestic production grows.

In general, it was found that Brazil's industrial sectors depend on imports of intermediate goods to expand their level of production. Moreover, as noted in the graphical analyses, the external dependency of Brazilian industry has intensified in the last two decades, owing to the effects of economic liberalization combined with a policy of currency appreciation. This increased incentives to replace domestic suppliers with foreign ones, since domestic industry was unable to compete with the imported content. The change and the intensive reduction of tariff and non-tariff barriers made it cheaper to buy foreign goods; and, as they represented lower costs for domestic companies, they succeeded in permeating the industrial fabric on an ongoing basis, as was seen in the analysis of the results. The process of replacing domestic suppliers with foreign ones was not reversed in the 2000 decade. On the contrary, it was maintained, possibly owing to the productive restructuring of the previous decade and the continuation of the strong currency policy.

Thus, a large part of the indirect effects generated by Brazilian industrial production is appropriated by the external sector, insofar as the gaps in the industrial matrix are partly filled by imported intermediate goods. Moreover, the main sectors that demand imported inputs are those with production that incorporates major technological content, such as differentiated and scale-intensive industries and the oil refining sector.

Nonetheless, the method used here has shortcomings, as noted in Schuschny's work (2005, p. 26). These relate to how the input-output table is constructed, which aggregates a large number of products in sectors assuming perfect substitutability between factors of production. Moreover, the assumption of fixed technical coefficients eliminates the possibilities for sectors to obtain gains from (dis)economies of scale. Lastly, filling the gaps in the matrices by monetary values assumes a price system that is perfectly homogeneous between sectors; but this does not exist in practice.

Bibliography

Aurea, A. P. and A. C. F. Galvão (1998), "Importação de tecnologia, acesso às inovações e desenvolvimento regional: o quadro recente no Brasil", *Texto para Discussão*, No. 616, Brasilia, Institute of Applied Economic Research (IPEA).

Bonelli, R. and R. Fonseca (1998), "Ganhos de produtividade e de eficiência: novos resultados para a economia brasileira", *Pesquisa e Planejamento Econômico*, vol. 28, Rio de Janeiro, Institute of Applied Economic Research (IPEA).

Brógio, A. (2002), "O comércio intrafirma na indústria farmacêutica brasileira", *Pensamento & Realidade*, vol. 11, São Paulo.

Canchumani, R. M. L. (2009), "A produção de fármacos e medicamentos no Brasil e na Índia: uma análise comparativa (1995–2001)" [online] http://bibliofarma.com/download/13087/.

Cardoso, E. (2001), "A crise monetária no Brasil: migrando da âncora cambial para o regime flexível", *Brazilian Journal of Political Economy*, vol. 21, No. 3, São Paulo, Center of Political Economy.

Carvalho, P. G. and C. A. Feijó (2000), "Produtividade industrial no Brasil: o debate recente", *Indicadores Econômicos FEE*, vol. 28, No. 3.

Chenery, H. B., S. Robinson and M. Syrquin (1986), *Industrialization and Growth: A Comparative Study*, Washington, D.C., World Bank.

Coutinho, L. (1997), "A especialização regressiva: um balanço do desempenho industrial pós-estabilização", *Brasil: desafios de um país em transformação*, J. P. R. Velloso (org.), Rio de Janeiro, José Olympio.

Feijó, C. A., P. G. Carvalho and J. S. G. Almeida (2005), "Ocorreu uma desindustrialização no Brasil?", Industrial Development Study Institute [online] https://iedi.org.br/admin_ori/pdf/20051129_desindustrializacao.pdf.

Fonseca, R. (2010), "Valorização cambial no Brasil e as armas para defender a indústria na guerra cambial", *Revista Brasileira de Comércio Exterior*, No. 105, Rio de Janeiro, Centre for Foreign Trade Studies Foundation (FUNCEX).

Fonseca, R., M. C. Carvalho Jr. and H. Pourchet (1998), "A orientação externa da indústria de transformação brasileira após a liberalização comercial", *Texto para Discussão*, No. 135, Rio de Janeiro, Centre for Foreign Trade Studies Foundation (FUNCEX).

Furtado, C. (1964), *Development and Underdevelopment*, Berkeley, University of California Press.

Gereffi, G., J. Humphrey and T. Sturgeon (2005), "The governance of global value chains", *Review of International Political Economy*, vol. 12, No. 1, Abingdon, Taylor & Francis.

Gorini, A. P. F. and S. H. Siqueira (1997), "Complexo têxtil brasileiro" [online] https://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/conhecimento/bnset/bsesptex.pdf.

Gouveia, F. (2006), "Indústria de alimentos: no caminho da inovação e de novos produtos", *Inovação Uniemp*, vol. 2, No. 5, Campinas, Uniemp Institute.

Guilhoto, J. J. M. (2004), "Análise de insumo e produto: teoria e fundamentos", São Paulo, University of São Paulo.

Hirschman, A. O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.

Ishikawa, J. (1992), "Trade patterns and gains from trade with an intermediate good produced under increasing returns to scale", *Journal of International Economics*, vol. 32, No. 1, Amsterdam, Elsevier.

Kaldor, N. (1957), "A model of economic growth", *The Economic Journal*, vol. 67, No. 268, Wiley.
Kon, A. and D. C. Coan (2009), "Transformações da indústria têxtil brasileira: a transição para a modernização", *Revista de Economia Mackenzie*, vol. 3, No. 3.
Lastres, H. M. M. and J. E. Cassiolato (2000), "Sistemas de inovação: políticas e perspectivas", *Parceiras Estratégicas*, vol. 5, No. 8.
Levy, P. M. and M. I. F. Serra (2002), "Coeficientes de importação e exportação na indústria", *Boletim de Conjuntura*, No. 58, Rio de Janeiro, Institute of Applied Economic Research (IPEA).
Magacho, G. R. (2013), "Incorporating import coefficients into a structural decomposition analysis: an empirical investigation on Brazilian growth sources" [online] https://www3.eco.unicamp.br/neit/images/Downloads/seminarioagosto13.pdf.
___(2010), "Desarticulação das cadeias produtivas no Brasil: impacto sobre a geração de emprego e a renda (1995-2008)", *Boletim NEIT*, No. 15, Campinas, Institute of Economics, State University at Campinas.
Maia, K. (2001), "Progresso tecnológico, qualificação da mão-de-obra e desemprego", thesis, Brasilia, Department of Economics, University of Brasilia.
Marconi, N. and F. C. Barbi (2010), "Taxa de câmbio e composição setorial da produção: sintomas de desindustrialização da economia brasileira", *Texto para Discussão*, No. 255, São Paulo, São Paulo School of Economics of Getulio Vargas Foundation.
Marconi, N. and M. Rocha (2012), "Taxa de câmbio, comércio exterior e desindustrialização precoce – o caso brasileiro", *Economia e Sociedade*, vol. 21, special issue, Campinas, State University at Campinas.
Miller, R. E. and P. D. Blair (2009), *Input-Output Analysis: Foundations and Extensions*, New York, Cambridge University Press.
Montebello, A. E. S. and C. J. C. Bacha (2011), "O setor de celulose e papel na economia brasileira", *O Papel*, vol. 72, No. 4, São Paulo.
Morceiro, P. (2012), "Desindustrialização na economia brasileira no período 2000-2011: abordagens e indicadores", São Paulo, Cultura Acadêmica.
Morceiro, P., R. Gomes and G. R. Magacho (2014), "Conteúdo importado na produção industrial e na demanda final do Brasil recente: uma proposta de indicadores de importação e de conteúdo nacional/estrangeiro", *Anais do XL Encontro Nacional de Economia*, Association of Centers for Post-Graduation in Economics (ANPEC).
Moreira, M. (1999), "A indústria brasileira nos anos 90: o que já se pode dizer", *A economia brasileira nos anos 90*, F. Giambiagi and M. M. Moreira (orgs.), Rio de Janeiro, National Bank for Economic and Social Development (BNDES).
Moreira, M. and S. Najberg (1998), "Abertura comercial: criando ou exportando empregos?", *Pesquisa e Planejamento Econômico*, vol. 28, No. 2, Rio de Janeiro, Institute of Applied Economic Research (IPEA).
Nakabashi, L., F. D. Scatolin and M. J. V. da Cruz (2010), "Impactos da mudança estrutural da economia brasileira sobre o seu crescimento", *Revista de Economia Contemporânea*, vol. 14, No. 2, Rio de Janeiro, Institute of Economics, Federal University of Rio de Janeiro.
Nassif, A. (2008), "Há evidências de desindustrialização no Brasil?", *Brazilian Journal of Political Economy*, vol. 28, No. 1, São Paulo, Center of Political Economy.
OECD (Organization for Economic Cooperation and Development) (2005), *Science, Technology and Industry Scoreboard 2005*, Paris.
Oreiro, J. L. and C. A. Feijó (2010), "Desindustrialização: conceituação, causas, efeitos e o caso brasileiro", *Revista de Economia Política*, vol. 30, No. 2, São Paulo, Center of Political Economy.
Pavitt, K. (1984), "Sectoral patterns of technical change: towards a taxonomy and a theory", *Research Policy*, vol. 13, No. 6, Amsterdam, Elsevier.
Prebisch, R. (1950), The Economic *Development of Latin America and its Principal Problems* (E/CN.12/89/Rev.1), New York, United Nations.
Rangel, A. S., M. M. Silva and B. K. Costa (2010), "Competitividade da indústria têxtil brasileira", *Revista de Administração e Inovação*, vol. 7, No. 1, São Paulo, University of São Paulo.
Rossi Júnior, J. L. and P. C. Ferreira (1999), "Evolução da produtividade industrial brasileira e abertura comercial", *Texto para Discussão*, No. 651, Rio de Janeiro, Institute of Applied Economic Research (IPEA).
Sá Porto, P. C., O. Canuto and A. A. L. Mota (2017), "As possibilidades de inserção do Brasil nas cadeias globais de valor", *Informe GEPEC*, vol. 21, No. 1, Toledo, Paraná, State University of Western Paraná.
Sato, G. S. (1997), "Perfil da indústria de alimentos no Brasil: 1990–97", *Revista de Administração de Empresas*, vol. 37, No. 3, São Paulo.

Schuschny, A. R (2005), "Tópicos sobre el modelo de insumo-producto: teoría y aplicaciones", *Statistical and Prospective Studies series*, No. 37 (LC/L.2444-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Soares, S., L. M. S. Servo and J. S. Arbache (2001), "O que (não) sabemos sobre a relação entre abertura comercial e mercado de trabalho no Brasil", *Texto para Discussão*, No. 843, Rio de Janeiro, Institute of Applied Economic Research (IPEA).

Thorstensen, V., L. Ferraz and L. Gutierre (2014), "O Brasil nas cadeias globais de valor", *Dossiê*, special issue, vol. 2, year 13, Brazilian Center for International Relations (CEBRI).

UNCTAD (United Nations Conference on Trade and Development) (2013), *World Investment Report. Global Value Chains: Investment and Trade for Development* (UNCTAD/WIR/2013), New York, United Nations.

Veeramani, C. (2009), "Impact of imported intermediate and capital goods on economic growth: a cross country analysis" [online] https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID1325181_code729291.pdf?abstractid=1325181&mirid=1.

External constraints on the Cuban economy in the current environment of uncertainty

Juan Carlos Palacios Cívico

Abstract

This study seeks to explore the external factors that are acting as constraints on the Cuban economy and to identify the main opportunities that are open to it and the main threats that it faces in the current context of uncertainty. In order to accomplish this, a balance-of-payments-constrained growth model is used which, unlike any other model of this type that has been used before, incorporates the effect of the different flows of foreign exchange on the short- and long-run growth paths of the Caribbean economy.

Keywords

Economic conditions, economic growth, foreign trade, balance of payments, economic policy, econometric models, economic indicators, Cuba

JEL classification

P27, N16, F43

Author

Juan Carlos Palacios Cívico is a professor with the Department of Economic History, Institutions, Policy and the World Economy of the University of Barcelona in Spain. Email: jcpalacios@ub.edu.

I. Introduction

Cuba's recent history reflects its great vulnerability to changes in its economic environment. Events such as its entry into the Council for Mutual Economic Assistance (COMECON), the disappearance of the Union of Soviet Socialist Republics and its membership in the Bolivarian Alliance for the Peoples of Our America (ALBA) are crucial considerations in any analysis of the country's economic growth path during recent decades. Its dependence on external factors is also of pivotal importance for an understanding of how external shocks such as the political and economic crisis that has erupted in the Bolivarian Republic of Venezuela or recent changes in its relations with the United States may influence the material living conditions of the Cuban population in coming years.

This study seeks both to gather empirical evidence concerning the external constraints that may be limiting Cuba's economic growth and to arrive at disaggregated estimates of the extent of the effect that the main foreign exchange flows —exports, foreign direct investment (FDI), remittances and external loans— may be having on Cuba's GDP growth. The ultimate aim of this research effort is to identify the main opportunities that are open to the country and the chief threats that it is facing. The methodology used for this purpose involves the econometric estimation of the theoretical balance-of-payments-constrained growth model developed by Thirlwall and Hussain (1982), in which a country's economic rent is expressed as a function of export growth, the terms of trade and external financing. Short-run departures from equilibrium are estimated using an error correction mechanism. The study period runs from 1975 to 2013. The available statistical data for the different variables included in the model constitute the justification for its selection.

The study is structured as follows. Section II describes the theoretical model and the major general and Cuba-specific empirical studies that have been conducted on balance-of-payments-constrained growth models. Section III looks at the correlation existing between Cuba's GDP and its foreign trade flows and presents an analysis of the main scenarios and policies that may have a favourable or unfavourable influence on the country's balance-of-payments equilibrium and its economic growth. In section IV, a balance-of-payments-constrained growth model is estimated for Cuba, and confirmation is provided of the importance of the role played by access to foreign capital and the conclusion of preferential agreements in alleviating external constraints on the Cuba economy. Economic policy recommendations and conclusions are presented in section V.

II. The theoretical framework and existing empirical evidence

The identification of the determinants of economic growth and inter-country differences in national income has been one of the central issues dealt with in the economic literature ever since the emergence of economics as a scientific field of study. The works of classical authors such as Adam Smith, Thomas Malthus, John Stuart Mill, David Ricardo and Karl Marx all reflect their concern with the growth of national economies.

Based on John Maynard Keynes's work on static equilibrium, the writings of economists R. Harrod and D. Domar, who took a long-term view in their analysis of the instability of capitalism, inspired subsequent studies on balanced growth with full employment that ultimately served as the foundation for modern theories of economic growth.

Later on, some economists began to question the exogenous nature of factors of production and reintroduced demand into the explanation for economic growth. The arguments that they put forward dealt with the flexibility of labour in adapting to different phases of the business cycle, the nature of the goods being produced with capital inputs or the steady growth of both of these factors of production throughout history. This line of thinking, whose origin and theoretical foundation are to be found in the work of Kaldor and Thirlwall, explained growth by reference to the expansion of aggregate demand and, more specifically, to export demand as the only autonomous component of total demand.

Thirlwall (1979) used Harrod's foreign trade multiplier as his starting point for the line of thought that eventually led to his conclusion that, in the long run, an economy's pace of growth is limited by its supply of foreign exchange, which is, in turn, determined by exports and the income elasticity of the demand for imports. The basic idea is that a country's growth rate cannot surpass the rate consistent with its balance-of-payment equilibrium, since it would be unable to finance an endlessly expanding deficit.

One of the most controversial aspects of balance-of-payments-constrained growth models has been the assumption of price stability or the failure to consider the role of external financing in determining long-run growth rates (a flow of foreign exchange that is particularly important for less developed countries). In response to this second criticism, Thirlwall and Hussain (1982) added in external financing as an explanatory variable for long-term growth.

The empirical evidence for balance-of-payments-constrained growth models resoundingly corroborates the validity of Thirlwall's Law. Its relevance for developed economies can be found in works such as those of McCombie and Thirlwall (1994), Atesoglu (1997) and Hieke (1997). Meanwhile, the work of Moreno-Brid (1998), Moreno-Brid and Pérez (1999), López and Cruz (2000), Holland, Vilela and Canuto (2002), Yongbok (2006) and Arevilca and Risso (2007), among others, has focused on external growth constraints in developing economies.

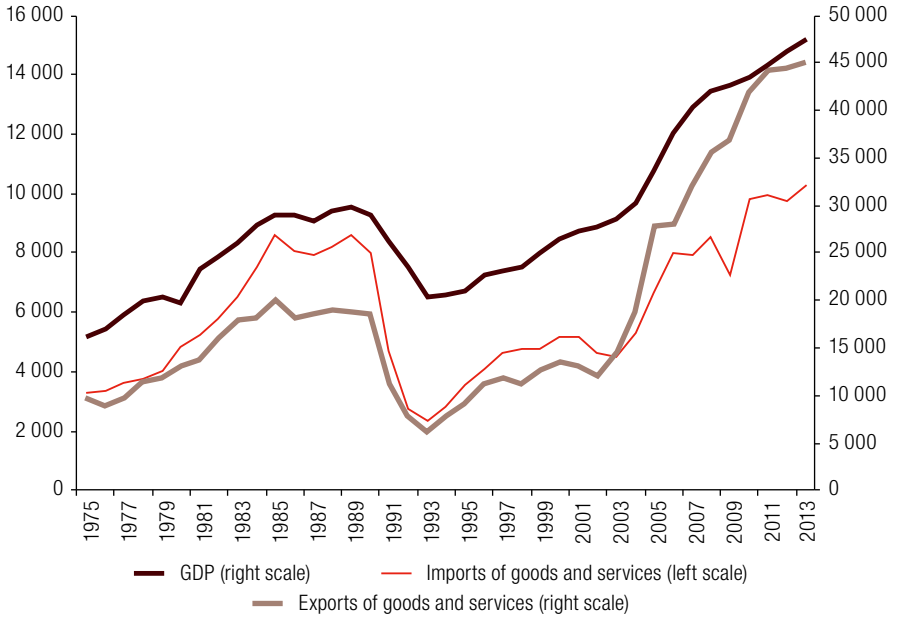
The empirical studies on this question of Mendoza and Robert (2000), Moreno-Brid (2000), Cribeiro and Triana (2005), Alonso and Sánchez (2005), Vidal and Fundora (2008) and Fugarolas, Matesans and Mañalich (2009) have validated the use of balance-of-payments-constrained growth models for the case of Cuba. It can be inferred from the income elasticity of import demand as estimated in the literature that, in the long run, each 1% expansion of Cuba's GDP has required an expansion of around 2% in its exports. Other conclusions shared by most of the studies on this subject include the negative sign of the price elasticity of imports and the stability problems associated with the estimated parameters.

III. External constraints on the Cuban economy: short- and medium-term growth opportunities and threats

Viewing balance-of-payments equilibrium as an economic growth constraint appears to be a plausible hypothesis in the case of open, developing economies such as Cuba's. Scant foreign exchange reserves and the difficulty that the country has had in gaining access to international financing in past decades (as a result of the economic embargo and its suspension of debt payments in 1986) appear to be likely reasons for the extreme sensitivity to export performance historically displayed by Cuban imports. Figure 1 shows how the two series have moved in step with one another during the period from 1975 to 2013 and illustrates the strong correlation between both series and GDP.[1]

[1] The GDP correlation coefficients are 0.85 for the import series and 0.96 for the export series.

Figure 1
Cuba: GDP and exports and imports of goods and services, 1975–2013
(Millions of pesos at constant 1997 prices)



Source: Prepared by the author on the basis of data from the National Office of Statistics and Information (ONEI) and the National Economic Research Institute (INIE).

While it is true that correlation does not always imply causation, an analysis of these series and their inflection points clearly shows that Cuba's GDP is highly sensitive to changes in external sector conditions, thereby suggesting that, in this case, there is a cause-and-effect relationship.

The first sustained growth phase seen during the study period coincides with Cuba's entry into COMECON, which assured it of preferential treatment for its exports and imports.[2] A second inflection point in the GDP series corresponds to the collapse of the Union of Soviet Socialist Republics in 1990 and the end of the advantageous trade relations that Cuba had maintained with the socialist bloc. In response to those events, the Cuban government introduced a reform programme that enabled the country to swiftly find a place for itself in the international economy and paved the way for the recovery of its GDP starting in 1994. That recovery began to gather more steam in 2004 as a result, once again, of changes in the external sector: the upswing in international prices for some of the country's main products (nickel and tobacco) (Chuairey, 2008, p. 77) and the conclusion of trade agreements with Cuba's partners in ALBA, under which it began to export professional services and import Venezuelan oil on preferential terms. Then, however, the combined effect of the deterioration of the country's terms of trade,[3] the international economic crisis, the amortization of Cuba's debt and the critical situation in the Bolivarian Republic of Venezuela led to a contraction of Cuban imports between 2010 and 2014 and cut its average annual growth rate for this period to a meagre 0.81%.[4]

The evident sensitivity of Cuba's GDP to changes in its balance of payments makes a case for examining factors which, given the prevailing degree of uncertainty, may alter its incoming foreign exchange flows in the coming years.

[2] The terms of trade improved by 90% between 1973 and 1975 (ONEI, several years).

[3] The terms of trade worsened by 38% in 2008 (ONEI, several years).

[4] According to the National People's Assembly of Cuba, it planned to make approximately US$ 5.299 billion in payments on its external debt in 2016. See [online] http://www.cubadebate.cu/opinion/2017/01/18/la-economia-cubana-2016-2017-valoracion-preliminar-ii/#.WTBBN8YIHIU.

1. Obama-era agreements and measures that have not been rolled back by Donald Trump

President Barack Obama's arrival in the White House brought the relaxation of some aspects of the economic embargo and, starting in April 2009, of restrictions on travel and remittances to Cuba.[5] Then, during his second term in office, came the historic day of 17 December 2014, when President Raúl Castro and President Barack Obama announced to the world that they were embarking on an effort to normalize relations between the two countries. In the political arena, they agreed to restore diplomatic relations, reopen their embassies, remove Cuba from the list of State sponsors of terrorism, exchange prisoners and put an end to the United States special immigration policy for Cubans arriving on United States soil (commonly referred to as the "wet foot, dry foot" policy). On the economic front, the Obama Administration eased restrictions on travel to Cuba[6] and on sending remittances from the United States to that country,[7] approved new commercial regulations and gave authorization for United States citizens travelling to Cuba to open and hold bank accounts in that country, for airlines and shipping companies to establish direct routes to Cuba without obtaining special permission from the Treasury Department's Office of Foreign Assets Control and for United States firms to set up offices, stores and other facilities in Cuba in such sectors as the press, farming, construction, telecommunications and travel.[8]

The potential impact of these measures in terms of an increase in the supply of foreign exchange in Cuba will be assessed here, while bearing in mind that, since the products covered by these agreements represent no more than a very small portion of Cuba's goods exports, the potential trade effect is very limited.[9] Another factor that greatly limits the potential impact of these agreements on Cuban export trade as a whole is the fact that the State has a monopoly on external sales and can choose to restrict exports by the non-State sector as it sees fit or to block activity that would not be conducive to the business activity of the military.

The new regulations' impact on earnings from service exports and especially from tourism may be quite different, however. Despite restrictions on the reasons for travel (such as the prohibition of individual educational or "people-to-people" travel) and other changes announced by President Trump, the new regulations open up the possibility for any United States resident to travel to Cuba, thereby significantly expanding the potential Cuban tourism market. The importance of the new regulations on travel to Cuba lies in three factors: the substantial relative size of the tourism sector in the Cuban economy, the proximity and size (in both demographic and economic terms) of the United States market and the considerable interest that people can be expected to have in visiting a country with a different political and economic system to which entry had been barred for over 55 years.[10] According to some of the projections made before the change of Administration, such as the forecast prepared by the Boston Consulting Group, over 2 million people from the United States could be visiting Cuba each year by 2025; this projection appears to be borne out by the growth

[5] All travel and remittance restrictions on United States residents with close family members in Cuba were lifted and the restrictions on other United States residents were eased (persons in the latter category were allowed to send up to US$ 500 in remittances per quarter and were allowed to travel to Cuba for the purpose of educational, religious or "people-to-people" exchanges).

[6] United States citizens who do not have family ties to persons residing in Cuba were allowed to travel to Cuba for any of 12 authorized reasons, with no spending limit during their stay.

[7] In September 2015, limits on donative remittances and on the amount of money that authorized travellers could carry with them were eliminated.

[8] In order to promote private enterprise, the Obama Administration authorized exports of building materials, tools, farm equipment and telecommunications technology to Cuba. In addition, the non-State sector was allowed to export coffee, textile products and mobile applications to United States firms, which were also allowed to hire Cuban workers.

[9] In 2015, exports of coffee, tea, spices and extracts accounted for only 0.25% of Cuba's total merchandise exports, while external sales of yarn, fabric and articles made of textile fibres accounted for just 0.01% (ONEI, 2016).

[10] With revenues of US$ 2.8 billion in 2015, tourism was the second-biggest source of foreign exchange for Cuba, coming just after exports of professional services (ONEI, 2016).

rate in travel to the country seen in the last few years, although it may be slowed somewhat by the regulations issued by the new Administration.[11]

One of the most visible effects of the new regulations has undoubtedly been the upswing in remittances. As a result of the regulatory changes introduced in 2009 by the Obama Administration, Cuba witnessed the largest increase in remittances of any Latin American country between 2008 and 2015, as they jumped from US$ 1.447 billion in 2008 to US$ 3.355 billion in 2015 (Morales, 2016). The further relaxation of regulations agreed upon in September 2015, which has not been reversed by the Trump Administration, gives reason to believe that this upward trend will continue in the coming years, especially in view of the fact that the total volume of remittances received by Cuba is still below the levels flowing into other countries of the region whose economies have similar characteristics.

2. A return to international capital markets

The rapprochement initiated by Obama opened up new opportunities in areas of particular importance for a country's growth and development, such as access to medium- and long-term financing at a reasonable cost. Cuba's participation in capital markets had been extremely limited in past decades by the United States embargo and its 1986 default on its external debt. Although the agreements between Cuba and the United States did not put an end to the sanctions imposed on financial institutions, they have allowed the country to finance its non-farm imports, have improved its medium- and long-term growth prospects (and, hence, buoyed market confidence) and have enabled it to garner support from the international community for the reform process approved at the sixth and seventh sessions of the Congress of the Community Party of Cuba (PCC).[12]

Another crucial factor in boosting market confidence has been the priority that the Cuban government has placed on fulfilling the payment obligations agreed upon in the course of the debt restructuring exercise of recent years. Under that restructuring agreement, 14 of the 20 members of the Paris Club forgave nearly 80% of Cuba's debt and extended the remaining maturities up to 18 years.[13] As a result, the country's external debt had been cut from US$ 35 billion in 2001 to US$ 15 billion by 2016. This has enabled the Cuban government to begin to lay the groundwork for the Cuban economy's re-entry into international financial circles. Although this new strategy will only bear fruit slowly and gradually, the market's growing confidence in Cuba has already produced some early results, such as Moody's upward adjustment of the country's credit rating in 2015, the conclusion of major financial agreements with Saudi Arabia, China and the Russian Federation, and its acceptance as a member of the Central American Bank for Economic Integration (CABEI) in April 2017.[14]

3. The growth of foreign investment

The literature on the growth effect of foreign direct investment (FDI) offers a range of divergent opinions, but there appears to be a consensus that, in Cuba's case, this type of investment has had a positive impact on the economy since it was first authorized in 1994 (Pérez, 1999).

In addition to serving as a channel for fresh capital, FDI has given Cuba access to new technologies and to key international markets, such as tourism, mining, energy and telecommunications. The Cuban

[11] Three times as many United States tourists visited Cuba in 2016 as in 2014 (Fitzgerald, 2017).

[12] According to an EFE news agency report of January 2017, between December 2014 and January 2016, the Obama Administration levied US$ 2.843 billion in fines on 11 (7 United States and 4 foreign) institutions (see [online] https://www.efe.com/efe/espana/mundo/cuba-denuncia-multas-de-eeuu-a-ong-y-banco-canadiense-por-violar-el-embargo/10001-3150572).

[13] US$ 8.5 billion out of a total of US$ 11 billion was forgiven.

[14] In its December 2015 risk assessment report, Moody's upgraded Cuba's rating outlook from stable to positive.

government also seems to share this view, since it has identified the promotion of FDI as a basic tool for updating the country's economic model, approved a new law on FDI in March 2014 (which authorizes foreign investment in all sectors except education, health and defence and offers more generous tax benefits and greater protection for foreign capital) and, each year since 2014, has published a portfolio of investment opportunities in over 300 projects for which it wants to attract foreign capital.[15] In May 2014, Vice President Marino Murillo put the goal for annual FDI inflows at between US$ 2 billion and US$ 2.5 billion, which is far above the levels of FDI received by Cuba since its authorization in 1994 and appears to be a harbinger of the strong growth in this type of investment that is very likely to be seen in the coming years.[16]

In addition to the island's natural attractions, its security level is high, it enjoys political and social stability, and its population is highly skilled —all of which puts it in a position to absorb much more foreign investment than it currently receives.

The country's efforts to attract external capital have been greatly aided by its new relations with the United States and by its debt restructuring agreements. Although significant limitations are still placed on investments from the United States, the change in regulations has begun to bear fruit, as is demonstrated by the investment plans (authorized by the United States Department of the Treasury) announced by Cleber LLC and Starwood Hotels and Resorts Worldwide and by the start-up of operations by American Express and MasterCard in Cuba. United States businesses' interest in Cuba is also reflected in the nearly 500 permits for investments in Cuba (for a total of US$ 4.3 billion) issued in 2015 by the United States Department of Commerce.[17] Nevertheless, the greatest potential source of growth in FDI for Cuba lies beyond the borders of the United States, thanks to the renewed interest in Cuba that the normalization process has triggered in much of the international community in the wake of the country's rapprochement with the United States and the improvement in its business outlook (especially in the tourism sector).[18]

4. Relaunching the reform process

The reform process could provide yet another opportunity to spur economic growth and improve the country's balance of payments. Widening inequalities and the failure to meet people's expectations have fuelled a growing sense of unease in some segments of the population that has heightened internal divisions within the Communist Party and has all but brought the implementation of the reforms to a halt. Even so, the reform programme ratified at the seventh session of the Congress of the Community Party of Cuba still holds out great promise for heightening the efficiency of the Cuban economy.

In view of the ground gained thus far, there would appear to be a need for a comprehensive socialist reform programme that would introduce an integral package of complementary measures while sequencing them in such a way as to permit their effective implementation and thus achieving the desired results. Some of the major reforms approved at the sixth session of the Communist Party Congress which still remain to be put into effect six years later include monetary and exchange unification. These measures are of pivotal importance but have been deferred for two main reasons: the fact that they could drive prices up and thus reduce the purchasing power of wages and the fact that they could make imports become more costly, thereby pushing many State enterprises into the red. One way of curbing inflationary pressures and providing more manoeuvring room for restructuring

[15] The promotion of FDI is identified as a basic tool for the updating of the economic model in policy guidelines Nos. 78 and 79 as approved at the seventh sesión of the Congress of the Communist Party of Cuba.

[16] The anual flow of FDI for the period 1994–2013 is estimated at US$ 328 million.

[17] See [online] https://noticias.infocif.es/noticia/cuba-la-espera-de-la-inversion-estadounidense.

[18] The interest awakened by the normalization process is attested to by the Political Dialogue and Cooperation Agreement signed by Cuba and the European Union on 12 December 2016 and the repeal of the Common Position.

the business and labour sectors might be to use a sequential devaluation scheme such that each of a long series of partial devaluations would be preceded by productivity gains. This could make firms' real efficiency levels more apparent and could help to make Cuban exports more competitive and to improve the country's balance of payments.

Some of the main factors that may pose a threat to Cuba's economic growth in the coming years are discussed below.

(a) A tightening of the embargo by the Trump Administration

Although most of the agreements concluded by the Obama Administrations have not been undermined by the changes announced so far by the Trump Administration, it is clear that President Trump's attitude towards Cuba has dampened the expectations created by the normalization process. Furthermore, as the new president's main policy objective is to roll back Obama's policies, a further hardening of the conditions underlying relations between the two countries cannot be ruled out. This would be even more likely if the era of *Chavismo* were to come to an end in the Bolivarian Republic of Venezuela, as this would very probably trigger a deep economic crisis in Cuba that could be seen as an opportunity for the political and social destabilization of that country.

There are many reasons for thinking that the course plotted by Obama in December 2014 will not be entirely reversed, however. Some of the main ones are that a majority of voters in Florida, in particular, and in the United States as a whole view the rapprochement with Cuba as a positive development[19], that a number of United States firms have a great deal at stake (especially in the agricultural, tourism and telecommunications sectors), that a steady stream of Republican governors and legislators have been visiting the country, that a number of major port agreements have been signed and that the embargo has clearly been ineffective.[20]

(b) A change of government in the Bolivarian Republic of Venezuela

Relations between Cuba and the Bolivarian Republic of Venezuela have grown so much closer since 2000 that the latter is now Cuba's largest foreign investor and trading partner.[21] Its degree of dependency has become all the more apparent since the Bolivarian Republic of Venezuela plunged into a severe political and economic crisis, with trade flows between the two countries plummeting by 51% between 2012 and 2015 (ONEI, 2017), Venezuelan oil shipments dropping from 105,000 barrels per day in September 2014 to just 55,000 barrels per day since then, a contraction of Venezuelan imports of Cuban medical services and the absence of Venezuelan investments in Cuba (Mesa-Lago, 2015, p. 3). As a result, in 2016 Cuba's GDP did not only fail to meet its 2% growth target but, for the first time since 1993, actually shrank (by 0.9%).

[19] According to a 2016 survey conducted by the Florida International University, 64% of Cuban Americans in Miami support the policies introduced by President Obama in an effort to improve relations with Cuba. Another survey, published in 2014 by the Atlantic Council, put support for the thawing of relations between the two countries at 64% in the United States as a whole and at 67% in Miami.

[20] Agreements have been signed with Cuba by the ports of Lake Charles and New Orleans, in Louisiana, and ports in Alabama and Virginia during the current Administration.

[21] Between 2010 and 2015, 40% of Cuba's total trade was with the Bolivarian Republic of Venezuela (ONEI, 2017), which supplied more than half of Cuba's total fuel needs and accounted for the lion's share of its exports of medical services (Quiñones and Mañalich, 2010, p. 11).

IV. Estimation of a balance-of-payments-constrained growth model for Cuba

The central idea underlying the model developed by Thirlwall (1979) is that current account imbalances cannot be sustained indefinitely, so a country's long-term growth must be consistent with its balance-of-payments equilibrium. In his analysis, that author cast exports and the income elasticity of the demand for imports as the fundamental variables in determining the long-run economic growth rate.

It follows from that model that all of the world's economies cannot be balance-of-payments constrained at the same time; it is sufficient for one country or one group of countries to not be constrained in order for the rest to be so.

The analysis starts from the identity that defines the balance of payments in equilibrium:

$$P_t^d X_t + E_t F_t = P_t^f M_t \tag{1}$$

where X_t stands for real exports, P_t^d is the local-currency price of exports, F_t is the flow of capital measured in the foreign currency, M_t stands for real imports, P_t^f for the foreign-currency price of imports and E_t for the nominal exchange rate expressed in units of the domestic currency per unit of foreign exchange.

In this model, the economy has two sources of foreign exchange: exports and external financing. The relative share of foreign exchange provided by exports is given by the following expression:

$$\theta = \frac{P_t^d X_t}{P_t^d X_t + E_t F_t} \tag{2}$$

Export and import demand are assumed and expressed as a function of income and price levels at constant elasticities.

$$X_t = \left(\frac{P_t^d}{E_t P_t^f} \right)^{\Psi} Z_t^n \qquad \begin{matrix} \psi, p > 0 \\ \eta, f > 0 \end{matrix} \tag{3}$$

$$M_t = \left(\frac{E_t P_t^f}{P_t^d} \right)^{\phi} Y_t^{\pi} \qquad \begin{matrix} \phi, p > 0 \\ \pi, f > 0 \end{matrix} \tag{4}$$

where Z_t stands for world income, Y_t for national income, Ψ and η for the price and income elasticities of export demand, and θ and π for the price and income elasticities of the demand for imports.

Using logarithms, equations (1), (3) and (4) can be expressed in growth rates:

$$\theta\left(p_t^d + x_t\right) + \left(1 - \theta\right)\left(e_t + f_t\right) = e_t + p_t^f + m_t \tag{5}$$

$$m_t = \phi\left(p_t^f - e_t - p_t^d\right) + \pi y_t \tag{6}$$

$$x_t = \psi\left(p_t^d + e_t - p_t^f\right) + \eta z_t \tag{7}$$

The combination of equations (5), (6) and (7) expresses the growth rate that is consistent with the balance of payments, as follows:

$$y_t = \frac{\theta\eta z_t + (\theta\psi + \phi + 1)(p_t^d - e_t - p_t^f) + (1-\theta)(e_t + f_t - p_t^d)}{\pi} \quad (8)$$

This expression can be simplified if it is assumed that purchasing power parity obtains over the long term $(p_t^d - e_t - p_t^f = 0)$ and the exchange rate remains stable ($e_t = 0$).

$$y_t = \frac{\theta\eta z_t + (1-\theta)(f_t - p_t^d)}{\pi} \quad (9)$$

Thirlwall (1979) also considers that capital flows remain stable over time $(f_t - p_t^d)$ or represent only a small percentage of total foreign exchange flows ($\theta = 1$). Therefore, equations (7) and (8) can be combined to produce the following equation:

$$y_t = \frac{x_t}{\pi} \quad (10)$$

Equation (10), which is known in the literature as Thirlwall's Law, can be used to estimate the growth rate that is consistent with balance-of-payments equilibrium based on the growth of exports and the income elasticity of imports.

The data used in the econometric analysis are the aggregate annual series for 1975–2013.

The GDP series is at constant market prices (using 1997 as the base year) and is taken from ONEI (several years). Because of methodological changes in the way Cuba's GDP is measured (social and personal services had formerly been measured in terms of their cost, but later began to be calculated at estimated market prices), the original series for 2007–2013 needs to be corrected since, as a result of those changes, in 2004 this sector's GDP soared by over 84% (jumping from 11.6% of total GDP in 2003 to 31.3% of GDP in 2004) and since then has inflated aggregate growth rates.[22] Thus, from that year onward, output is recalculated by applying the growth rate of the production sector (which is not altered by the change in methodology) to the figure for the preceding year.[23]

The data on exports of goods and services are taken from the breakdown of the balance of payments given in the statistical yearbooks published by Cuba and from the National Economic Research Institute (INIE).

In much of the literature on balance-of-payments-constrained growth, the external financing variable is proxied by the current account deficit. In order to capture the effect of remittances and FDI on the Cuban economy, the proxy for external financing needs to make it possible to differentiate between this economy's main external flows: external credits, remittances and FDI. External credits are proxied by the difference between the trade deficit (ONEI, several years) and FDI flows and remittances. This is a valid approach because, in an economy such as Cuba's that lacks foreign exchange reserves, the bulk of the deficit that is not financed either by FDI or by remittances will have to be financed via external credits.[24]

The statistical yearbooks published by Cuba that provide official data on FDI flows cover only the period 1994–2001, so the rest of the series has been obtained from the estimates provided by the *Economist Intelligence Unit* (n/d).

[22] For 2004, 2005, 2007 and 2008, the economy's overall growth rates were more than doublé the rates for the production sector (ONEI, several years).

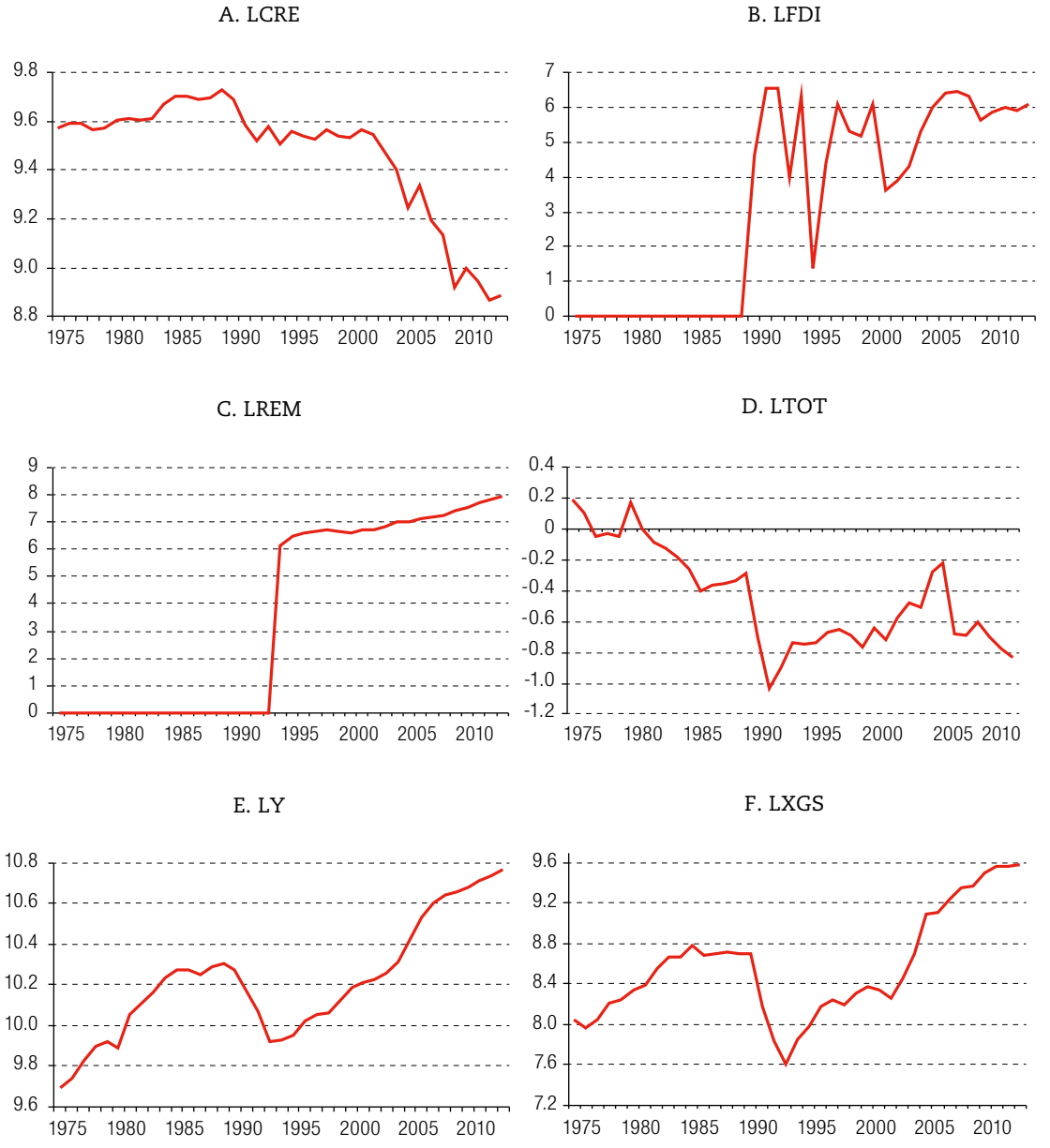
[23] The growth rates used here are taken from ONEI, and the calculations are based on its definition of the production sector, which includes agriculture, industry, mining and energy, tourism, consstruction, and transport and communications.

[24] Following Vidal and Fundora (2008), twice the mínimum value is added to the entire series in order to avoid having negative data in the years where the deficit on current account was smaller than the volume of FDI. This makes it possible to express the variables in logarithms and obtain their elasticities.

Official data on remittances are available only for the years from 1994 to 2004 (ONEI, several years), so this series has been rounded out with data from the Havana Consulting Group for 2005–2013. Both series are in current prices. Data from ONEI and INIE have been used for the terms of trade.

Figure 2 traces the trends reflected in the series used for this analysis.

Figure 2
Time series trends, 1975–2013
(Logarithms)



Source: Prepared by the author.
Note: CRE: external financing in the form of credits; FDI: foreign direct investment; REM: remittances; TOT: terms of trade; Y: GDP; XGS: exports of goods and services. The LFDI and LREM series begin in 1990 and 1994, respectively, because before those dates foreign investment and remittances were not permitted.

The series' stationarity is analysed using augmented Dickey-Fuller tests. The results are shown in table 1.

Table 1
Series stationarity tests, 1975–2013[a]
(Log statistics)

	t-statistic	Constant and trend	Lags
Y	-1.846	Yes	1
XGS	0.962	No	1
REM	0.403	No	0
FDI	-1.723	Constant	0
TOT	-1.933	Constant	0
CRE	-1.702	No	0
ΔY	-2.927*	No	0
ΔXGS	-3.561*	No	0
ΔREM	-5.673*	No	0
ΔFDI	-7.790*	No	0
ΔTOT	-5.527*	No	1
ΔCRE	-6.718*	Constant	0
Resid[b]	-6.672**	No	0

Source: Prepared by the author.
Note: Y: GDP; XGS: exports of goods and services; REM: remittances; FDI: foreign direct investment; TOT: terms of trade; CRE: external financing in the form of credits.
[a] Augmented Dickey-Fuller test.
* Stationary at 1%.
** The values calculated from the t (tau) statistic are compared with the critical values computed in Engle and Yoo (1987), since, in this case, the Dickey-Fuller and MacKinnon (1996) critical values are not derived directly from an underlying stochastic process.

The results of the augmented Dickey-Fuller tests show that the series used for this econometric analysis are not stationary at an order of integration of 1, I(1); any cointegration relationship that may exist between them can therefore be analysed.

To this end, the logarithmic transformations of equations (8) and (10) are alternately analysed in order to see which of the two specifications is the best fit for Cuba's economic growth over the past few decades. A proxy value is also included in the model that takes a value of 1 for the years during which Cuba was covered by preferential trade agreements and a value of 0 for the years when this was not the case in order to capture the benefits provided by those agreements that are not reflected in the official statistics.[25]

$$log\, Y_t = \alpha_1 + \alpha_2\, log XGS_t + e_t \tag{11}$$

$$log\, Y_t = \beta_0 + \beta_1\, log XGS_t + \beta_2\, log\, FDI_t + \beta_3\, log\, REM_t + \beta_4\, log TOT_t + \beta_5\, log\, CRE_t + PA_t + e_t \tag{12}$$

where e_t is the random white-noise error term and the β parameters represent the long-term elasticities of the respective explanatory variables.

The minimum least squares (MLS) estimates for equations (11) and (12) are given in table 2.

[25] Cuba had preferential trade agreements with the Union of Soviet Socialist Republics from 1975 to 1989 and with the Bolivarian Republic of Venezuela from 2001 to 2013.

Table 2
Cuba: minimum least squares (MLS) estimates for equations 11 and 12[a]
(Log statistics)

GDP_t	Equation (11)		Equation (12)	
	Coefficient	t-statistics	Coefficient	t-statistic
Constant	5.920[b]	19.737	3.419[b]	5.893
XGS	0.501[b]	14.993	0.496[b]	29.279
FDI	---	---	0.025[b]	3.274
CRE	---	---	0.239[b]	4.938
REM	---	---	-0.007[c]	-2.425
TOT			-0.324[b]	-7.186
PA			0.114[b]	4.374
Adjusted R^2	0.865	(-1.513)	0.980	
Akaike (Schwarz)	-1.598		-3.424	(-3.126)
Durbin-Watson	0.322		2.020	

Source: Prepared by the author.
Note: XGS: exports of goods and services; FDI: foreign direct investment; CRE: external financing in the form of credits; REM: remittances; TOT: terms of trade; PA: preferential agreements.
[a] Standard errors corrected for heteroscedasticity (Huber-White).
[b] Significant at 1%.
[c] Significant at 5%.

The greater explanatory power of the adjusted R^2 and the improvement in the Akaike and Schwarz criteria and in the Durbin-Watson statistic show that, in the case of Cuba, it is better to use balance-of-payments-constrained growth models that include the terms of trade and foreign exchange flows other than export earnings (such as FDI, external credits and remittances). Both of these models fulfil the assumptions of homoscedasticity and normality of residual and the absence of structural changes. The autocorrelation problems detected in the residuals estimated in equation (11) disappear when other foreign exchange flows, the terms of trade and the proxy variable are included in equation (12) (see the annex).

The variables' cointegration is analysed using the methodology developed by Engle and Granger (1987), in which a cointegration vector can be found such that, when the model's variables are integrated in the same order, these variables can be combined in a lesser order.[26] In the case at hand, the results of the augmented Dickey-Fuller test shown in table 1 indicate that the estimated residuals are stationary, which confirms the existence of a cointegration relationship between the model's variables.[27] Ruling out the possibility that the correlation could be the result of a spurious relationship between the variables makes it possible to interpret such log parameters as long-run elasticities. All the parameters are significant at a 95% confidence level.

The estimated income elasticity of exports (2.02) (which is calculated when using balance-of-payments-constrained growth models as the inverse of the export parameter ($1/\beta_2$), is significant, positive and very close to the values estimated in previous studies that have used balance-of-payments-constrained growth models to analyse the situation in Cuba. The elasticity for FDI confirms the existence of a positive effect on the growth of the Cuban economy. In addition, the positive sign of the parameter for the CRE variable, as expected, indicates that the profitability of Cuban investments financed by external loans has outdistanced the high interest rates charged on those loans. On the other side of

[26] The cointegration methodology developed by Engle and Granger is used here because there are some problems with the generation of nearly singular matrixes when Johansen's test is applied to small samples (Matesanz, Fugarolas and Candaudap, 2007, p. 36).

[27] For the cointegration test, the values for the t-statistic are compared with the critical values calculated by Engle and Yoo (1987), since, in this case, the Dickey-Fuller and MacKinnon (1996) critical values are not directly derived from an underlying stochastic process but are instead the result of a series that is constructed after the model's parameters have been estimated.

the coin, the negative price elasticity of the parameter for the terms of trade is in line with the findings of earlier studies on Cuba and could be accounted for by the lesser importance of the price variable in trade between Cuba and other COMECON members and by the structure of Cuban imports, which are largely composed of staple goods for which demand is less sensitive to price trends. The parameter for remittances was the only one for which the results ran counter to expectations. While the scarcity of consistent public information on remittances to Cuba makes it necessary to exercise caution when evaluating the results of this type of analysis, the negative sign of this parameter may be attributable to the country's strict regulations on investment, which place such tight restrictions on the investment of remittances in the production sector that virtually all of these funds have to be used to improve the consumption levels of their recipients or to pursue highly informal activities involving very low levels of value added.

Following this long-term estimate, given Granger's representation theorem (which states that if a vector of variables is CI (1,1), then there is a valid error correction mechanism (ECM) for representing the data generation process) (Intriligator, Bodkin and Hsiao, 1996), an ECM model can be applied to the present analysis. By combining variables in levels with variables in first differences, this model makes it possible to link a long-term equilibrium analysis with the short-term adjustment pattern and estimate how quickly any departures from long-term equilibrium will be corrected.

The Engle-Granger two-step method, which involves including the estimated residuals, lagged one period, in the ECM model, can then be used:

$$\Delta \log Y_t = \beta_0 + \beta_1 \Delta \log XGS_t + \beta_2 \Delta \log FDI_t + \beta_3 \Delta \log CRE_t + \beta_4 \Delta \log REM_t + \beta_5 \Delta \log TOT_t + \beta_6 PTA_t + \beta_7 errorLT_{t-1} + e_t \quad (13)$$

The results obtained from equation (13) are shown in table 3, which also gives the results obtained after eliminating the variables that had non-significant parameters in the first regression.

Table 3
Error correction mechanism[a]
(Log statistics)

ΔGDP_t	Equation (13)		Equation (13)[b]	
	Coefficient	t- statistic	Coefficient	t-statistic
Constant	-0.006	-0.689	---	---
Δ XGS	0.351[c]	6.552	0.337[c]	5.424
Δ FDI	0.007	1.937	---	---
Δ CRE	0.183	1.551	---	---
Δ REM	-0.001	-0.150	---	---
Δ TOT	-0.204[c]	-2.722	-0.176[c]	-2.738
PA	0.024[c]	2.304	0.016[d]	2.121
LT error(-1)	-0.722[c]	-2.883	-0.706[c]	-3.069
Adjusted R^2	0.682		0.666	
Akaike (Schwarz)	-3.817	(-3.473)	-3.852	(-3.680)
Durbin-Watson	1.886			1.931

Source: Prepared by the author.
Note: XGS: exports of goods and services; FDI: foreign direct investment; CRE: external financing in the form of credits; REM: remittances; TOT: terms of trade.
[a] Standard errors corrected for heteroscedasticity (Huber-White).
[b] Estimation of equation (13), excluding variables that are not significant at 5%.
[c] Significant at 1%.
[d] Significant at 5%.

At a confidence level of 95%, the model fulfils the assumptions of homoscedasticity, non-autocorrelation and normality of residuals (see the annex). Cointegration is confirmed by the significance of the error correction term. The parameter for the estimated speed of adjustment is 0.706, which indicates that temporary departures from long-term equilibrium are fully adjusted in less than two years. The estimated short-term elasticities keep the same sign for all the variables, although, in the short run, only exports, the terms of trade and the proxy variable are significant. This suggests that it takes a longer time for the effect on GDP of credits, foreign investment and remittance to become apparent.

V. Economic policy recommendations and conclusions

The Cuban economy's small size and openness, its lack of foreign exchange reserves and its extremely limited access to international capital markets account for the fact that its growth is so sensitive to its external sector's performance.

The proposed cointegration analysis confirms this hypothesis and supports the conclusion that, although remittances did not have the expected impact on GDP during the study period, FDI, external credits and preferential agreements have all played a significant and positive role in determining the Cuban economy's long-run growth rates.

Consequently, one of the biggest challenges for the country in the long run will be to develop industrial and commercial policies that will reduce the economy's dependence on imports. The external constraints to which it is subject will be fundamental considerations when designing an economic policy that will enable the country to cope with the threats and seize the opportunities that will arise in the coming years. A change of government in the Bolivarian Republic of Venezuela or a hardening of the embargo by the Trump Administration would bring a steep cutback in the amount of foreign exchange that would be available to Cuba and would very likely push the country into another economic crisis during this time of greater political uncertainty so soon after Miguel Díaz-Canel has taken the place of his predecessor, Raúl Castro. In view of this possible scenario, it would appear to be a reasonable choice for the Cuban government to take advantage of the opportunities opened up by the thawing of relations with the United States to revitalize its domestic reform process.

In all probability, in order to ease its external constraints, Cuba will also need to boost FDI, continue to find its way back into capital markets and alter its regulations on the productive investment of remittances. To that end, investment in the non-State sector should be opened up for more highly productive professions and activities so that greater advantage can be taken of Cuba's enormous stock of human capital, much of which is currently underemployed in unskilled or very low-skilled activities. The potential and sustainability of this new framework will hinge on the Cuban government's ability to reconcile higher efficiency levels and the expansion of production capacity with its socialist principles by placing priority on cooperative forms of ownership and implementing a tax policy that will limit inequality and raise the real wages of the population as a whole.

Bibliography

Alonso, J. A. and J. M. Sánchez (2005), "La competitividad desde una perspectiva macro: la restricción externa al crecimiento", *Tecnología, competitividad and capacidad exportadora de la economía cubana: el desafío de los mercados globales*, Havana.

Arevilca, B. J. and A. W. Risso (2007), "Balance of payments constrained growth model: evidence for Bolivia 1953–2002", *MPRA Paper*, No. 5645 [online] https://mpra.ub.uni-muenchen.de/5645/1/MPRA_paper_5645.pdf.

Atesoglu, H. S. (1997), "Balance-of-payments-constrained growth model and its implications for the United States", *Journal of Post Keynesian Economics*, vol. 19, No. 3, Taylor & Francis.

Chuairey, A. (2008), "La sustitución de importaciones en Cuba: un enfoque de elasticidades", thesis, Havana, University of Havana.

Cribeiro, Y. and L. Triana (2005), "Las elasticidades en el comercio exterior cubano: dinámica de corto y largo plazo", thesis, Havana, Faculty of Economics, University of Havana.

Economist Intelligence Unit (n/d), "Country Report Cuba" [online] https://store.eiu.com/product/country-report/cuba.

Engle, R. F. and C. Granger (1987), "Co-integration and error correction: representation. Estimation and testing", *Econometrica*, vol. 55, No. 2, New York, The Econometric Society.

Engle, R. F. and B. S. Yoo (1987), "Forecasting and testing in co-integrated systems", *Journal of Econometrics*, vol. 35, No. 1, Amsterdam, Elsevier.

Fitzgerald, M. (2017), "Taking the long view on Cuba's tourism opportunity" [online] https://www.bcg.com/publications/2017/transportation-travel-tourism-winning-emerging-markets-taking-long-view-cubas-tourism-opportunity.aspx.

Fugarolas, A. U., D. Matesans and I. Mañalich (2009), "Empirical evidence of the balance of payments constrained growth in Cuba. The effects of commercial regimes since 1960", *Versus Acadêmica*, vol. 3.

Hieke, H. (1997), "Balance-of-payments-constrained growth: a reconsideration of the evidence for the U.S. economy", *Journal of Post Keynesian Economics*, vol. 19, No. 3, Taylor & Francis.

Holland, M., F. V. Vilela and O. Canuto (2002), "Economic Growth and the Balance of Payments Constraint in Latin America", paper presented at the Seventh National Political Economy Meeting [online] http://www.sep.org.br/eventos.asp?evento=s_sete.

Intriligator, M., R. Bodkin and C. Hsiao (1996), *Econometric Models, Techniques and Applications*, New Jersey, Prentice Hall.

López, J. and A. Cruz (2000), "Thirlwall's law and beyond: the Latin American experience", *Journal of Post Keynesian Economics*, vol. 22, No. 3, Taylor & Francis.

MacKinnon, J. (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Econometrics*, vol. 11, No. 6, Wiley.

Matesanz, D., G. Fugarolas and E. Candaudap (2007), "Balanza de pagos y crecimiento económico restringido. Una comparación entre la economía argentina y la mexicana", *Revista de Economía Mundial*, No. 107, Huelva, World Economy Society.

McCombie, J. S. L. and A. P. Thirlwall (1994), *Economic Growth and the Balance-of-Payments Constraint*, New York, Palgrave Macmillan.

Mendoza, Y. and L. Robert (2000), "El crecimiento económico y las restricciones en el sector externo. Una aplicación al caso cubano", *Cuba: Investigación Económica*, year 6, No. 3, Havana, National Economic Research Institute (INIE).

Mesa-Lago, C. (2015), "Normalización de relaciones entre EEUU y Cuba: causas prioridades, progresos, obstáculos, efectos and peligros", *Working Paper*, No. 6/2015, Madrid, Elcano Royal Institute.

Morales, E. (2016), "Cuba: the fastest growing remittances market in Latin America", The Havana Consulting Group and TECH [online] http://www.thehavanaconsultinggroup.com/en-/Articles/Article/20.

Moreno-Brid, J. C. (2000), "Crecimiento económico y escasez de divisas", *La economía cubana. Reformas estructurales y desempeño en los noventa* (LC/G.2020/Rev.1), Mexico City, Economic Commission for Latin America and the Caribbean (ECLAC)/Fondo de Cultura Económica.

___(1998), "On capital flows and the balance-of-payments constrained growth model", *Journal of Post Keynesian Economics*, vol. 21, No. 2, Taylor & Francis.

Moreno-Brid, J. C. and E. Pérez (1999), "Balanza de pagos and crecimiento en América Central, 1950–1996", *Comercio Exterior*, vol. 50, No. 1, Mexico City, Banco Nacional de Comercio Exterior (BANCOMEXT).

ONEI (National Office of Statistics and Information) (2017), *Anuario Estadístico de Cuba, 2016*, Havana.
___(2016), *Anuario Estadístico de Cuba, 2015*, Havana.
___(various years), *Anuario Estadístico de Cuba*, Havana.
Pérez, O. E. (1999), "La inversión extranjera directa en Cuba. Peculiaridades", Centre for the Study of the Cuban Economy (CEEC) [online] https://www.nodo50.org/cubasigloXXI/economia/villanueva2_300602.htm.
Quiñones, N. and I. Mañalich (2010), "El sector externo cubano y sus retos estructurales", Havana, National Economic Research Institute (INIE).
Thirlwall, A. (1979), "The balance of payments constraint as an explanation of international growth rate differences", *BNL Quarterly Review*, vol. 32, No. 128, Banca Nazionale del Lavoro.
Thirlwall, A. P. and M. N. Hussain (1982), "The balance of payments constraint, capital flows and growth rate differences between developing countries", *Oxford Economic Papers*, vol. 34, No. 3, Oxford, Oxford University Press.
Vidal, P. and A. Fundora (2008), "Trade-growth relationship in Cuba: estimation using the Kalman filter", *CEPAL Review*, No. 94 (LC/G.2357-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
Yongbok, J. (2006), "Balance-of-payment-constrained growth: the case of China, 1979-2002", *Working Paper Series*, No. 6, Salt Lake City, Utah, University of Utah.

Annex A1

Table A1.1
Statistical test: ordinary least squares (OLS) estimates

Equation	BP[a]	BPG[b]	Jarque Bera
(1)	1.010	1.379	4.451
(2)	22.855	14.481	0.858
(3)[c]	0.741	0.641	2.655

Source: Prepared by the author.
[a] Breusch-Pagan autocorrelation test.
[b] Breusch-Pagan-Godfrey heteroscedasticity test.
[c] Estimate from equation (13) after the elimination of redundant variables.

Who has been driving the creation of industrial employment in Argentina? An analysis of the role of innovation

Mariano Pereira and Ezequiel Tacsir

Abstract

This paper analyses the relationship between innovation and job creation in firms. In particular, it seeks out data on the role played by innovation during the latest phase of expansion in Argentine manufacturing employment (2010–2012). It uses the model proposed by Harrison and others (2014), taking an instrumental variables approach and drawing data from the recently concluded National Survey of Employment Dynamics and Innovation (ENDEI). The results show that process innovations do not influence employment growth, but that this is positively affected by product innovations. The latter also enable production efficiency to be increased by more than it can with existing products. Where the composition of employment in terms of skills is concerned, product innovation is found not to present any particular bias.

Keywords

Employment, technological innovations, employment creation, industry, manufacturing enterprises, employment statistics, Argentina

JEL classification

D22, J23, O31

Authors

Mariano Pereira is a researcher and lecturer at the Institute of Industry (IDEI) of General Sarmiento National University (UNGS) and coordinates the Information, Monitoring and Evaluation Unit (UIME) of the Interdisciplinary Centre for Studies in Science, Technology and Innovation (CIECTI). Email: mpereira@ungs.edu.ar or lic.mpereira@gmail.com.

Ezequiel Tacsir is a senior researcher with the Centre for Economic Research (CINVE) and the United Nations University-Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT). Email: tacsir@cinve.org.uy.

I. Introduction

Employment in Argentine manufacturing industry has followed a path characterized by phases of very deep contractions and strong expansions. Between 1998 and 2001, when the economy was moving towards an abrupt exit from the currency board regime, formal private sector employment contracted by an average of 5% a year. In 2002, following devaluation of the Argentine peso, industrial employment went through a phase of strong expansion, with increases averaging 8.5% a year. During 2009, in the midst of the international financial crisis, there was a large decline (2.2% a year) in the number of jobs. The recovery following the contraction was short-lived but steep: from 2010 to 2012, employment increased by an average of about 3% a year. Lastly, industrial employment has shown no signs of resuming growth since 2013, but has been remarkably stagnant.

The above description leaves room for analysis of the determinants of this performance. In particular, it invites questions about the role played by innovation as a driver of employment. The lack of microdata at the individual firm level formerly made this impossible to investigate. The publication of the National Survey of Employment Dynamics and Innovation (ENDEI), however, has provided an extremely useful tool for answering this and other questions. In particular, the database has allowed attention to be focused on the latest period of expansion in industrial employment (2010–2012) and the following questions to be answered: (i) what effect do the different types of innovation (product, process, organizational change) have on employment (job creation or displacement)? (ii) how are different effects on firms of different sizes and in different sectors (potentially) produced? (iii) do the different types of innovation affect employment quality (skills composition)?

To answer all this, it is necessary to distinguish between the different innovations introduced in firms and their influence on employment via multiple channels. The literature identifies four types of innovation: process, product, marketing and organizational. The debate centres on the first two, which are those considered technological in nature. The purpose of this article is to understand the impact of technological innovations on employment in Argentine manufacturing firms during the latest phase of expansion. It proposes to follow the methodology developed by Harrison and others (2014). This model, hereinafter called the Harrison and others (2014) model, has been employed in most empirical studies carried out with firm-level microdata in recent years.

The article is organized as follows. After this introduction, the second section analyses the relationship between innovation and employment from a theoretical perspective, expanded by a review of the literature on Argentina. The third section expounds the methodological strategy, setting out by presenting the Harrison and others (2014) model and paying special attention to issues related to difficulties with the identification strategy and the need to implement estimates based on instrumental variables (IV) in order to obtain consistent results. The fourth section presents the information used and the main characteristics of the firms, together with their behaviour during the period under analysis. The fifth presents the effects of innovation on employment growth at the firm level. The sixth and seventh sections also expand these results by determining the impact on employment by skill type and break down employment growth into its main factors. Lastly, the eighth section contains conclusions and implications relevant to policy design.

II. The complex relationship between innovation and employment growth

The discussion about the effects of innovation processes (at both the firm level and the aggregate level) on employment is both long-standing and complex (Yoguel, Barletta and Novick, 2013). The effect of innovation is contingent on the level of analysis (direct effects at the firm level and sectoral or

economy-wide indirect effects), transmission mechanisms, institutional aspects and feedback (Pianta, 2006; Vivarelli, 2011). Again, these effects are bound to depend on the technology in use and the impact of these innovations on productivity, as well as on demand conditions. Thus, a variety of compensation mechanisms can be observed.[1]

Similarly, innovation may generate dissimilar effects at the sectoral level, depending on the reaction of other firms to innovations in their sector of activity. Thus, it is possible to envisage redistribution of production and employment levels (loss of market share, comparable to the process of creative destruction) from less innovative to more innovative firms. There may also be situations such as the destruction of jobs due to the withdrawal of non-innovative firms or, conversely, the creation of new firms and jobs (spin-offs) that can exploit the opportunities opened up by the innovations concerned. The final outcome in the sector (i.e., the sum of employment in innovative and non-innovative firms) will depend on the elasticities of substitution within each sector and between different sectors. In this connection, Greenan and Guellec (2000) find, first, that product-innovating firms create more jobs than non-innovating ones and that these sectors as a whole are more dynamic. Second, process innovation, while generating employment at the firm level, has the opposite effect at the sectoral level. Lastly, there may be different effects at the general equilibrium level, depending on the interaction between different markets. Simply put, the speed and responsiveness with which innovators meet increased demand will depend on how quickly other industries can provide the required inputs. At the same time, innovation can affect employment through complementarities in the consumption of goods, increases in variety or improvements in the quality of intermediate inputs. Lastly, the introduction of new products can boost the creation of new economic activities.

Various aspects associated with the characteristics of the productive sector and innovation determinants and behaviour imply that the above-mentioned results cannot be automatically extrapolated to countries such as Argentina. Indeed, knowledge embodied through the acquisition of machinery and equipment (often via international trade) plays an important role, as does technology transfer. Technology and production processes designed for conditions in more developed economies, where innovations are often aimed at improving efficiency in the use of labour (deemed relatively scarce), may not be perfectly adaptable to the context in question, as they will have different effects on employment and its composition. At the same time, the objectives and scope of the innovation process, often oriented towards the adaptation and imitation of products and processes developed at the production frontier, can reinforce these differences.

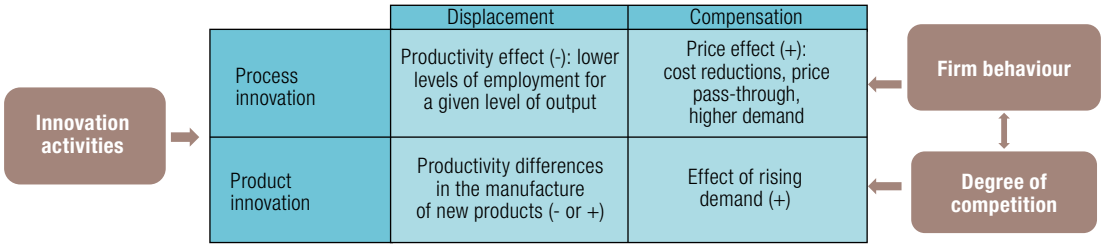
At the same time, the production structure is characterized by a greater presence of SMEs, whose routines and ability to innovate are often based on informal processes, the acquisition of technology rather than investment in intangibles such as research and development (R&D) and a greater focus on less sophisticated markets. Similarly, low-technology manufacturing activities dominate employment and production. With these characteristics, there tend to be lower levels of highly skilled human resources and a preponderance of process innovations over product innovations. Since the prevalence of the different types of innovation may differ between sectors, these effects can be expected to exhibit sectoral heterogeneity. At the same time, it is possible that labour regulations, together with the prevalence of informal working, may affect companies of different sizes in different ways.[2] Consequently, this study will pay special attention to the effects associated with various sectoral groupings (according to their levels of labour informality and technological intensity) and to differences attributable to company size.

Diagram 1 summarizes the displacement and compensation mechanisms characterizing the relationship between innovation and employment growth.

[1] This applies to both process and product innovations. While process innovations can displace employment in the short run, it is reasonable to expect employment to increase in the long run as productivity gains manifest themselves in lower prices to which consumers react. The opposite may occur in the case of product innovations. With the latter, changes in the demand for new goods or services may cause competition to increase, with imitators exercising a compensation effect.

[2] Informal working is a complex, multidimensional and multifaceted phenomenon. Throughout this article, it will be deemed equivalent to non-registration of wage employment in the social security system.

Diagram 1
Process and product innovation mechanisms and employment effects



Source: Prepared by the authors, on the basis of R. Harrison and others, "Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries", *International Journal of Industrial Organizatio*n, vol. 35, Amsterdam, Elsevier, 2014; and G. A. Crespi and E. Tacsir, "Effects of innovation on employment in Latin America", *MERIT Working Papers*, No. 1, Maastricht, United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), 2013.

As stated earlier, the objective of this study is to determine the role played by the generation of innovations during the latest phase of expansion in industrial employment in Argentina (2010–2012). Within this framework, the theoretical procedure allowed the following research questions to be specified: (i) how strong were the compensation and displacement effects? (ii) what ultimately was the balance between them? (iii) do the results change when sectoral and size specificities are taken into account? (iv) was innovation skewed towards opportunities for creating more highly skilled jobs?

1. Empirical background

The literature review shows that few studies have analysed the effects of innovation on the quantity and quality of employment in Argentina. This striking dearth is largely explained by the lack of firm-level microdatabases in the post-convertibility phase. Almost all the studies that do exist analyse the 1990s.

The earliest study is Albornoz (2002), which uses the technology surveys of the first half of the 1990s and finds that the employment substitution effect was stronger than the effect of the complementarities generated. The author argues that this is because the innovation capacity of firms centred more on embodied than on non-embodied innovation efforts. In particular, the positive effects of automation and cost rationalization on employment failed to balance the negative effects of product, process and organizational innovations. The author also analysed the impact of these variables on employment by skill level and showed that innovation did not influence changes in skill requirements.

The study by Roitter, Erbes and Trajtemberg (2007) analyses the relationship between innovation and employment in a group of companies in the Argentine metallurgy sector. The authors argue that during the convertibility crisis (1998 to 2001) the intensity of the innovation process was not associated with changes in employment, which shows how central the cycle is in explaining this variable. The panel analysis reveals that the most innovation-intensive firms in 1992–1996 contributed 13% more employment during the period 1992–2001.

De Elejalde, Giuliodori and Stucchi (2011) estimate the Harrison and others (2014) model with a sample of manufacturing firms obtained from a single survey in 2003 containing retrospective information on the state of the firms for each year since 1998–2001. According to their results, there are no significant data demonstrating the impact of process innovation on employment in those years. As regards product innovation, there were no significant efficiency differences between the production of new and old goods. In decomposing employment growth, they therefore conclude that there is no evidence of a displacement effect resulting from the introduction of product innovations. Employment was only created because of increased demand for older products. Nor do they find that process innovation affects employment, since that type of innovation did not lead to large productivity gains.

Lastly, the only study to move forward into the post-convertibility stage is Yoguel, Barletta and Novick (2013), using a database developed by splicing the records of the Integrated Retirement and Pension System and the SME activity monitoring survey of the Ministry of Labour, Employment and Social Security (MTEySS). The study finds that innovation efforts and intensity both increased the likelihood that firms would achieve high employment growth rates. The positive association of innovation process inputs and outputs with employment dynamics meant that, for the first time, productivity gains were not associated with restructuring processes involving job losses.

III. Methodological strategy

1. The Harrison and others (2014) model: innovation and employment growth

To try to distinguish between the displacement effect and the compensation effect with firm-level data, most empirical studies of recent years have used the methodology developed in Harrison and others (2014). This model includes the estimation of some structural parameters and proposes alternative instruments for solving the problem of endogeneity in covariates.

Harrison and others (2014) show that, to separate the potential employment growth effect due to innovation from that associated with displacement due to the changes made, it is helpful to distinguish between product innovations and process innovations. This article takes the same starting point and differentiates between two types of products: existing products manufactured at the start of the period and new products. Thus, employment growth is broken down into one part associated with improvements in the efficiency of existing products (resulting from process, organizational and commercial innovations with potential labour displacement and any compensation mechanisms associated with increased market size due to a reduction in the prices of these products) and another associated with the introduction of products (product innovation).

Consequently, it may be supposed that a firm can produce two types of products: "existing products" and "new products". Production of these at time t is denoted Y_{1t} and Y_{2t}, respectively. The information available allows each individual firm to be observed at two different points in time: the start of the period (t=1) and the end (t=2). The initial assumption is that each type of product is created with an identical and separable production function, with constant returns to scale.[3] Each technology has an efficiency parameter (θ_{it}) which changes over time. New products may be manufactured with higher or lower levels of efficiency than existing products, and firms can influence production efficiency by means of process (and organizational) innovations. The cost function at time t can be written thus:

$$C\left(w_{1t}, w_{2t}, Y_{1t}, Y_{2t}, \theta_{1t}, \theta_{2t}\right) = c\left(w_{1t}\right)\frac{Y_{1t}}{\theta_{1t}\mathrm{e}^{\eta+\omega_{1t}}} + c\left(w_{2t}\right)\frac{Y_{2t}}{\theta_{2t}\mathrm{e}^{\eta+\omega_{2t}}} \quad (1)$$

where $c(w)$ is a function of input prices. Firms' productivity is affected by a specific unobservable component of fixed effects and shocks (η and ω, respectively). The term η captures all factors that affect productivity but remain constant over time (e.g., the best management skills and motivation), while ω captures shocks that vary over time in their effects on production (e.g., energy shocks, labour disputes and conflicts, and unforeseen problems). According to Shephard's lemma, the conditional demand for labour in the manufacture of each of the products is:

[3] De Elejalde, Giuliodori and Stucchi (2011) propose similar exercises for other production functions.

$$L_{it} = C_L(w_{it})\frac{Y_{it}}{\theta_{1t}e^{\eta+\omega_{it}}} \tag{2}$$

where $C_L(w)$ is the derivative of $c(w)$ with respect to wages. The starting assumption is that $C_L(w)$ remains constant in the reference period and that it is identical for the manufacture of each type of product.[4] In this case, the employment growth rate at the firm level is given by the rate of employment growth in the manufacture of existing products plus the rate for the manufacture of new products. If it is assumed that no new products are created at the start of the period ($Y_{21}=0$), employment growth can be approximated as:

$$l = \frac{\Delta L}{L} = -\left(\frac{\theta_{12}-\theta_{11}}{\theta_{11}}\right) + \left(\frac{Y_{12}-Y_{11}}{Y_{11}}\right) + \frac{\theta_{11}}{\theta_{22}}\frac{Y_{22}}{Y_{11}} - (\omega_{12}-\omega_{11}) \tag{3}[5]$$

This expression indicates that employment growth is the result of change in the efficiency of the production process for existing products, the rate of change in these products and growth attributable to new products. These efficiency gains can be expected to be greater for firms that introduce process innovations associated with existing products (i.e., without product innovations). Again, the effect of product innovation will depend on the difference in efficiency levels between the processes for existing products and new products. If new products were manufactured more efficiently, this ratio would be less than 1 and the growth rate would not be the same as for the product in question owing to the introduction of these new products. Equation (3) therefore suggests the following regression to estimate the effects of innovation on employment:

$$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + v \tag{4}$$

where l is overall employment growth, y_1 is the real rate of growth in sales of existing products, y_2 is the real rate of growth in sales of new products and d captures the introduction of process innovations in the manufacture of existing products. The error term, v, captures productivity shocks. Generally speaking, it seems reasonable to think that the introduction of process innovations tends to displace employment, while product innovations tend to create employment, except when new products replace existing products and those new products are characterized by greater efficiency than the existing products.[6]

2. Identification strategy

The correct identification of equation (4) can be affected by two problems: the possible endogeneity of the innovation variables and the measurement errors generated by using sales at current prices rather than actual sales as regressors. With regard to endogeneity, consistent estimation of (4) requires non-correlation of the variables representing process and product innovations with the error term. Innovations are the result of investment decisions that companies should make in advance. These

[4] This is the case if relative prices do not change much over time or between existing products and new products.

[5] To simplify, this sets out from the assumption that $w_{11} \sim w_{22}$.

[6] Real growth in sales of existing products ($y1$) is the outcome of three different effects: (i) the autonomous increase in demand for existing products experienced by the firm, (ii) the compensation effect induced by price changes after the introduction of process innovations and (iii) the substitution effect resulting from the introduction of new products. Since it is not possible to separate these components without more information, in practice $y1$ will simply be subtracted from l, so an alternative specification of equation (4) is to use the inverse of labour productivity growth as a dependent variable.

decisions depend on the productivity of the firm, which can be characterized as an unobservable element composed of two factors: attributes of the firm that are fairly constant over time (e.g., management skills, shown as η in the above expressions) and productivity shocks (ω). If investments in innovation are correlated with productivity, so are the results. Consequently, the results of innovation are endogenous, which creates a serious identification problem.

Since equation (4) is specified as the real growth rate, it is to be expected that the specific components (fixed effects) of the firm have been removed from the error term. The correlation between innovative products and productivity shocks, meanwhile, will depend on when investment decisions are made. If adopted in advance of shocks (even if there is a delay between decision-making and investments actually being made), the variables related to innovation in equation (4) will not be correlated with the error term and it will be possible to estimate the equation using the ordinary least squares (OLS) method.[7] However, if investment decisions are taken at the same time as productivity shocks occur, the innovation results may be endogenous in equation (4).

In this case, it is interesting and informative to explore the direction of the bias. If process innovations (d) were positively correlated with productivity shocks in the manufacture of existing products in the second period (ω_{12}), the fact that these shocks enter into the error term preceded by a minus sign in (4) means that the correlation should be negative. Thus, the OLS estimation will tend to overestimate the displacement effect or underestimate any compensation effect due to innovation. At the same time, a negative correlation with the error term is also to be expected in the case of product innovations. This means that the OLS method will underestimate the true impact of product innovation on employment growth. Consequently, the impacts estimated by means of OLS are to be interpreted as a "lower bound" to the ratio between these two variables.

The identification of this ratio will depend on the availability of appropriate instruments (i.e., instruments correlated with the innovation variables but not with the error term). Although innovation surveys provide a number of variables that can be used as instruments, the great majority are more suitable for identifying product innovation than process innovation, which has more idiosyncratic characteristics. It should be mentioned that most of the companies that report having introduced product innovations have done so in combination with process innovations ("coinnovation"). For empirical purposes, these firms are considered to be product innovators. The number of firms that only introduce process innovations (i.e., without product innovations) is small. For that reason, even considering the negative bias described above, their influence can be expected to be marginal. Consequently, empirical implementation will focus on obtaining reliable estimates for product innovations, on the assumption that process innovations tend to be exogenous.[8]

A second source of endogeneity is the presence of measuring errors. Ideally, equation (4) should contain information about real-term production of existing products (y_1) and new products (y_2). Instead, all it contains is nominal sales growth (g_1 and g_2), as firm-level prices are not available. For both products, current sales growth can be decomposed into two terms: real growth and price changes. In other words, $g_1 = y_1 + \pi_1$ for existing products and $g_2 = y_2 + \pi_2$ for new products. If these two expressions are substituted into (4) and nominal sales growth for existing products is moved to the left of the expression, the result is:

$$l - g_1 = \alpha_0 + \alpha_1 d + \beta g_2 + \left(-\pi_1 + \beta\pi_2 + v\right) \tag{5}$$

[7] These are the type of investment decisions found in Olley and Pakes (1996).

[8] There are good reasons to think that process innovations are indeed exogenous. As Harrison and others (2014) explain, it is realistic to assume that companies are not able to predict labour problems, disruptions in their supply chains or organizational shocks when they make decisions about their process investments. Similarly, this paper maintains the hypothesis that process innovations are exogenous.

Thus, growth in the prices of both products appears in the error term, and the correlation between the prices of the new products (π_2) and g_2 has the potential to create an additional bias in product innovation. As in the previous case, this will be manifested as an attenuation bias in the estimation of β using the OLS method. To deal with the measurement problem, we have followed Harrison and others (2014) and used instrumental variables correlated with real growth in the manufacture of new products, but not with nominal growth.

According to Harrison and others (2014), using the nominal sales growth rate is also bound to affect interpretation of the process innovation results. The rate of price growth for existing products may be affected by the efficiency impact of process innovations, since efficiency gains are manifested in prices. In other words, it is possible that $\pi_1 = \pi_0 + \gamma\alpha_1 d$, where γ is a parameter measuring price pass-through in an interval [0,1]. Replacing this expression in equation (5) gives:

$$l - g_1 = \alpha_0 + (1-\gamma)\alpha_1 d + \beta g_2 + (-\pi_1 + \beta\pi_2 + v) \tag{5.1}$$

The lack of price data at the firm level means that the true displacement effect may be underestimated. How severe this underestimation is will depend on the extent to which higher efficiency due to innovation passes through to prices. If pass-through were high, with γ~1, process innovations could prove non-significant. To correct this problem, we have followed the strategy developed by Harrison and others (2014), which consists in approximating prices at the firm level (π_1) using deflators at the level of the relevant sector of activity (π). Thus, the estimation consists in:

$$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + (-(\pi_1 - \pi) - \beta\pi_2 + v) \tag{6}$$

If prices at the firm level do not deviate much from the deflators at the sectoral level $(\pi \approx \pi_1)$, it will be possible to obtain more consistent estimators of the displacement effect caused by process innovations for existing products.

Innovation can have different effects on the creation of skilled and unskilled employment. If it is skill-biased, as a number of theoretical studies (Card and DiNardo, 2002; Acemoglu, 1998, among others) have argued, higher levels of innovation may be associated with lower rates of growth in unskilled employment and higher growth in skilled employment.

To analyse the effect of innovation on the composition of employment, the approach described in the previous section is followed and a variant of equation (6) is used. Specifically, the growth rate of each type of employment, skilled (l^s) and unskilled (l^{us}), is estimated separately.

$$l_{it}^{s} - (g_{1it} - \pi) = \alpha_0^s + \alpha_1^s d_{it} + \beta^s g_{2it} + \varepsilon_{it} \tag{7}$$

$$l_{it}^{us} - (g_{1it} - \pi) = \alpha_0^{us} + \alpha_1^{us} d_{it} + \beta^{us} g_{2it} + \eta_{it} \tag{8}$$

The dependent variable is employment growth (for each skill type) minus the real increase in sales of existing products. Equations (7) and (8) can be used to analyse how each type of innovation separately influences the growth of the different employment types. Similarly, and for the reasons already described, instrumental variables are used.

IV. Database and descriptive statistics

To model the relationship between innovation and employment growth, use was made of the ENDEI with information on Argentine manufacturing firms for the period 2010–2012. This database is the product of a joint study by the Ministry of Science, Technology and Productive Innovation (MINCyT) and the Ministry of Labour, Employment and Social Security (MTEySS) of Argentina. The form prepared for the ENDEI was based on the Oslo and Bogotá Manual for collecting information on innovation activities in firms. The sampling frame was composed of private firms with 10 or more workers registered in the Argentine Integrated Social Security System (SIPA). From this, a sample stratified by branch of activity and size was selected. Some firms were incorporated by stratified random sampling and others by forced inclusion. The population distribution for which the survey was designed was 18,900 firms, while 3,995 cases were selected for the sample, with a response rate of 92% (3,691 cases). The ENDEI contains detailed information on the characteristics of firms, their innovation activities and their employment (in terms of both evolution and composition), making it possible to calculate the percentage of sales of new products and thence nominal growth in sales of new products (g_2).[9]

To describe the results of this database, a taxonomy of firms was constructed by types of innovation behaviour: product innovators, process innovators (only) and non-innovators.[10] As in Harrison and others (2014), firms that innovated (in both processes and products) were classified as product innovators. This decision was based on the fact that firms innovating in both categories behave more like product innovators than those that are only process innovators, or those making organizational changes.

Table 1 presents a series of descriptive statistics for the total sample, stratified by sectoral technology content and size. Where the innovation performance of these firms is concerned, between 2010 and 2012 about 50% stated that they had introduced some product innovation, just over 7% introduced process innovations only and about 43% did not introduce any new products or processes. Small firms in high-technology sectors are overrepresented in the category of non-innovative companies. On the other hand, medium-sized and large firms in low-technology sectors are overrepresented among the innovators.

With regard to employment growth, it may be mentioned that whilst non-innovative firms destroyed jobs, those that introduced an innovation grew strongly enough to offset this decline, so that employment grew overall. This result is quite robust when different types of sectors or company sizes are compared. The results are similar for firms that are both process and product innovators, without there being any a priori reason to believe that process innovation is detrimental to employment, suggesting the presence of compensation effects. In the case of product innovations, sales of existing products show positive growth rates, with growth in new products coming on top of this.

The ENDEI can also be used to analyse employment growth by skill level. There was net destruction of low-skilled jobs among non-innovative firms, this being particularly intensive among low-technology firms. At the same time, there was subdued growth in high-skilled employment in innovative firms. Second, skilled employment in innovative firms grew faster than low-skilled employment, a finding that does not change when the technology content of the sector to which the firm belongs or its size is controlled for. Third, when the entirety of firms is analysed, what stands out is the growth of skilled employment among small low-technology firms. Low-skilled employment, meanwhile, only grew strongly among low-technology firms.

[9] The ENDEI includes a question about the proportion of sales at the end of the period that correspond to product innovations. This proportion is called s. It also includes information about nominal sales growth (g). Given that sales of new products at the beginning of the period are by definition zero, it can easily be deduced that nominal growth in sales of new products can be calculated as $g_2 = s\,(1+g)$.

[10] Includes organizational and marketing-related changes.

Table 1
Product and process innovators: growth in employment, sales, productivity, employment and prices, 2010–2012[a]
(Percentages)

	Total	Technology content[b]		Size[c]	
		Low	High	Small	Medium and large
Number of firms					
Non-innovators (process or product)	43.3	2.3	52.6	46.2	19.2
Process innovators only	7.4	5.6	7.9	6.8	13.2
Product innovators	49.3	92.1	39.5	47.1	67.5
Employment growth[d]					
Non-innovators (process or product)	-1.9	-2.6	-1.9	-1.7	-6.6
Process innovators only	2.4	10.7	1.0	4.0	-4.6
Product innovators	6.6	4.2	7.9	7.1	3.5
All firms	2.6	4.4	2.2	2.9	0.5
low-skilled[e]					
Non-innovators (process or product)	-2.2	-3.1	-2.2	-2.0	-6.3
Process innovators only	1.7	9.9	0.4	3.1	-4.6
Product innovators	6.7	3.9	8.2	7.1	4.5
All firms	2.5	4.1	2.1	2.6	1.2
high-skilled					
Non-innovators (process or product)	0.4	-0.4	0.4	0.4	0.1
Process innovators only	4.2	9.0	3.4	2.6	10.7
Product innovators	5.5	5.8	5.3	5.2	6.9
All firms	3.2	5.8	2.6	2.8	6.1
Sales growth					
Non-innovators (process or product)	22.8	18.2	22.9	23.2	16.1
Process innovators only	23.3	24.9	23.0	24.6	17.5
Product innovators	24.3	22.4	25.4	24.6	22.7
Sales are divided into:					
old products	7.8	5.0	9.3	7.9	6.8
new products	16.5	17.4	15.9	16.6	15.9
All firms	23.6	22.5	23.9	23.9	20.8

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] The statistics reported are from the expanded ENDEI.
[b] Low-technology: firms whose R&D intensity relative to sales is below the sample mean; high-technology: firms whose R&D intensity relative to sales is above the sample mean.
[c] Small firms: up to 25 employees; medium-sized and large firms: 26 or more employees.
[d] Statistics on firms are reported with data for total, skilled and unskilled employment. Thus, the totals may differ from those reported earlier.
[e] High-skilled: employees with a university or tertiary degree; low-skilled: employees with less than a university or tertiary degree.

V. Results

The purpose of the first exercise carried out is to obtain a naive estimate using OLS (see table 2). The specification is based on regressing employment growth with growth in deflated total sales, binary variables for different types of innovation (process and product) and sectoral indicators. The results show that employment growth rates are positively affected by real sales growth as well as process or product innovations in each of the specifications presented.

The methodological discussion indicates that direct estimation by classical least squares (CLS) yields biased results if: (i) the innovation results are correlated with productivity shocks, or (ii) part of the growth in prices ends up being captured by the error term. While the first scenario can be dismissed because bounded rationality prevents firms from anticipating unforeseen productivity shocks, the second

scenario needs to be considered. The estimates presented are therefore inconsistent, although they show partial correlations that are very informative for describing the data, but not for identifying the effect of innovation on employment growth.

Table 2
Naive estimates of the relationship between innovation and employment, all firms[a b]

	(1)	(2)	(3)
Process innovator only (not product innovator)	-0.733	5.605**	
	(1.990)	(2.134)	
Product innovator only (not process innovator)	0.724		7.055**
	(1.785)		(1.916)
Product and process innovator	6.338**		
	(1.059)		
Product innovator		6.464**	
		(1.052)	
Process innovator			6.232**
			(1.062)
Real sales growth	0.388**	0.388**	0.388**
	(0.075)	(0.075)	(0.075)
Constant	-6.309**	-6.307**	-6.308**
	(0.996)	(0.996)	(0.996)
Observations	3.517	3.517	3.517
R squared	0.164	0.164	0.164
H0: Product and process = Process only	0.00284		
H0: Product and process = Product only	0.0116		

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.

The identification strategy consists in using instruments that are correlated with the product innovation results whilst being orthogonal to the error term. Two instruments are proposed: (i) access to new markets as a result of the innovations brought in by the firm and (ii) knowledge (not necessarily use) of public innovation support instruments.[11] An instrument must meet two conditions to be valid. The first is known as the orthogonality condition and holds that the instrument should not be correlated with the error term. In the context of the present study, this implies that it must be orthogonal to (or conditionally independent of) growth in new product prices. In relation to the first instrument, access to new markets does not imply a specific direction for price growth: a higher market share could entail lower prices; likewise, the introduction of a new product could lead to an increase in prices. In relation to the second instrument, the identification strategy is based on the implausibility of the correlation between knowledge of public programmes supporting innovation and growth in new product prices (De Elejalde, Giuliodori and Stucchi, 2011). At the same time, once the sector, size and time-fixed productivity shocks are controlled for, both instruments can also be considered exogenous. First, since information is costly to acquire, only the largest and most productive companies could make the necessary investment. These effects are taken into account by controlling for size and for productivity fixed effects. Second, access to new markets is usually correlated with the size of firms and the sector they are in. These effects are controlled for by incorporating sector and size fixed effects.

The second requirement is known as a relevance condition and requires non-trivial correlation between the proposed instrument and the endogenous variable. This condition can be subjected to a test of joint significance on the instruments proposed in the first stage of the regression. Stock, Wright and Yogo (2002) recommend an F-statistic value greater than 10 to avoid problems of weak instruments that could introduce biases into the instrumental variables estimation.

[11] In both cases, binary variables are used to determine access to new markets or knowledge of public instruments.

Tables 3 and 4 present these results, controlled for by size and sectoral technology content. In neither case are there found to be effects on employment due to the introduction of process innovations in employment. As highlighted in the literature, there is a positive effect on employment from the introduction of products. Interestingly, the data indicate that new products are produced more efficiently than existing ones (i.e. the g_2 coefficient is less than 1), so employment growth is associated with the expansion of innovations in a context of expanding demand. The negative coefficient of the constant suggests productivity improvements in the manufacture of existing products. In the case of SMEs, although they show greater efficiency for new products than for existing ones, the possibility of this coefficient being equal to 1 cannot be ruled out.

Table 3
Employment growth by size: instrumental variables estimation[a b c d]

Variable	(1) [IV-Total]	(2) [IV-Small]	(3) [IV-Medium-sized and large]
Sales growth from new products	0.640**	0.829**	0.608**
	(0.030)	(0.062)	(0.034)
Process innovator (*d*)	-2.063	-0.926	-2.210
	(1.854)	(2.421)	(2.365)
Constant	-7.182**	-6.023*	-8.026**
	(1.747)	(2.577)	(2.116)
Observations	3.517	729	2.788
R squared	0.164	0.294	0.151
Sector dummies	Yes	Yes	Yes
Wu-Hausman test	2.256	2.550	1.031
p-value	0.133	0.111	0.310
Sargan test	128.2	7.441	109.6
p-value	0	0.00638	0

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] Small firms: up to 25 employees; medium-sized and large firms: 26 or more employees.

Table 4
Employment growth by technology content: instrumental variables estimation[a b c d]

Variable	(1) [IV-Total]	(2) [IV-Low-technology]	(3) [IV-High-technology]
Sales growth from new products	0.640**	0.538**	0.658**
	(0.030)	(0.048)	(0.038)
Process innovator (*d*)	-2.063	-2.849	-1.810
	(1.854)	(4.229)	(2.063)
Constant	-7.182**	-1.410	-8.084**
	(1.747)	(3.899)	(1.945)
Observations	3.517	767	2.750
R squared	0.164	0.194	0.148
Sector dummies	Yes	Yes	Yes
Wu-Hausman test	2.256	1.334	1.033
p-value	0.133	0.248	0.25
Sargan test	128.2	37.50	85.98
p-value	0	9.16e-10	0.010

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] Low-technology: firms whose R&D intensity relative to sales is below the sample mean; high-technology: firms whose R&D intensity relative to sales is above the sample mean.

Combining these categorizations, table 5 presents an estimation differentiated by size and sectoral technology intensity. Although the results are similar to those presented in the two previous tables, it can be observed that medium-sized firms, especially those operating in high-technology sectors, show less of an efficiency gain when they replace existing products with new products in their portfolios. At the same time, it is interesting to note that firms operating in low-technology sectors (as seen in table 5) do not show productivity gains associated with expanding demand.

Table 5
Employment growth by size and technology content: instrumental variables estimation[a b c d e]

Variables	(1) [IV-Total]	(1) [Small and low-technology]	(2) [Small and high-technology]	(3) [Medium-sized and large and low-technology]	(4) [Medium-sized and large and high-technology]
Sales growth from new products	0.640**	0.522**	0.617**	0.639**	0.899**
	(0.030)	(0.054)	(0.043)	(0.113)	(0.076)
Process innovator (*d*)	-2.063	-4.236	-1.601	1.549	-1.950
	(1.854)	(5.688)	(2.603)	(5.244)	(2.682)
Constant	-7.182**	-1.652	-8.935**	-1.786	-6.994*
	(1.747)	(4.969)	(2.330)	(5.219)	(2.883)
Observations	3.517	580	2.208	187	542
R squared	0.164	0.185	0.133	0.328	0.319
Sector dummies	Yes	Yes	Yes	Yes	Yes
Wu-Hausman test	2.256	0.479	0.382	0.405	2.903
p-value	0.133	0.489	0	0.526	0.0118
Sargan test	128.2	38.45	70.80	0.160	6.334
p-value	0	5.63e-10	0	0.689	0.0890

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] Low-technology: firms whose R&D intensity relative to sales is below the sample mean; high-technology: firms whose R&D intensity relative to sales is above the sample mean.
[e] Small firms: up to 25 employees; medium-sized and large firms: 26 or more employees.

VI. Innovation and its impacts on employment composition (quality)

This section presents the results of the estimates of equations (7) and (8), controlling for fixed effects at the sectoral level. As in the previous section, the strategy applied is based on the use of instrumental variables. Taking into account the validity of the instruments used, the same instruments as were presented in the previous sections are employed again.

The results presented in table 6 suggest some interesting patterns as regards impacts on employment composition. First, the coefficients associated with product innovation are significant and show a tendency to improve efficiency when new products come to be manufactured. Second, coefficients associated with g_2 do not differ between employment skill types, implying that product innovation has no specific bias. Where process innovation is concerned, although the coefficients are not significant, a higher numerical value is observed for skilled employment (albeit with more imprecise coefficients). It is worth noting that improvements in trend productivity (captured by the constant) exhibit greater destruction of high-skilled employment.

Table 6
Employment growth by skill level: instrumental variables estimation[a b c d e]

Variable	(1) [IV-Total]	(2) [IV-High-skilled]	(3) [IV-Low-skilled]
Sales growth from new products	0.670**	0.560**	0.670**
	(0.031)	(0.034)	(0.033)
Process innovator (*d*)	-2.401	-1.533	-2.816
	(1.865)	(2.029)	(1.978)
Constant	-7.065**	-3.801*	-7.121**
	(1.760)	(1.915)	(1.867)
Observations	3.433	3.433	3.433
R squared	0.170	0.104	0.158
Sector dummies	Yes	Yes	Yes
Wu-Hausman test	1.801	10.64	1.057
p-value	0.180	0	0.304
Sargan test	108.3	77.03	95.03
p-value	0	0.00111	0

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] High-skilled: employees with a university or tertiary degree; low-skilled: employees with less than a university or tertiary degree.
[e] Estimates for firms with data on total, skilled and unskilled employment are reported. Thus, the totals may differ from those reported earlier.

The results are similar for small enterprises with different sectoral technological intensities (see tables 7 and 8). First, the g_2 coefficients for small enterprises are close to 1, especially where low-skilled employment is concerned. This shows that there are no changes in production efficiency when switching from existing products to new products. Second, process innovations have a skilled personnel displacement effect in the case of larger firms.

Table 7
Employment growth by skill level and technology content: instrumental variables estimation[a b c d e f]

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Small			Medium-sized and large		
	[IV-Total]	[IV-High-skilled]	[IV-Low-skilled]	[IV-Total]	[IV-High-skilled]	[IV-Low-skilled]
Sales growth from new products	0.813**	0.728**	0.818**	0.644**	0.515**	0.644**
	(0.063)	(0.093)	(0.070)	(0.035)	(0.036)	(0.037)
Process innovator (*d*)	-1.006	4.327	-1.634	-2.764	-4.759+	-3.145
	(2.409)	(3.575)	(2.689)	(2.399)	(2.463)	(2.528)
Constant	-5.833*	2.095	-5.298+	-7.839**	-6.008**	-8.100**
	(2.564)	(3.805)	(2.862)	(2.145)	(2.203)	(2.260)
Observations	725	725	725	2.708	2.708	2.708
R squared	0.291	0.141	0.256	0.157	0.105	0.148
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wu-Hausman test	2.332	3.117	2.366	0.681	7.340	0.169
p-value	0.127	0.00497	0.124	0.409	0.00679	0.681
Sargan test	7.672	7.892	4.344	92.39	61.60	83.98
p-value	0.00561	0.0779	0.0371	0	0	0

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] Small firms: up to 25 employees; medium-sized and large firms: 26 or more employees.
[e] High-skilled: employees with a university or tertiary degree; low-skilled: employees with less than a university or tertiary degree.
[f] Estimates for firms with data on total, skilled and unskilled employment are reported. Thus, the totals may differ from those reported earlier.

Table 8
Employment growth by skill level and size: instrumental variables estimation[a b c d e f]

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Low-technology			High-technology		
	[IV-Total]	[IV-High-skilled]	[IV-Low-skilled]	[IV-Total]	[IV-High-skilled]	[IV-Low-skilled]
Sales growth from new products	0.613**	0.430**	0.619**	0.664**	0.563**	0.665**
	(0.051)	(0.057)	(0.057)	(0.039)	(0.042)	(0.041)
Process innovator (*d*)	-1.392	-3.093	-1.403	-2.498	-0.974	-2.945
	(4.195)	(4.720)	(4.662)	(2.083)	(2.247)	(2.188)
Constant	-2.574	5.940	-2.844	-7.702**	-5.337*	-7.739**
	(3.865)	(4.349)	(4.295)	(1.967)	(2.122)	(2.066)
Observations	751	751	751	2.682	2.682	2.682
R squared	0.212	0.110	0.188	0.150	0.092	0.143
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wu-Hausman test	1.071	3.702	0.535	0.631	6.496	0.349
p-value	0.301	0.000621	0.465	0	0.0109	0
Sargan test	19.27	11.71	15.40	80.85	59.31	71.51
p-value	1.14e-05	0.0547	8.69e-05	0.427	0	0.555

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).
[a] Robust standard errors in brackets.
[b] Statistical significance levels: ** p<0.01, * p<0.05, *** p<0.1.
[c] All estimates include two-digit industry dummies as additional controls.
[d] Low-technology: firms whose R&D intensity relative to sales is below the sample mean; high-technology: firms whose R&D intensity relative to sales is above the sample mean.
[e] High-skilled: employees with a university or tertiary degree; low-skilled: employees with less than a university or tertiary degree.
[f] Estimates for firms with data on total, skilled and unskilled employment are reported. Thus, the totals may differ from those reported earlier.

VII. Decomposition of the effects of innovation on employment

The results obtained can be used to break employment growth down into four components. Going by the specification presented in equation (6) and the results obtained using instrumental variables, employment growth for each firm can be written as follows:

$$l = \left[\sum_j \left(\hat{\alpha}_0 + \hat{\alpha}_{0j}\right) ind_j\right] + \hat{\alpha}_1 d + \left[1 - 1\left(g_2 > 0\right)\right]\left(g_1 - \pi_1\right) + 1\left(g_2 > 0\right)\left(g_1 - \pi_1 + \hat{\beta} g_2\right) + \hat{u}$$

The first component $\left[\sum_j \left(\hat{\alpha}_0 + \hat{\alpha}_{0j}\right) ind_j\right]$ measures the change in employment that is attributable $\left(\widehat{\alpha_1 d}\right)$ to the (sector-specific) productivity trend in the manufacture of existing products. The second term measures firm-specific productivity growth due to process innovation. The third component $\left[1 - 1\left(g_2 > 0\right)\right]\left(g_1 - \pi_1\right)$ is the change in employment associated with growth in output of existing products at firms that did not bring new products to market. Lastly, $1\left(g_2 > 0\right)\left(g_1 - \pi_1 + \hat{\beta} g_2\right)$ gives the net contribution of product innovation (i.e., after allowing new products to be substituted for existing products). The term $\hat{u}$ is a residual component with an average of zero.

Table 9 sets out the results of applying this decomposition on the basis of the descriptive statistics presented in table 1 and the coefficients obtained in the instrumental variables estimation of tables 5 and 6.

Table 9
Decomposition of total employment in manufacturing industry: instrumental variables estimation, 2010–2012

	Total	Size		Technology content	
		Small	Medium and large	Low	High
Employment growth	2.2	2.5	1.6	3.8	1.8
Productivity trends in the manufacture of old products	-6.9	-8.1	-4.7	0.0	-8.0
Gross effect of process innovation in the manufacture of old products	-0.2	-0.1	-0.3	-0.2	-0.2
Contribution of growth in the manufacture of old products	4.9	5.5	2.5	0.6	6.0
Net contribution of product innovation	4.4	5.2	4.0	3.4	4.0
Contribution of existing products (product innovators)	1.4	1.7	-0.3	-4.8	2.1
Contribution of new products (product innovators)	3.0	3.5	4.4	8.2	1.9

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).

The first component shows that improving productivity for existing products is a significant cause of lower employment for a given level of output. The effects are very large, except in low-technology companies, where the opposite seems to occur.

Although growth in production levels during this period of expansion brings increased demand for employment (the third component), this greater demand is not enough to compensate for the reductions stemming from trend improvements in sectoral productivity. The lowest level of compensation in this regard is observed in firms in low-technology sectors.

For their part, process innovations are responsible for a reduction in employment, which produces a small displacement effect. Drawing on Harrison and others (2014), this effect can be explained in part by underestimation and by the fact that few firms introduce process innovations without product innovations. Thus, while process innovations can lead to large reductions in employment on occasion, they have only a small effect in terms of aggregate changes in employment.

Consequently, it is clear that product innovations are the ones playing the fundamental role in job creation at the firm level. This result is maintained in the whole panel of firms and in the estimates by size and technology content. This is particularly so for small businesses, which would show significant job destruction without this effect.

Table 10 presents the results of applying this decomposition by means of the descriptive statistics presented in tables 1 and 8, plus the coefficients obtained in the instrumental variables estimation of table 9.

Table 10
Decomposition of total high- and low-skilled employment in manufacturing industry: instrumental variables estimation, 2010–2012

	Total employment	High-skilled employment	Low-skilled employment
Employment growth	2.2	4.1	2.2
Productivity trends in the manufacture of old products	-6.8	-4.7	-7.0
Gross effect of process innovation in the manufacture of old products	-0.2	-0.1	-0.2
Contribution of growth in the manufacture of old products	4.9	4.9	4.9
Net contribution of product innovation	4.4	4.1	4.6
Contribution of existing products (product innovators)	1.4	1.4	1.4
Contribution of new products (product innovators)	3.0	2.7	3.2

Source: Prepared by the authors, on the basis of data from the Employment and Innovation Dynamics National Survey (ENDEI).

The components explanation yields a scenario similar to the previous one. The destruction of employment attributable to improved productivity in the manufacture of existing products is very considerable (especially in the low-skilled segment). However, it is not fully compensated for by the increase in demand for labour resulting from the growth in production levels, so that it is product innovations that are responsible for net job creation in the period.

VIII. Conclusions

This article has analysed the effect of innovation on the job creation process. In particular, it has attempted to identify the role played by innovation during the latest phase of employment growth in Argentine manufacturing industry. To this end, it applied the model originally proposed by Harrison and others (2014), applying an instrumental variables approach in which use was made of the recently introduced ENDEI with information from the period 2010–2012. The results show that while process innovations are responsible for a small reduction in employment by generating a small displacement effect, compensation effects tend to prevail in the overall outcome. Employment growth is positively affected by product innovations. This result holds for firms of different sizes operating in sectors of different technology intensity. At the same time, new products were found to be manufactured more efficiently than existing products, so employment growth is associated with the expansion of innovations in a context of growing demand. With regard to the effects on the composition of employment, product innovation is found to have no specific bias. The skilled employment displacement effect caused by process innovations is greater in larger firms.

The results provide important inputs for the literature on innovation and employment in Argentina. For the first time, and contrary to what was shown by studies analysing the convertibility period, compensation effects prevailed over mechanisms that displaced jobs following the introduction of innovations. Although empirical data confirm that innovation is a major determinant of growth and productivity at the firm level, the evidence is scant. This paper thus makes an important contribution to the literature by highlighting the leading role played by innovation during the industrial employment expansion phase in the period 2010–2012.

From another perspective, analysing the contribution of work to policy design yields results with implications worth highlighting. In particular, they show that it is essential to understand the relationship between innovation and employment at the firm level to be able to predict how different types of innovation will affect job creation, thus allowing innovation policies to be better designed. At the same time, they show that innovation plays an extremely important role as an engine of employment growth. This study breaks new ground with regard to the technological specificities of each sector and the size of each firm. This poses major challenges for policymakers, as the design of interventions aimed at stimulating growth in employment (especially highly skilled employment) requires the interaction of the industrial and scientific spheres.

Bibliography

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

Albornoz, F. (2002), "Los efectos de la innovación sobre la calidad y calidad del empleo industrial en Argentina: sustitución importada y una complementariedad trunca", *Apertura e innovación en la Argentina: para desconcertar a Vernom, Schumpeter y Freeman*, R. Bisang, G. Lugones and G. Yoguel, Buenos Aires, Miño y Dávila.

Card, D. and J. DiNardo (2002), "Skill-biased technological change and rising wage inequality: some problems and puzzles", *Journal of Labor Economics*, vol. 20, No. 4, Chicago, The University of Chicago Press.

Crespi, G. A. and E. Tacsir (2013), "Effects of innovation on employment in Latin America", *MERIT Working Papers*, No. 1, Maastricht, United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT).

De Elejalde, R., D. Giuliodori and R. Stucchi (2011), "Employment generation, firm size and innovation: microeconometric evidence from Argentina", *Technical Notes*, No. IDB-TN-313, Washington, D.C., Inter-American Development Bank (IDB).

Greenan, N. and D. Guellec (2000), "Technological innovation and employment reallocation", *Labour*, vol. 14, No. 4, Wiley.

Harrison, R. and others (2014), "Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries", *International Journal of Industrial Organization*, vol. 35, Amsterdam, Elsevier.

Olley, G. S. and A. Pakes (1996), "The dynamics of productivity in the telecommunications equipment industry", *Econometrica*, vol. 64, No. 6, New York, The Econometric Society.

Pianta, M. (2006), "Innovation and employment", *The Oxford Handbook of Innovation*, J. Fagerberg and D. C. Mowery (eds.), Oxford, Oxford University Press.

Roitter, S., A. Erbes and L. Trajtemberg (2007), "Determinantes cíclicos y estructurales del comportamiento de las firmas metalmecánicas argentinas frente al empleo durante los noventa", paper presented at the Eighth National Congress of Labour Studies, Buenos Aires, August.

Stock, J., J. H. Wright and M. Yogo (2002), "A survey of weak instruments and weak identification in generalized method of moments", *Journal of Business & Economic Statistics*, vol. 20, No. 4, Taylor & Francis.

Vivarelli, M. (2011), "Innovation, employment and skills in advanced and developing countries: a survey of the literature", *Technical Notes*, No. IDB-TN-351. Washington, D.C., Inter-American Development Bank (IDB).

Yoguel, G., F. Barletta and M. Novick (2013), "Aportes desde la experiencia y la literatura internacional en materia de innovación y empleo para América Latina: los desafíos de las nuevas tecnologías", unpublished.

Annex A1

Description of variables used

Table A1.1
Description of variables used

Variable	Description
Total employment growth (l)	Annualized employment growth between 2010 and 2012. Calculated as the simple difference of the logarithm of employment in each year.
Process innovation only (d)	Binary variable taking the value 1 if the firm introduced a process innovation in the manufacture of old products, or if it introduced an organizational change (without new products).
Nominal growth in sales of old products (g_1)	$ln(Y_{12}) - ln(Y_{11})$ where Y_{12} is the real value of sales of old products in 2012 and Y_{11} is the real value of sales of old products in 2010. Sales of old products are calculated as: $Total\ sales_t - pnd * Total\ sales_t$ where pnd is the percentage of sales that are of new products and is sales in the domestic and external markets.
Price growth at the sector level (π)	Annualized growth in the producer price index (IPP) of the National Institute of Statistics and Censuses (INDEC). Calculated as the simple difference between the logarithm of the IPP in 2012 and the logarithm of the IPP in 2010.
Nominal growth in new product sale (g_2)	Y_{22}/Y_{11} where Y_{22} is the real value of sales of new products in 2012 and Y_{11} is the real value of sales of new products in 2010. Sales of new products are calculated as: $pnd * Total\ sales_t$
Access to new markets in consequence of innovation	Binary variable taking the value 1 if the firm stated it had entered a new external market in consequence of an innovation made between 2012 and 2010.
Knowledge of the existence of public programmes supporting innovation	Binary variable taking the value 1 if the firm stated it was aware of the existence of public programmes supporting innovation, irrespective of whether it had applied for such support.

Source: Prepared by the authors.

The great divide: economic complexity and development paths in Brazil and the Republic of Korea

Gustavo Britto, João P. Romero, Elton Freitas and Clara Coelho[1]

Abstract

This paper uses the product space methodology to gain new perspectives on the relationship between economic complexity and economic development, illustrated by case studies of Brazil and the Republic of Korea. It takes import data as an indicator of revealed comparative disadvantage to highlight the relevance of the local market. Product space networks for each decade between 1960 and 2000 are then presented, revealing the significant changes in each country's position in the international division of labour. Lastly, a structural development index is used to measure economic development in each country. The revealed comparative advantage and disadvantage indices indicate that while both countries had similar levels of per capita gross domestic product (GDP) in the early 1960s, the Republic of Korea saw faster growth than Brazil thanks to its early specialization in more complex, technology-intensive goods.

Keywords

Economic development, development models, comparative analysis, productivity, production diversification, economic indicators, Brazil, Republic of Korea

JEL classification

O1, O2, O57

Authors

Gustavo Britto is Professor in the Department of Economics of the Centre for Regional Development and Planning at the Federal University of Minas Gerais, Brazil. Email: gustavo@cedeplar.ufmg.br.

João P. Romero is Associate Professor in the Department of Economics of the Centre for Regional Development and Planning at the Federal University of Minas Gerais, Brazil. Email: jpromero@cedeplar.ufmg.br.

Elton Freitas is a PhD candidate in the Department of Economics of the Centre for Regional Development and Planning at the Federal University of Minas Gerais, Brazil. Email: eltonfreitas@cedeplar.ufmg.br.

Clara Coelho is a MPhil student in the Department of Economics of the Georg-August-Universität Göttingen, Germany. Email: coelhoclaras@gmail.com.

[1] The authors gratefully acknowledge the financial support provided by the Foundation for Research of the State of Minas Gerais (FAPEMIG), the Coordination for the Improvement of Higher Education Personnel (CAPES) and the National Council for Scientific and Technological Development (CNPq). This paper won first prize in a competition held by the National Confederation of Industry (CNI) in 2015 for articles on Brazilian industry. The authors are also grateful to an anonymous referee for their valuable comments. The authors alone are responsible for any errors that remain.

I. Introduction

The relationship between different economic structures and distinct paths of economic development has long been discussed in economic literature, particularly with the rise of development economics from the 1950s onwards. According to the structuralist literature that flourished in that period, economic development is inextricably linked to changes in the sectoral composition of production (e.g. Lewis, 1955; Kuznets, 1966; Kaldor, 1966; Hirschman, 1958; Prebisch, 1962; and Furtado, 1964); development and growth depend on moving production towards sectors that produce complex goods that have high value added, at the expense of sectors that produce simple, low-value-added goods.

More recently, a number of studies have made the case for an ongoing process of structural change to foster economic development in the long run. These studies identify connections between the sectoral composition of production and the rates of growth in productivity, exports and, ultimately, per capita gross domestic product (GDP). The debate surrounding the dichotomy between the traditional and modern sectors identified in classical and structuralist theories of economic development is rekindled. The new literature highlights the importance of accumulating capabilities to produce more sophisticated goods, arguing that it is a prerequisite for structural change. These capabilities are associated with non-tradable inputs, such as tacit knowledge, and much of the literature on this approach has sought to identify and measure capabilities across countries or industries (e.g. Lall, 1992; Archibugi and Coco, 2005).

In this vein, Hidalgo and others (2007) and Hidalgo and Hausmann (2009) developed a methodology for the empirical analysis of the process of economic development. Instead of directly measuring capabilities, their methodology infers the complexity of a country's productive structure by using the number of goods a country produces with revealed comparative advantage (RCA) (diversity) and the number of countries capable of exporting each good with RCA (ubiquity), which allows the levels of complexity of each product and country to be calculated. These indices are strongly correlated with per capita GDP levels and with faster rates of growth in countries that have managed to move away from traditional, natural-resources-based sectors towards more modern, complex ones (Hausmann, Hwang and Rodrik, 2007; McMillan and Rodrik, 2011).

This methodology has been used to investigate empirically a wide variety of issues related to growth divergence as well as development paths in many other papers, ranging from case studies and cross-country studies, which show that economic complexity are strongly correlated with technological capabilities, to evaluations that use subnational data to highlight the importance of geographical location. A common thread that runs through the empirical studies is that structural change is fundamental for economic development, which has led analysts to re-examine the structuralist ideas put forward by ECLAC through the lenses of capability and complexity (Gala, Camargo and Freitas, 2017).

Studies that use this methodology have, given its origins, focused solely on the exports side of international trade. While they are very useful, indicators based on exports fail to take into consideration the impact of the local market on structural change and economic development. Depending on a country's size, factor endowments, trade openness, import requirements and finished or semi-finished goods may play as important a role as exports in promoting or hindering structural change and growth. However, the methodology can also be used to investigate development processes empirically over time. The methodology can be adapted to comparative studies, by taking into account changes in the international division of labour and thus in the composition of international trade in the last 50 years, as well as the effects of absolute levels of key variables, such as those related to country size, together with relative measures, such as relative advantages.

To address these issues empirically, this article applies the economic complexity methodology to a comparative analysis of Brazil and the Republic of Korea. The article's contribution to the existing literature is threefold. First, it analyses how the structure of production and trade has changed over

time by using trade data to construct product networks for each decade. Secondly, it evaluates the role played by the local market by compiling an index of revealed comparative disadvantage (RCD) based on import data: a decrease in the number of industries with RCD indicates a more competitive domestic productive sector. Lastly, it proposes replacing the economic complexity index with a structural development index in order to calculate the economic development of a country's productive structure.

Section II of this article discusses the theoretical framework and shows the evolution of the product space from 1965 to 2005. Section III examines the transformation of productive structures in Brazil and the Republic of Korea. Section IV provides some final thoughts.

II. Product and economic complexity

1. Revealed comparative advantage, diversification and ubiquity

As part of their investigation into the relationship between economic structures and economic growth, Hidalgo and others (2007) looked at whether a country's productive structure influences the path, cost and speed of change towards producing sophisticated goods. They found that the production of different types of goods requires different sets of capabilities. Consequently, a country's capabilities dictate the types of goods it can competitively produce and how difficult it is for that country to broaden its range of goods to include those that require different, or additional, capabilities. Conversely, the diversity and complexity of these goods indicates the extent of a country's capabilities.

To calculate how efficiently each economy produced each product, Hidalgo and Hausmann (2011) use the revealed comparative advantage (RCA) index developed by Balassa (1965):

$$RCA_{jkt} = \left(\frac{X_{jkt} / \sum_k X_{jkt}}{\sum_j X_{jkt} / \sum_j \sum_k X_{jkt}} \right) \quad (1)$$

where x are the exports of product k from country j at time t. A higher RCA index indicates that the production of a given product in that country is more competitive. A lower index indicates that the opposite is true.

Hidalgo and others (2007) also examine the proximity between goods by using conditional probabilities to establish how close to each other different products are in terms of the capabilities. This is based on the assumption that a country is more likely to produce and export two products if their production requires similar capabilities. The authors use trade data from UN Comtrade, which are highly disaggregated and cover a high number of countries and years, to calculate the probability of a country exporting product i with RCA given that it exports product k with RCA. Lastly, the authors map the product space by identifying linkages between goods based on their proximity.

Using the product space, Hidalgo and others (2007) show that less developed countries tend to produce goods with fewer linkages, which makes it difficult for these countries to diversify their production towards more sophisticated goods. The opposite is true of developed countries. These findings point to three important conclusions: (i) different productive structures and their associated capabilities create very different opportunities for boosting economic growth; (ii) for this reason, economic growth is path dependent; and (iii) diversifying towards sophisticated goods is time consuming, as new capabilities must be created and less sophisticated goods are not linked to many other activities.

To complement this approach, Hidalgo and Hausmann (2011) propose two additional indicators of product and economic complexity:

$$D_{jt} = \sum_{k} N_{jkt} \tag{2}$$

$$U_{kt} = \sum_{j} N_{jkt} \tag{3}$$

where D denotes diversification, U denotes ubiquity and $N=1$ if country j exports product k with RCA at time t, and $N=0$ otherwise. Diversification is the number of products that a country exports with RCA, while ubiquity is the number of other countries that export those products with RCA. Thus, the more diverse a country's exports are, the more complex its economy is. In contrast, if a product is less ubiquitous, the economy is more complex.

Hidalgo and Hausmann (2009) and Felipe and others (2012) use these indicators to show that growth is higher in those economies that have higher product diversification, producing less common goods. It should therefore not be a surprise that Felipe and others (2012) find that economic and product complexity are closely associated with the accumulation of technological capabilities, as measured in Schumpeterian works such as Archibugi and Coco (2005). The conclusion is that, in general, diversification is correlated positively with income levels and negatively with ubiquity.

These indices can therefore be merged to measure and compare the sophistication of products and countries' economies. On the one hand, a country will have a more sophisticated economy if the goods it produces are highly diverse and less ubiquitous. On the other hand, a product will have a higher degree of sophistication if it is less ubiquitous and produced by more diversified countries. Formally:

$$ES_{jt} = \left(\frac{1}{\sum_{k} N_{jkt} U_{kt}} \right) D_{jt} \tag{4}$$

$$PS_{kt} = \left(\frac{1}{U_{k}} \right) \sum_{j} N_{jkt} D_{jt} \tag{5}$$

where ES and PS stand for economic sophistication and product sophistication, respectively.

The indices shown above have been used to analyse a wide range of issues related to the link between economic complexity and economic growth in studies ranging from case studies to econometric investigations using national and subnational data. Felipe, McCombie and Naqvi (2010) argue that Pakistan's inability to produce more sophisticated goods has resulted in persistent balance-of-payments problems, reducing its growth rates. China, on the other hand, grew much faster because of sustained increases in the RCA of highly complex products such as machinery and electronic goods (Felipe and others, 2013). Boschma, Balland and Kogler (2013) examines the connections between technological proximity and technological change. Using patent data from the United States Patent and Trademark Office, the authors show that technological capabilities are linked to different trajectories of technological specialization in cities across the United Sates. In turn, Bahar, Hausmann and Hidalgo (2014) use measures of relative comparative advantages and of export similarity to evaluate how geographic proximity influences productive specialization. They show that neighbouring countries tend to have RCAs in similar products, most likely as a result of knowledge diffusion. Moreover, Romero and Britto (2018) investigate whether productive sophistication can explain not only productivity growth but also the size of income elasticities of trade in different technological sectors.

2. Revealed comparative disadvantage, bottlenecks and potential industries

While this basic methodology is being used more widely, to date studies have tended to focus exclusively on export data. Consequently, the analyses cover issues related to the competitiveness of a country's exports. As a result, very little consideration has been given to the local market. This gap in the literature can be filled using the rich data available on countries' imports. That data can be used to create indices of revealed comparative disadvantage (RCD), which are calculated analogously and can be analysed in conjunction with the RCA index.

Formally:

$$RCD_{jkt} = \left(\frac{m_{jkt} / \sum_k m_{jkt}}{\sum_j m_{jkt} / \sum_j \sum_k m_{jkt}} \right) \quad (6)$$

where m denotes imports of each good k for the country j at time t.

This measure captures the relative import needs of the local economic structure. If $RCD > 1$, the country's dependence on imports of good k is higher that the relevance of the good in the international trade, while if $RCD < 1$, the country is not an effective importer, meaning that it has a relatively small competitive disadvantage. Interestingly, when there is no RCA in the production of a given good k, there is a demonstrably important local market for this good. As Dornbusch, Fischer and Samuelson (1977) show, in theory, a country might produce goods in which it has a comparative disadvantage if transport costs or tariffs are large enough. However, it is also possible that some intermediate products are not imported because domestic production is too weak to use them, or because domestic income levels do not generate enough demand for them.

Thus, in parallel to the export diversification index D, an index can be developed to indicate the size of the bottlenecks (B):

$$B_{jt} = \sum_k M_{jkt} \quad (7)$$

where M=1 if country j imports product k with RCD at time t, and M=0 otherwise.

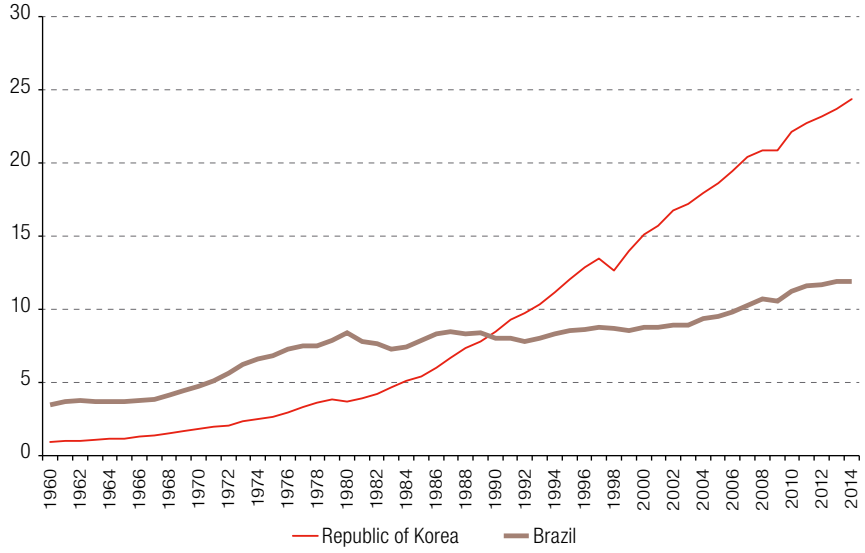
These indices allow us to evaluate how domestic production is performing in the local market and, more importantly, to see whether industries without RCA have the potential to export, or whether they are losing competitiveness and becoming industries with RCD.

III. The development trajectory of Brazil and the Republic of Korea

The aforementioned indices, together with the graphical analysis of the product space over time, are valuable tools to evaluate the very distinct paths of economic development in Brazil and the Republic of Korea over the past 50 years. These two countries are very different in terms of culture, history, natural resource endowments, area and population size. Nonetheless, as figure 1 shows, they shared a similar path of per capita GPD until 1980. Until then, Brazil's per capita GDP was considerably higher than that

of the Republic of Korea, and both were growing at similar rates. However, after 1980, Brazil followed a path of economic stagnation, while the per capita GDP of the Republic of Korea continued to grow, reaching a level compatible with that of developed countries by 2010.

Figure 1
Brazil and the Republic of Korea: per capita GDP, 1960–2014
(Thousands of constant 2010 US dollars)



Source: World Bank, World Development Indicators.

The trends shown in figure 1 explain why these two countries have been popular choices for comparative studies since the 1980s, as they illustrate how different policy choices in Asia and Latin America have, over the decades, led to contrasting realities.

It can be argued that apart from their per capita GDP growth rates prior to 1980, Brazil and the Republic of Korea have little in common. Every other socioeconomic indicator reveals differences rather than commonalities. Consideration should therefore be given to how those different characteristics under distinct circumstances have led to such divergent trends in terms of structural change and how that change is related to the complexity of the goods produced in each country.

To analyse the development of the productive structures of Brazil and the Republic of Korea between 1962 and 2010 using the methodology described in the previous section, trade data was gathered from UN Comtrade, disaggregated to the four-digit level of the Standard International Trade Classification (SITC), Revisions 1 and 2. This classification comprises 613 products in Revision 1 and 784 products in Revision 2. Both revisions are used here, with revision 2 utilized whenever possible; however, as revision 1 covers the period from 1962 to 1973 in some cases that revision had to be used for the purposes of making comparisons across the whole period under consideration. Industries were divided into 6 technological sectors, following the classification proposed by Lall (2000): (i) primary products, covering 135 industries in revision 1 and 148 industries in revision 2; (ii) resource-based manufactures, covering 187 industries in revision 1 and 197 industries in revision 2; (iii) low-technology manufactures, covering 128 industries in revision 1 and 161 industries in revision 2; (iv) medium-technology manufactures, covering 113 industries in revision 1 and 202 industries in revision 2; (v) high-technology manufactures, covering 38 industries in revision 1 and 66 industries in revision 2; and (vi) other manufactures, covering 12 industries in revision 1 and 10 industries in revision 2.

Table 1 shows the average product complexity of each technological sector and reveals a clear correlation between the technological content of each industry and the level of complexity of its production. This justifies the decision to divide the industries according to Lall's (2000) technological classification, since a process of structural change towards high-technology industries can also be interpreted the country's productive structure becoming increasingly complex.

Table 1
Average product complexity by technological sector

Primary products	Resource-based	Low-technology	Medium-technology	High-technology	Other manufactures
-0.711	-0.230	0.205	0.714	0.806	0.120

Source: Prepared by the authors.

1. Trade diversification and economic development over the last 50 years

As expected, the structural changes in Brazil and the Republic of Korea were the result of circumstances and economic policies. Figure 2 shows the number of industries with RCA by technological sector in Brazil and the Republic of Korea, thus charting the evolution of productive diversification in those countries. It conveys four important pieces of information. First, as expected, Brazil has always been more competitive in primary products than the Republic of Korea, while the latter has always been more competitive in low-technology manufactures than Brazil. Secondly, from 1978 onwards, Brazil has focused on increasing the competitiveness of its resource-based manufactures, while the Republic of Korea has focused on low-technology manufactures. Thirdly, diversification in medium-technology manufactures is, in general, similar in both countries throughout the period under consideration. Finally, there are considerably more high-technology manufactures with RCA in The Republic of Korea.

Figure 2
Trade diversification by technological intensity, 1962–2009
(Number of industries with revealed comparative advantage)

A. Brazil

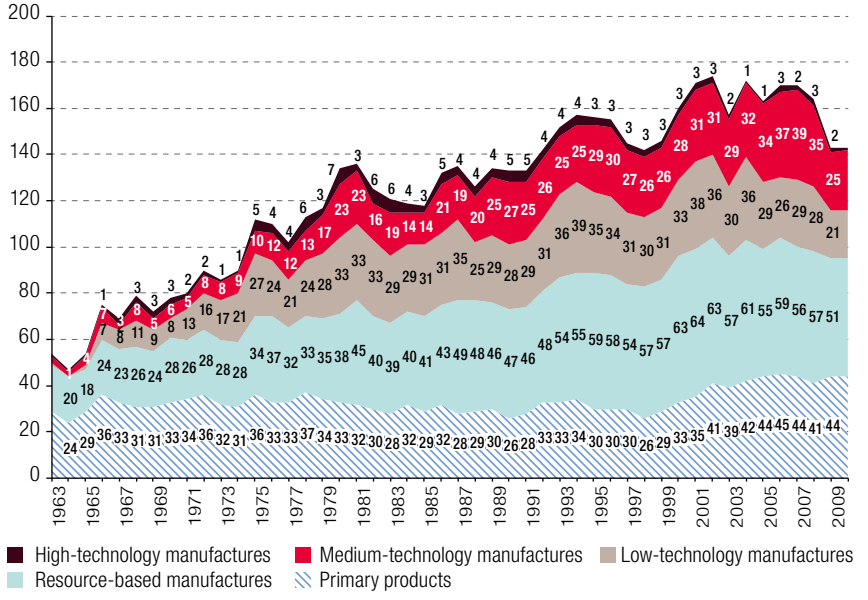
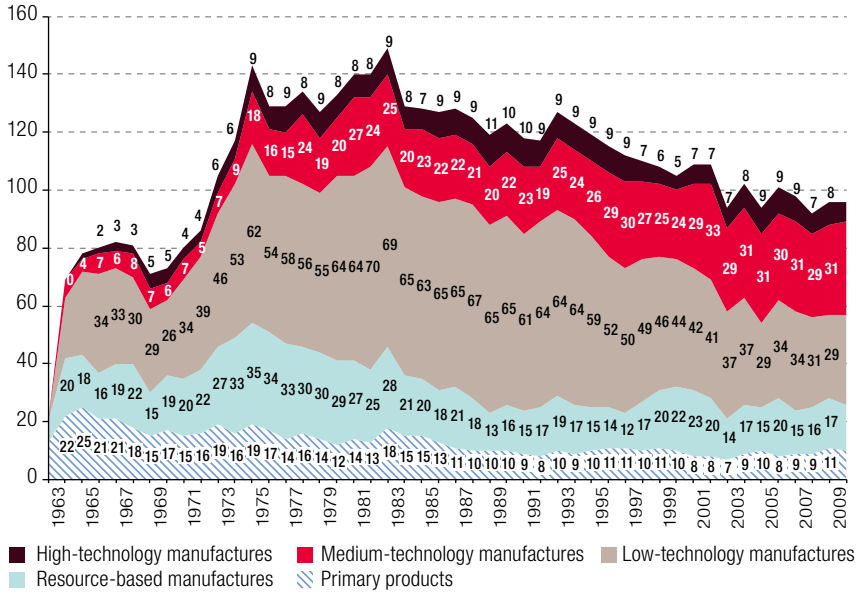


Figure 2 (concluded)

B. The Republic of Korea



Source: Prepared by the authors.
Note: Standard International Trade Classification (SITC), Revision 1, at the four-digit level was used for the whole period.

Brazil already had a considerable number of industries specializing in primary products and resource-based manufactures with RCA in 1960. Heavy industries had been created and supported during the period from 1930 to 1950, and automobile and communication industries sprang up in 1955. From 1964 to 1973, Brazil saw growth of over 8% per year, based on import substitution industrialization. However, with the first oil crisis in 1973, Brazil started to experience balance-of-payment difficulties, which led the military government to step up import substitution industrialization, increasing the domestic production of intermediate inputs and machinery (Burlamaqui, de Souza and Barbosa-Filho, 2006, p. 11).

In the 1980s, after the second oil crisis, Brazil's growing foreign debt forced a recessive adjustment and the country eventually defaulted on its payments in 1986. That decade was marked by slow growth and hyperinflation. The 1990s saw a process of rapid economic liberalization and privatization; however, Brazil was only able to beat hyperinflation in 1994 following monetary reforms. During these two decades, the average GDP growth rate was just over 2% (Netto, 2005). Growth rates only began to recover after 2004, averaging around 4%, thanks to a period of economic stability, an uptick in State investment and the adoption of policies that fostered wage increases and income distribution, boosting the domestic market (Serrano and Summa, 2011). Figure 2 indicates that the liberalization of the Brazilian economy that took place from 1994 onwards led to a process of "reprimarization".

In contrast, the Republic of Korea had about half as many industries with RCA as Brazil in the 1960s. The period from 1963 to 1972 marked the beginning of an industrialization effort, which initially focused on developing basic institutions to support the adoption of foreign technology. In that period, the governments of the Republic of Korea formulated a series of five-year plans for economic growth. The objective of the first two plans was to build an industrial base, increase energy production and encourage companies to invest in technology acquisition (Hong, Jeon and Kim, 2013; Kuznets, 1990; Collins, 1990).

The *chaebols*, family-run conglomerates, were concentrated in the production of low-technology manufactures during the 1960s, moving into heavy medium-technology manufactures and high-technology

manufactures industries, in particular the chemical, naval, automobile and machinery industries, during the 1970s (Jacobsson, 1993; Woo-Cumings, 1999). The number of high-technology manufacturing industries with RCA did not change significantly in the 1960s, but their share of exports grew in the 1980s, demonstrating the gains the economy had made in terms of competitiveness. While the number of industries with RCA in Brazil was around 100 in 1974, there were already some 150 in the Republic of Korea.

Political reforms were undertaken in the Republic of Korea in the 1980s that profoundly changed the State's relationship with *chaebols*' labour unions (Chang, 2006). These changes led to: (i) a shift in industry policies to provide more functional support to manufacturing; (ii) attempts to promote small and medium enterprises; (iii) financial liberalization; and (iv) trade liberalization with the introduction of a tariff that abolished exemptions for strategic industries in 1984 (Harvie and Lee, 2003).

Lastly, the Republic of Korea was affected by the Asian financial crisis in the late 1990s but was able recover quickly. As a result of that crisis, steps were taken to regulate the financial system through changes to corporate governance, which improved the feasibility of the banking sector and reduced the diversification of *chaebols* by eliminating subsidies and concentrating them by specialization (Haggard, 2000). The *chaebols* also became less diverse following the decision to lift restrictions on foreign competition, a process that started in the 1980s and was consolidated during the 1990s.

2. Changes in product space over time

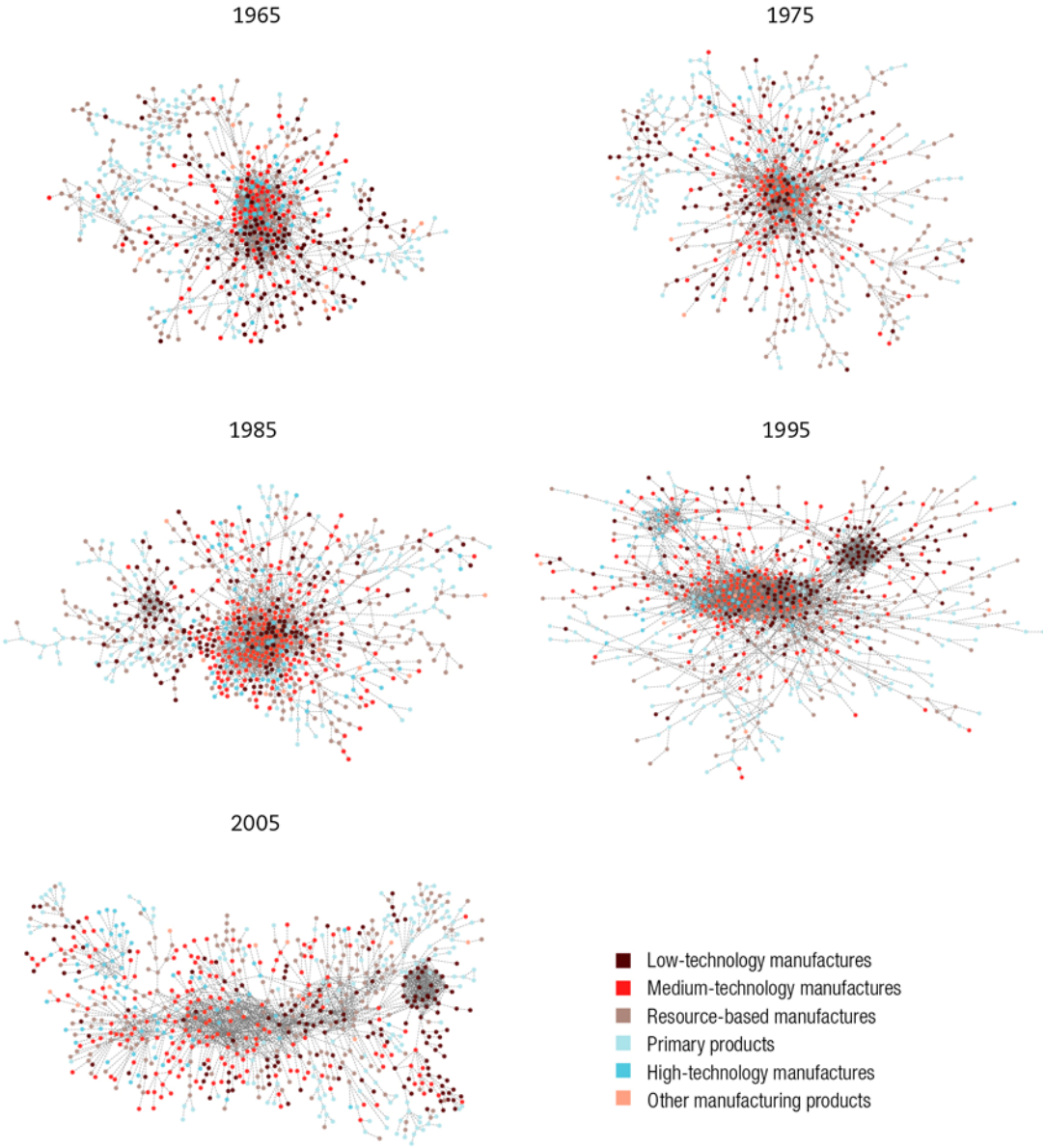
The trends in trade diversification set out above reflect the structural changes that took place in both countries. To illustrate how the structures of world production and trade have changed over time, a product space was constructed for each decade of the period under consideration (see figure 3). Changes in this network are associated with the evolution of the international division of labour, which are reflected in shifts in international trade. The first two product spaces show the long-term changes that took place at the global level between 1965 and 2005. The last three product spaces show the progressive changes over that period, by providing snapshots of each decade, 1975, 1985 and 1995, respectively.

As can be seen, the shape of the network for 2005 is the same as the one constructed by Haussmann and others (2011). However, this article classifies products using the technology categories developed by Lall (2000), instead of those introduced by Leamer (1984) used by Hidalgo and others (2007). Lall's classification provides more information about the characteristics of simple and sophisticated products.

In the product space for 2005, high- and medium-technology goods are positioned to the centre-left, which corresponds to electronic and chemical products on the network constructed by Haussmann and others (2011). Low-technology, resource-based and primary products are generally located to the centre-right of that product space, with the latter also positioned on the fringes of the network. A distinct node of low-technology products (garments) is visible on the centre-right of the network, surrounded by other low-technology and primary goods.

The product space for 1965 is concentrated around a large central node, formed mostly of high-, middle- and low-technology goods. A more disperse ring of those same goods appears around the central node, with low-technology goods spilling over to the lower left-hand side. Resource-based and primary products are found on the fringes of the network, particularly the upper left-hand side. This structure is consistent with a marked division of labour and trade between primary and manufactured goods. In addition, this radial geography of the product space in terms of technological intensity is suggestive of a centripetal path of development through successive waves of industrial upgrades from resource-based production towards higher technology, more complex goods in the middle.

Figure 3
World: product space by technological intensity, 1965–2005



Source: Prepared by the authors.
Note: Product spaces for 1965 and 1975 were calculated using Standard International Trade Classification (SITC), Revision 1, at the four-digit level, while those for 1985, 1995 and 2005 used Standard International Trade Classification (SITC), Revision 2, at the four-digit level.

All the networks were constructed using the maximum spanning tree method, under which a threshold must be set for the proximity between nodes to allow for a meaningful visualization of the links between them. This threshold decreases markedly for the product spaces over the period under consideration: to plot the network for 1965, the threshold was set at 0.70; for 1975 and 1985 it was 0.65; and for 1995 and 2005 it was 0.55. These calibration changes indicate shifts in international trade

patterns and country specializations, and that the probability of co-exporting a number of goods was much higher in the 1960s, which suggests that international trade was more concentrated in terms of value and more segmented in terms of sectors.

During the period under consideration, exported goods became increasingly diverse less developed countries began to account for a larger share of international trade. Meanwhile, product differentiation and complexity increased steadily, thanks to continuous technological developments in more advanced countries. As expected, the product space changes accordingly; the network becomes more elongated from one decade to the next, and goods are more clearly grouped according to technological intensity. The notional development path becomes a long U-shaped curve, as complex products move further away from simpler ones, suggesting a very distinct international division of labour and very low probabilities that such distinct products would be co-exported.

The changing shape of the network shows the importance of considering products' technological intensity in addition to more traditional resource-based classifications. As is clear from figure 3, exports have become increasingly segmented in terms of technological intensity over the course of the period under consideration, with a line leading from low-technology goods, on the right-hand side, though medium-technology ones in the middle, to high-technology products on the left-hand side in the network for 2005.

3. Revealed comparative advantages and disadvantages

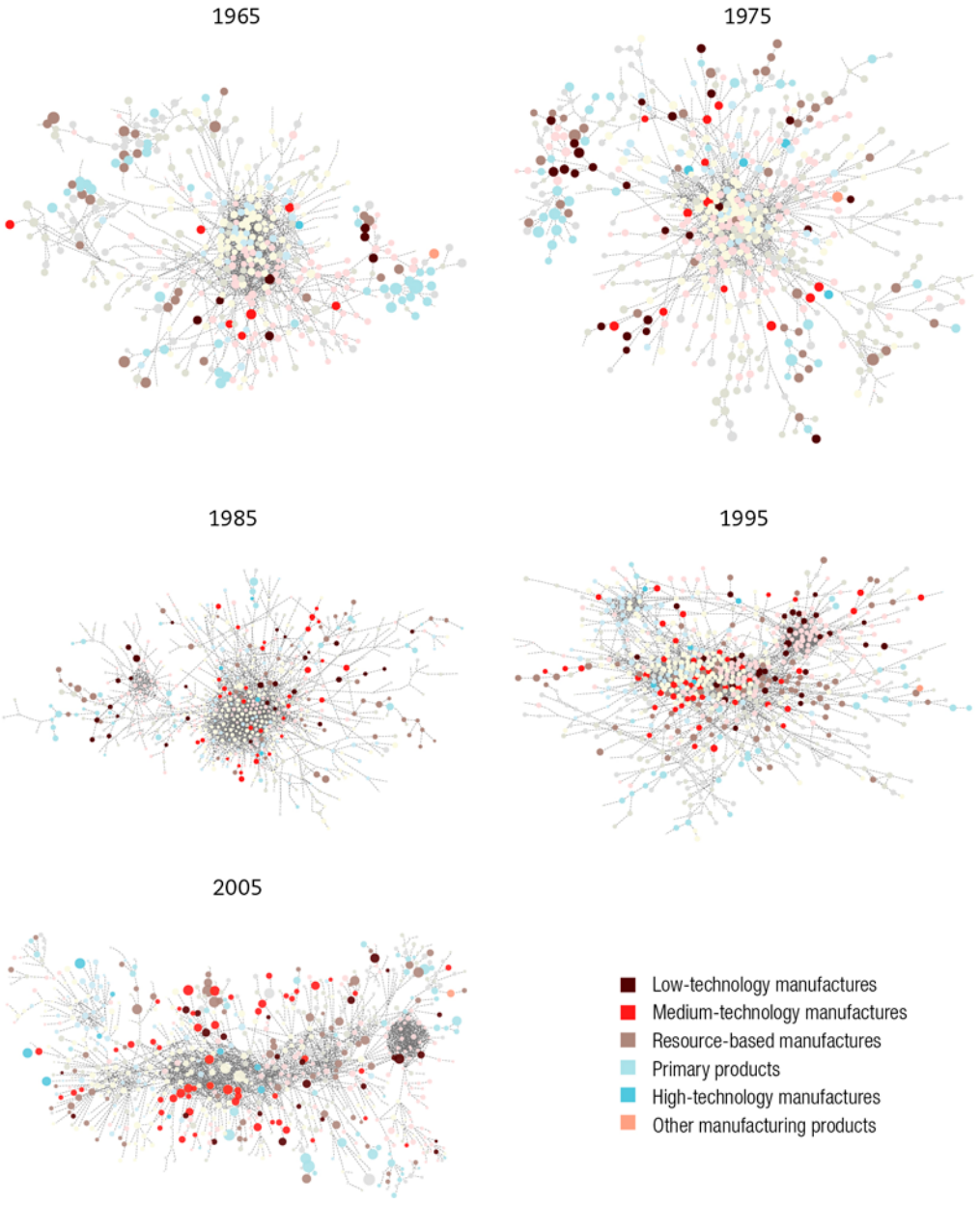
After examining the evolving product space and the changing economic structures in Brazil and the Republic of Korea, the next step is to analyse changes in comparative advantages in each country during the period under consideration. These changes reveal how productive competitiveness together with relative trade advantages and disadvantages are linked to the level of complexity —indicated by technological intensity— of goods traded.

The global product space is used to show how the productive structures of Brazil and the Republic of Korea have evolved, (see figures 4 and 5, respectively). In 1965 the productive structure of the Republic of Korea was already more focused on low-technology products, while Brazil was producing mostly primary products. This is an important finding, as other comparative literature unanimously focuses on the late 1970s and early 1980s as the point when the economic development of the two countries diverged.

The networks for 2005 show that the Brazilian productive structure has become more diversified, with a considerably larger number of industries with RCA across all sectors, but primary products and resource-based and medium-technology manufactures still made up the lion's share of Brazilian exports. Meanwhile, the number of primary and low-technology industries fell sharply in the Republic of Korea, offset by marked increases in the medium- and high-technology industries.

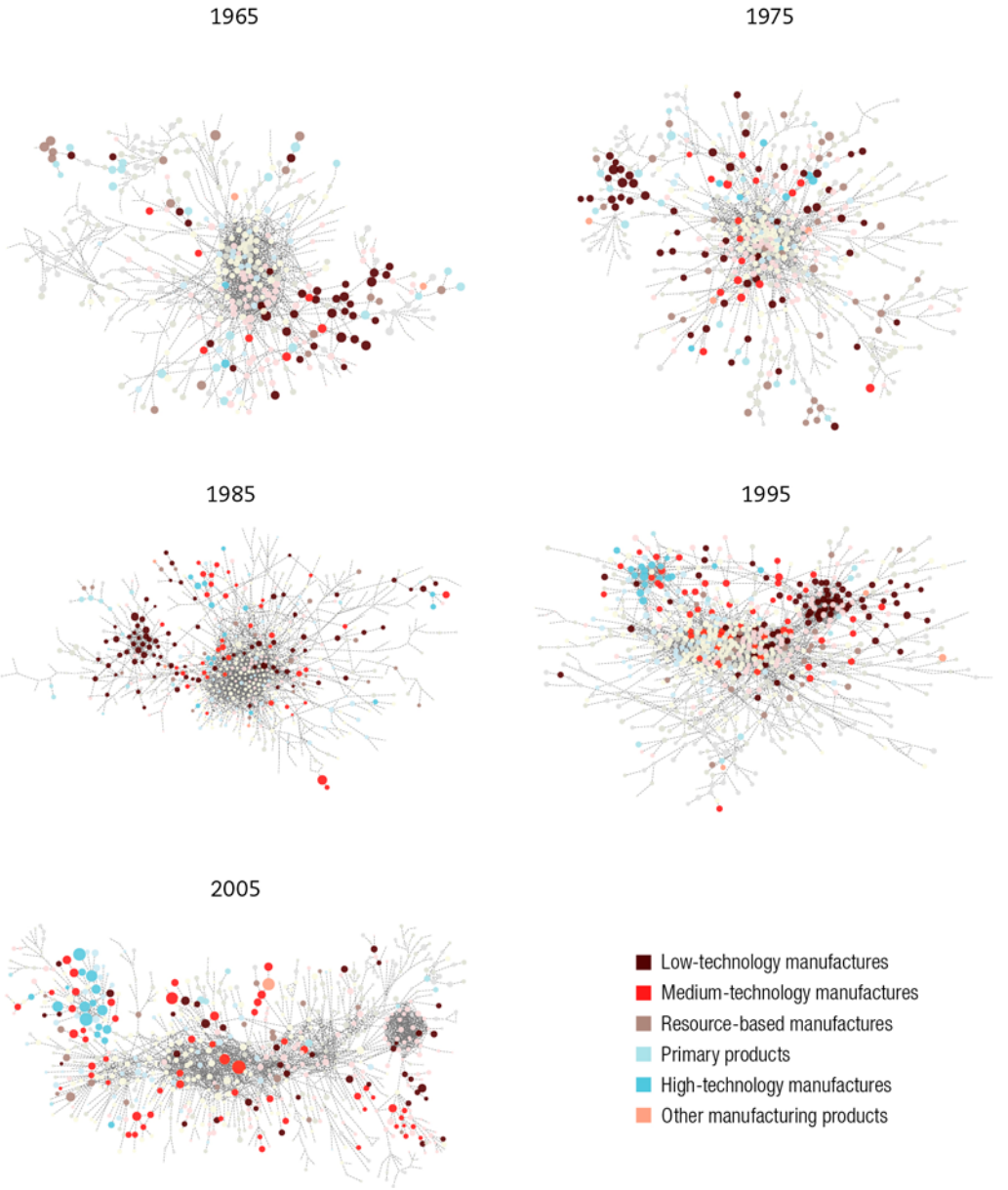
Figure 6 shows the share of each technological sector in the total exports of Brazil and the Republic of Korea, revealing a striking difference between the export structures of the two countries. On the one hand, Brazil had failed to reduce the share of both primary products and resource-based manufactures below 50% of total exports, while medium- and high-technology manufactures accounted for only 25% and 7% of total exports in 2009, respectively. On the other hand, the share of both primary products and resource-based manufactures fell to 8% of total exports of the Republic of Korea in that same year, while medium- and high-technology manufactures accounted for 44% and 29% of total exports, respectively.

Figure 4
Brazil: revealed comparative advantages and productive diversification by technological intensity, 1965–2005



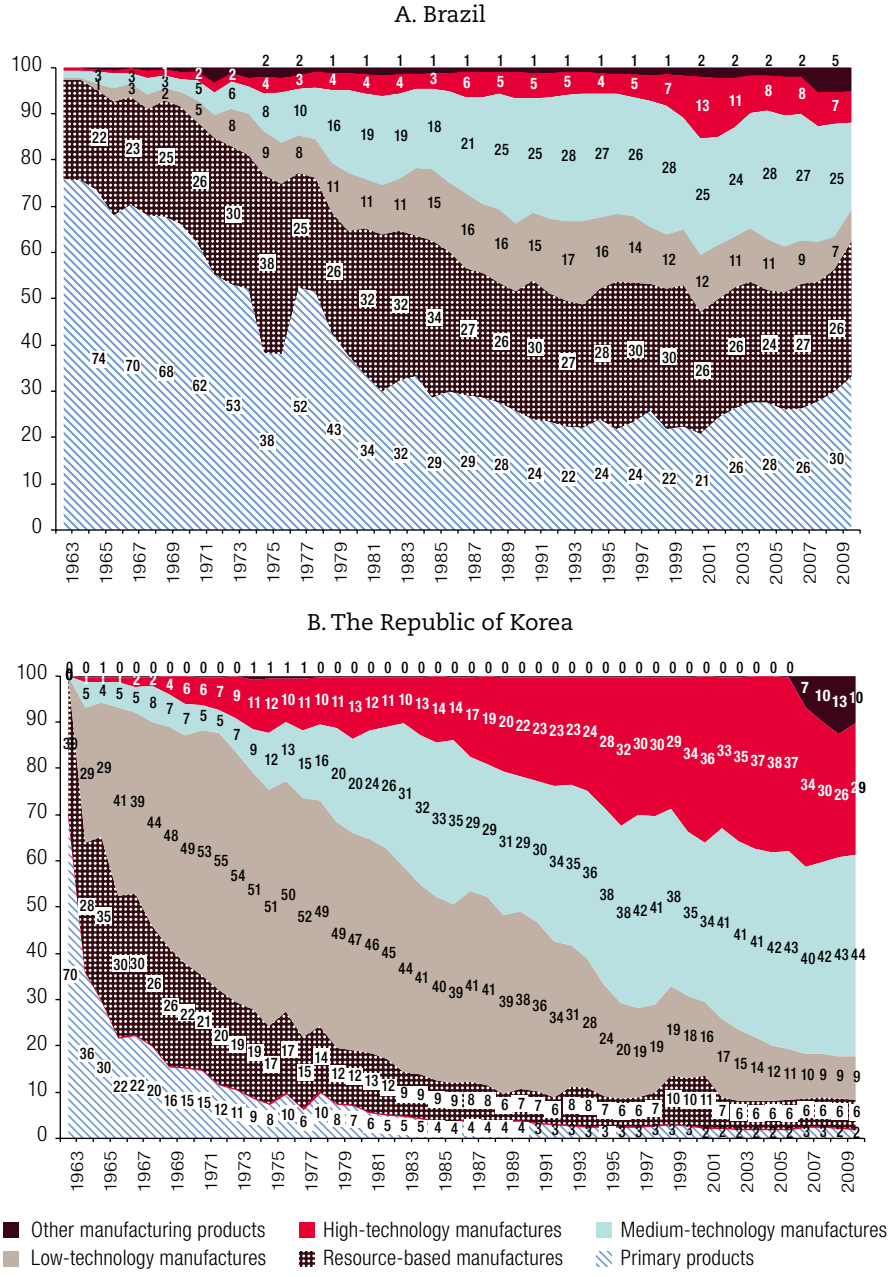
Source: Prepared by the authors.

Figure 5
The Republic of Korea: revealed comparative advantages and productive diversification by technological intensity, 1965–2005



Source: Prepared by the authors.

Figure 6
Share of exports by technological intensity, 1962–2009
(Percentages)



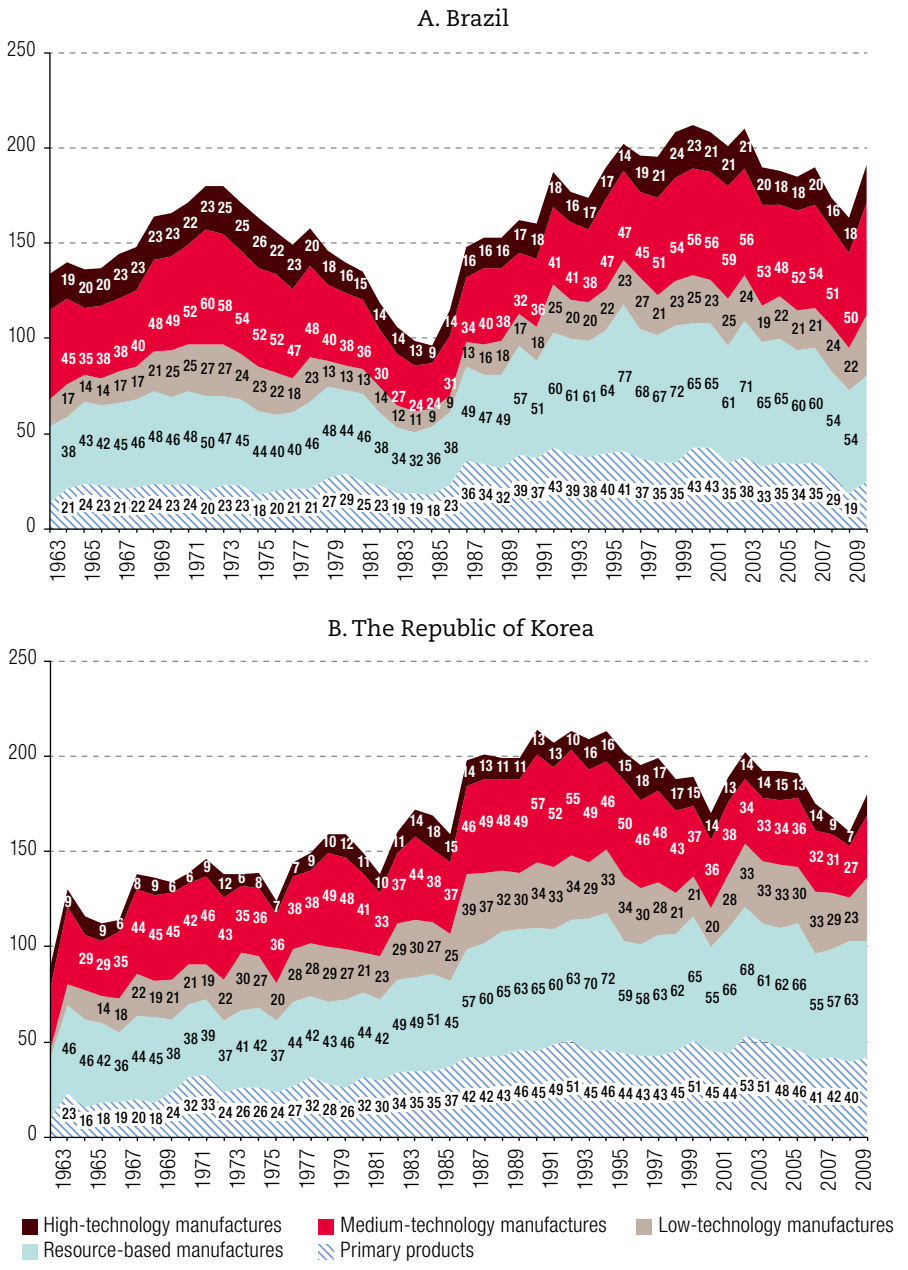
Source: Prepared by the authors.
Note: Standard International Trade Classification (SITC), Revision 1, at the four-digit level was used for the whole period.

Figure 6 indicates that low levels of diversification are not a problem if medium- and high-technology manufactures account for a sufficiently large share of exports; the number of industries with RCA is not as important as the share of those exports.

Analysis of how bottlenecks in the productive structures of Brazil and the Republic of Korea have evolved reveals five important pieces of information (see figure 7). First, Brazil has always been less competitive in medium- and high-technology manufactures than the Republic of Korea. Second,

Brazil and the Republic of Korea have had a similar number of bottlenecks in primary products and resource-based manufactures. Third, the number of bottlenecks in Brazil fell between 1980 and 1986 a result of the considerable decrease in the country's imports following the external adjustment that the economy underwent after the 1979 oil crisis. Fourth, the number of bottlenecks in primary products and resource-based manufactures sectors increased in the Republic of Korea after 1985. Lastly, from 2002 onwards the bottlenecks in primary products decreased in both economies.

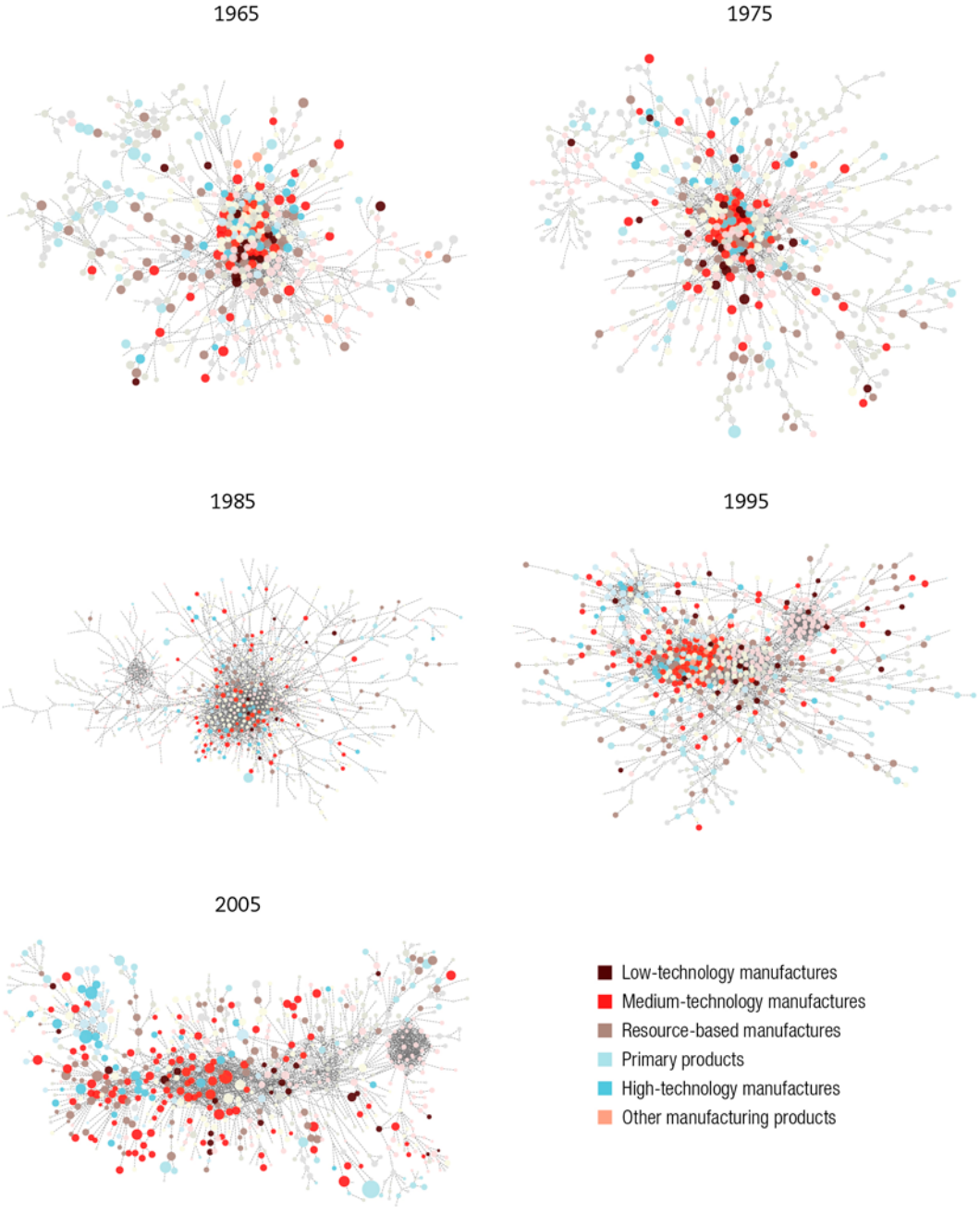
Figure 7
Bottlenecks by technological intensity, 1962–2009



Source: Prepared by the authors.
Note: Standard International Trade Classification (SITC), Revision 1, at the four-digit level was used for the whole period.

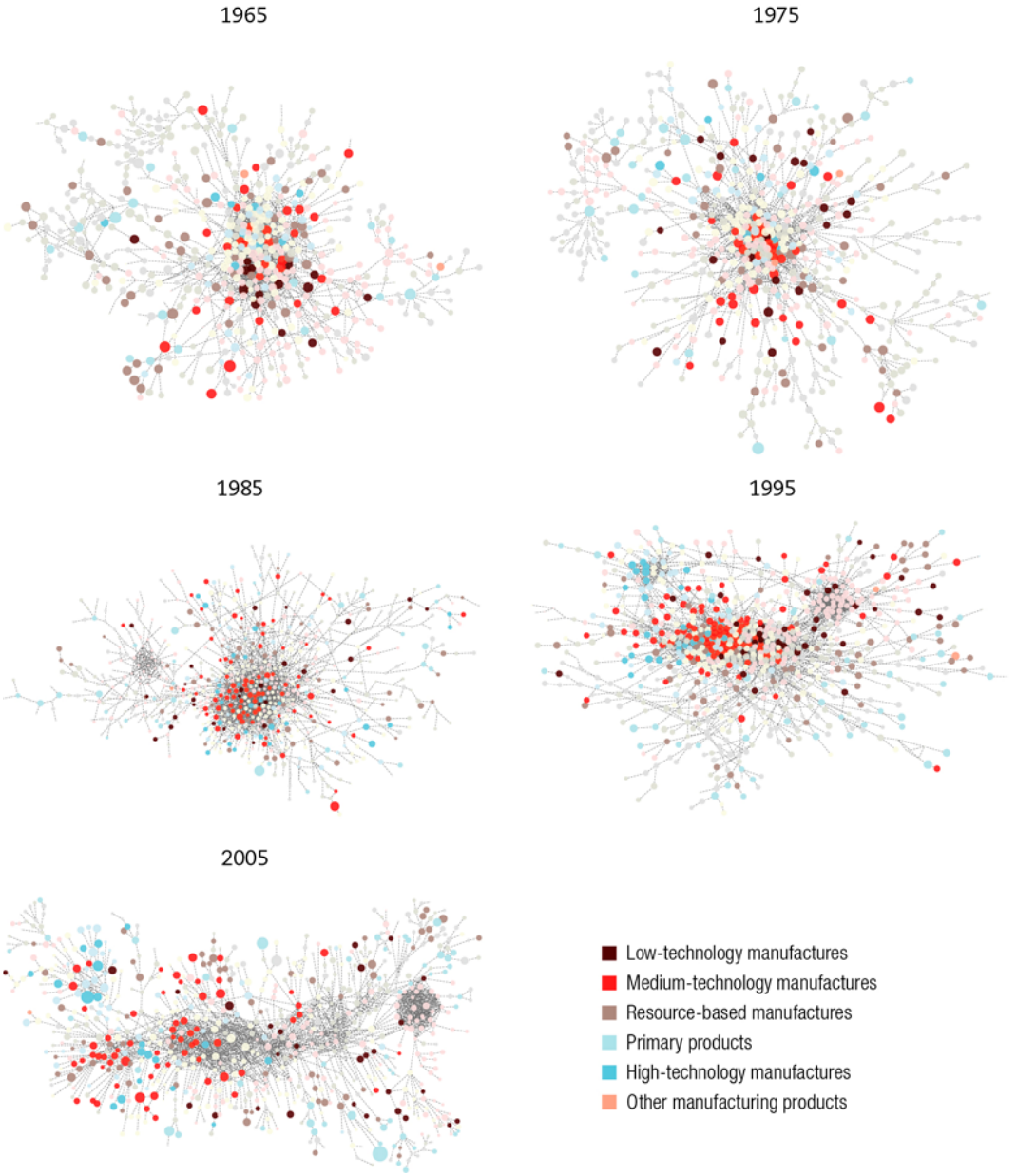
Figures 8 and 9 illustrate the evolution of RCD over the period under consideration in Brazil and the Republic of Korea, respectively. The networks for 1965 show that bottlenecks in the productive structures of Brazil and the Republic of Korea were similar at that time. The main import needs of both countries were concentrated in resource-based and medium-technology industries, followed by high-technology industries. By 2005, however, the product space shows that the Republic of Korea has reduced its import needs in medium-technology industries (in the centre of the network), while imports of primary products have risen (on the periphery of the network). Whereas, in Brazil, the distribution remained largely the same, with a slight increase in medium-technology industries.

Figure 8
Brazil: revealed comparative disadvantages by technological intensity, 1965–2005



Source: Prepared by the authors.

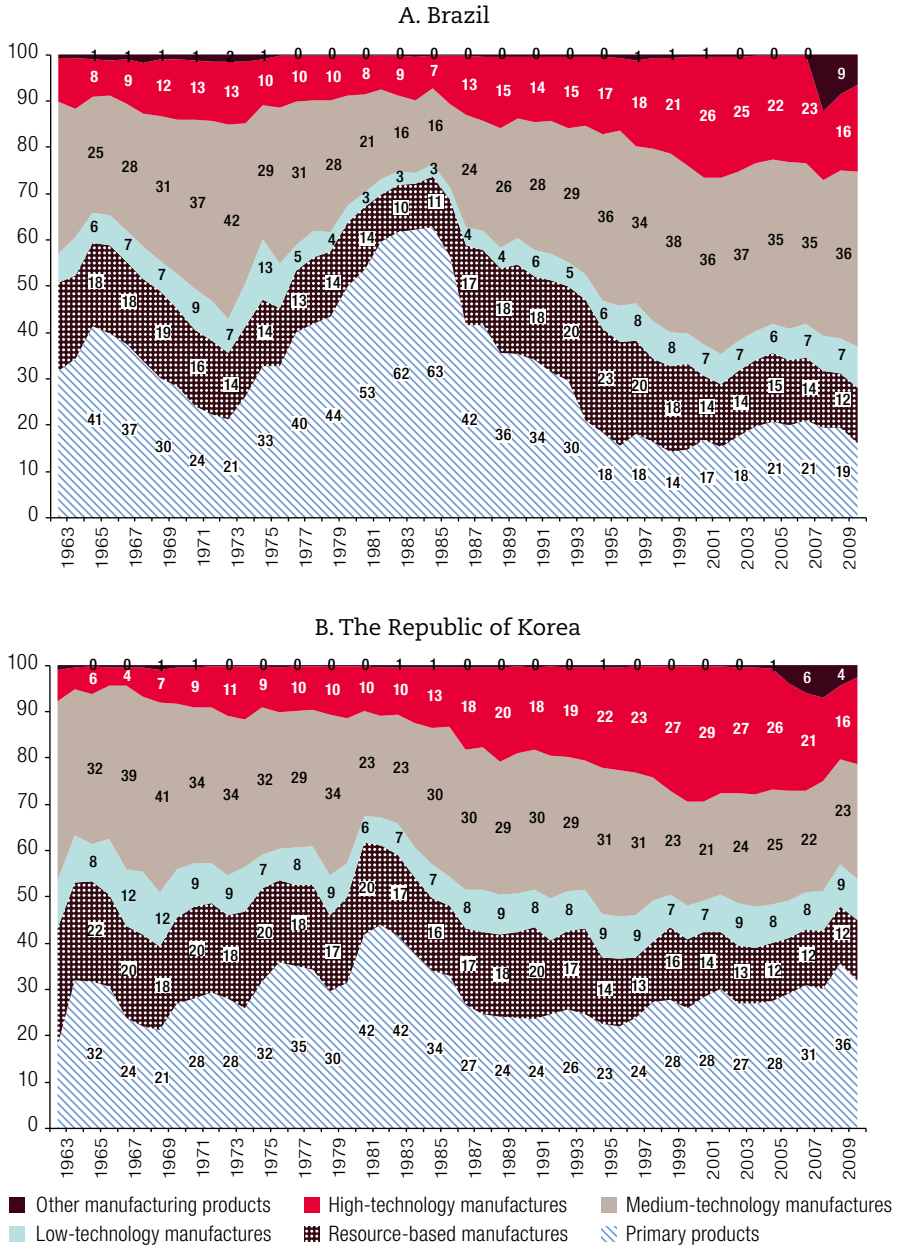
Figure 9
The Republic of Korea: revealed comparative disadvantages by technological intensity, 1965–2005



Source: Prepared by the authors.

Figure 10 shows the share of imports from each sector in the total imports of Brazil and the Republic of Korea, and reveals that the import structure of the two countries is, in fact, very similar, with only two minor differences. Firstly, the share of medium-technology manufactures in the total imports of Brazil had started to decrease but has ticked up since 1984, returning to levels similar to those observed in the 1970s. Secondly, the share of primary products in Brazilian imports has fallen since the second oil crisis and the debt crisis of mid-1980s; meanwhile the share of primary products in the total imports of the Republic of Korea has increased since 1996.

Figure 10
Share of imports by technological intensity, 1962–2009
(Percentages)



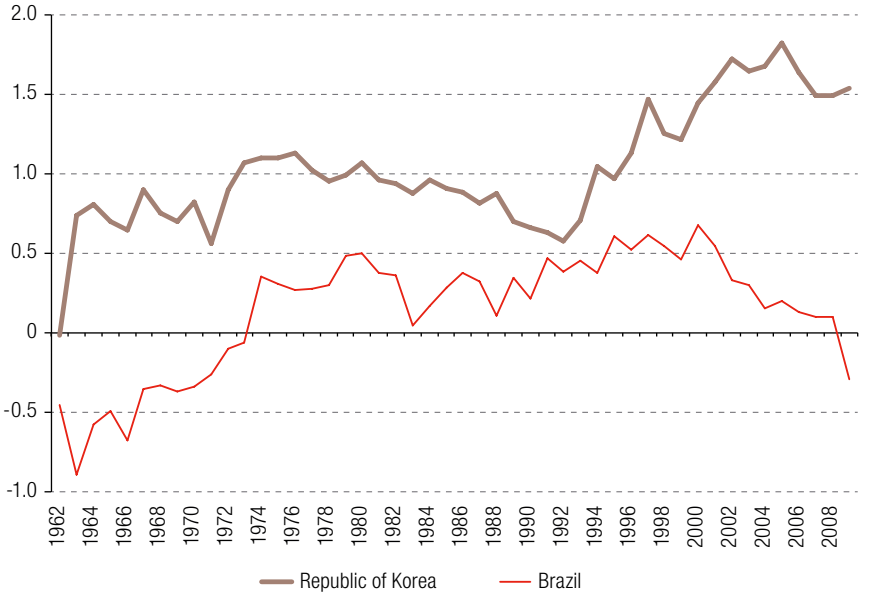
Source: Prepared by the authors.
Note: Standard International Trade Classification (SITC), Revision 1, at the four-digit level was used for the whole period.

It is interesting to note that despite the fact that high-technology manufactures account for a large share of exports from the Republic of Korea, the share of imports from this sector has also been increasing. This reveals two aspects of international trade: (i) the production of high-technology manufactures has a significant degree of international interdependency, with different components being produced in different countries; and (ii) there is a tendency towards the diversification of consumption in medium- and high-technology manufactures, which has contributed to the increase of intra-industry trade.

4. Economic complexity indicators

Figure 11 uses the economic sophistication (ES) index, described in equation (4), to analyse the evolution of the complexity of the economies of Brazil and the Republic of Korea. While the ES of the Republic of Korea was already much higher than Brazil's at the beginning of the period under consideration, the economies of both the Republic of Korea and Brazil went through rapid transformations between 1962 and 1975: the ES of the Republic of Korea increased from -0.01 to 1.1 and the ES of Brazil jumped from -0.45 to 0.35. From 1975 to 1992, the complexity of the productive structure of the Republic of Korea decreased (down to 0.58 by 1992), while that of Brazil remained virtually unchanged (0.38 in 1992). However, after 1992, the ES of the Republic of Korea started to increase rapidly once again, peaking at 1.82 in 2006, as the share of medium- and high-technology in total exports grew, up from 58% to 69% during that period (see figure 6). Meanwhile, the ES of Brazil increased slightly, reaching 0.68 by 2000, but after that the country's level of productive complexity plummeted, down to a negative ES (-0.29) in 2008. This fall in Brazil's economic complexity of is clearly a result of the reprimarization of the economy, as described above and reflected in figure 6, which shows that the share of both primary products and resource-based manufactures in the country's exports increased from 49% to 56% during this period.

Figure 11
Brazil and the Republic of Korea: economic sophistication, 1962–2008



Source: Prepared by the authors.

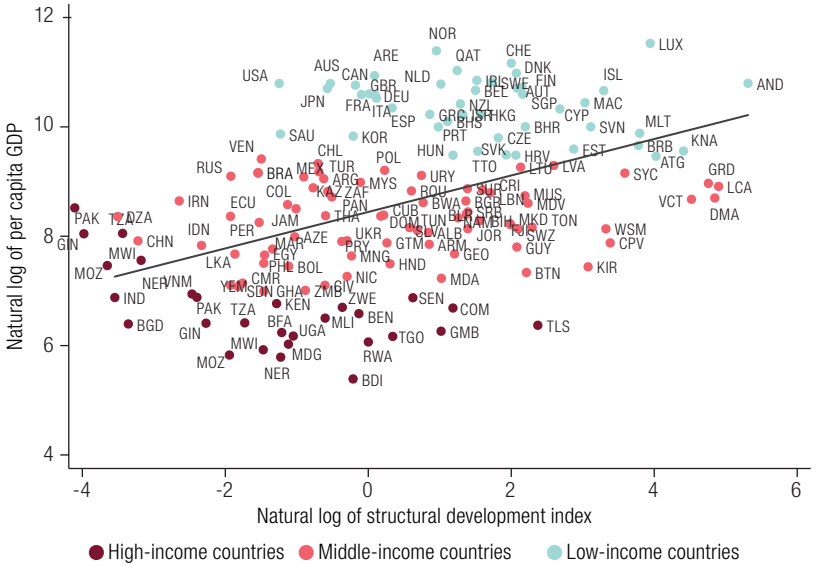
Analysis of figures 11 and 6 reveals that even moderate changes in export shares can determine a country's future development trajectory. In the case of Brazil, a 7-percentage point increase in the share of primary products and resource-based manufactures in national exports led to a considerable reduction in Brazil's economic complexity, raising concerns about the country's economic future. Meanwhile, in the Republic of Korea, exports of medium- and high-technology jumped by 11 percentage points as the economy became much more complex, which, in turn, consolidated process of income growth and structural change in that country.

Yet, while the analyses of the evolution of diversification and bottlenecks, presented in the previous sections, are enlightening, they do not fully explain the different development paths followed by the two countries.

Together with the data on diversification and sectoral export shares (see figures 3 and 6, respectively), one factor that should be taken into consideration when analysing the gap between the per capita GDP of the Republic of Korean and that of Brazil (see figure 1) is the difference in population size between the two countries. For the Republic of Korea, some 30 industries specializing in medium-technology manufactures with RCA and around 10 specializing in high-technology manufactures with RCA were enough to produce the impressive growth in per capita GDP. While Brazil had slightly fewer industries specializing in medium- and high-technology manufactures with RCA (some 25 and 2, respectively), its per capita GDP did not see a parallel increase. Using the ratio of medium- and high-technology manufacturing industries with RCA to total population as a basic indicator of the structural change required for development, we can see that the Republic of Korea reached a level (0.81) similar to that of developed countries, such as Canada (0.84) and the United Kingdom (0.92), while Brazil stayed on a level (0.21) closer to less developed economies, such as the Russian Federation (0.15) and the Bolivarian Republic of Venezuela (0.22).

Lastly, the structural development index is positively correlated with per capita GDP (see figure 12).

Figure 12
World: structural development index and per capita GDP, 2005
(Dollars at constant 2010 prices)



Source: Prepared by the authors.
Note: Low-income countries are those with less than US$ 1,045 per capita GDP per year; medium-income countries are those with between US$ 1,046 and 12,746 per capita GDP per year; high-income countries are those with over US$ 12,746 per capita GDP per year.

While the ratio of the Republic of Korea was as high as those of developed countries, the size of Brazil's population required further diversification and the country's economic policies failed to foster that process. As Jacobsson (1993) highlights, the time and costs needed to learn to efficiently produce high-technology goods have been increasing over time. Consequently, further diversification in these industries becomes more and more difficult over time.

IV. Final thoughts

This article shows that using indices of structural development, RCA and RCD to analyse economies' diversification, bottlenecks and complexity provides important information to understand development trajectories related to structural transformations.

Taking the economic sophistication index as the main indicator of each country's product conditions, the empirical investigation presented here reveals that the development trajectories of Brazil and the Republic of Korea can be divided into three distinct periods: (i) from 1965 to 1975: the productive structure of the Republic of Korea underwent a rapid transformation, with a marked increase in the production of low-technology goods with RCA, while that of Brazil only changed slightly; (ii) from 1975 to 1995: the structural gap between the two countries narrowed, as the economy of the Republic of Korea became less diverse while the number of medium- and high-technology industries with RCA rose, and that of Brazil became more diverse while also creating more medium- and high-technology industries with RCA; (iii) from 1995 onwards: the Republic of Korea consolidated its structural transformation that fostered high economic complexity by increasing the share of medium- and high-technology manufactures in national exports, while structural changes foundered in Brazil, leading to the reprimarization of the economy, dramatically reducing its complexity.

Given that the population of Brazil is much larger than that of the Republic of Korea, more medium- and high-technology industries with RCA are needed to boost per capita GDP rates. Consequently, the costs and effort needed to learn to produce a wider variety of such goods with RCA are higher. Therefore, the data presented here indicate that the economic complexity of Brazil remained moderate, because it did not have enough medium- and high-technology industries with RCA and those industries that did exist did not account for a high enough share of exports.

The indices discussed herein can be important tools for designing more effective industrial and technological policies. Firstly, by identifying the industries with RCA, policies can focus on the areas where domestic production is more efficient. Secondly, using the product space to identify industries with high product complexity that are close to industries with RCA allows the authorities to see where they should concentrate their economic development efforts. Thirdly, the data on those industries with RCD and the potential to become exporters, on those with RCA and on the proximity between industries indicates which industries are most likely to succeed at the global level.

Bibliography

Archibugi, D. and A. Coco (2005), "Measuring technological capabilities at the country level: a survey and a menu for choice", *Research Policy*, vol. 34, No. 2, Amsterdam, Elsevier.

Bahar, D., R. Hausmann and C. Hidalgo (2014), "Neighbors and the evolution of the comparative advantage of nations: evidence of international knowledge diffusion?", *Journal of International Economics*, vol. 92, No. 1, Amsterdam, Elsevier.

Balassa, B. (1965), "Trade liberalization and revealed comparative advantage", *The Manchester School*, vol. 33, No. 2.

Boschma, R., P.-A. Balland and D. F. Kogler (2013), "Relatedness and technological change in cities: the rise and fall of technological knowledge in U.S. metropolitan areas from 1981 to 2010", *Papers in Evolutionary Economic Geography*, No. 1316, Utrecht, Utrecht University.

Burlamaqui, L., J. A. P. de Souza and N. H. Barbosa-Filho (2006), "The rise and halt of economic development in Brazil, 1945-2004: industrial catching-up, institutional innovation and financial fragility", *Research Paper*, No. 2006/81, Helsinki, World Institute for Development Economics Research (UNU-WIDER).

Chang, H.-J. (2006), *The East Asian Development Experience. The Miracle, the Crisis and the Future*, Penang, Third World Network.

Collins, S. M. (1990), "Lessons from Korean economic growth", *The American Economic Review*, vol. 80, No. 2, Nashville, Tennessee, American Economic Association.
Dornbusch, R., S. Fischer and P. A. Samuelson (1977), "Comparative advantage, trade, and payments in a Ricardian model with a continuum of goods", *The American Economic Review*, vol. 67, No. 5, Nashville, Tennessee, American Economic Association.
Felipe, J., J. S. L. McCombie and K. Naqvi (2010), "Is Pakistan's growth rate balance-of-payments constrained? Policies and implications for development and growth", *Oxford Development Studies*, vol. 38, No. 4, Taylor & Francis.
Felipe, J. and others (2013), "Why has China succeeded? And why it will continue to do so", *Cambridge Journal of Economics*, vol. 37, No. 4, Oxford University Press.
___(2012), "Product complexity and economic development", *Structural Change and Economic Dynamics*, vol. 23, No. 1, Amsterdam, Elsevier.
Furtado, C. (1964), *Development and Underdevelopment*, Berkeley, University of California Press.
Gala, P., J. Camargo and E. Freitas (2017), "The Economic Commission for Latin America and the Caribbean (ECLAC) was right: scale-free complex networks and core-periphery patterns in world trade", *Cambridge Journal of Economics*, vol. 42, No. 3, Oxford University Press.
Haggard, S. (2000), *The Political Economy of the Asian Financial Crisis*, Washington, D.C., Institute for International Economics.
Harvie, C. and H.-H. Lee (2003), "Export-led industrialisation and growth: Korea's economic miracle, 1962–89", *Australian Economic History Review*, vol. 43, No. 3, Wiley.
Hausmann, R., J. Hwang and D. Rodrik (2007), "What you export matters", *Journal of Economic Growth*, vol. 12, No. 1, Springer.
Hausmann, R. and C. Hidalgo (2011), "The network structure of economic output", *Journal of Economic Growth*, vol. 16, No. 4, Springer.
Hausmann, R. and others (2011), *The Atlas of Economics Complexity: Mapping Paths to Prosperity*, New York, Puritan Press.
Hidalgo, C. and R. Hausmann (2009), "The building blocks of economic complexity", *Proceedings of the National Academy of Sciences of the United States of America*, vol. 106, No. 26, Washington, D.C., National Academy of Sciences.
Hidalgo, C. and others (2007), "The product space conditions the development of nations", *Science*, vol. 317, No. 5837, Washington, D.C., American Association for the Advancement of Science.
Hirschman, A. O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.
Hong, S. J., C. Jeon and J. Kim (2013), *2012 Modularization of Korea's Development Experience: The Internalization of Science and Technology in the Earlier Stage of Economic Development in South Korea* [online] https://www.kdevelopedia.org/mnt/idas/asset/2013/06/17/DOC/PDF/04201306170126736076481.pdf.
Jacobsson, S. (1993), "The length of the infant industry period: evidence from the engineering industry in South Korea", *World Development*, vol. 21, No. 3, Amsterdam, Elsevier.
Kaldor, N. (1966), *Causes of the Slow Rate of Economic Growth of the United Kingdom*, London, Cambridge University Press.
Kuznets, P. (1990), "Indicative planning in Korea", *Journal of Comparative Economics*, vol. 14, No. 4, Amsterdam, Elsevier.
Kuznets, S. (1966), *Modern Economic Growth*, New Haven, Yale University Press.
Lall, S. (2000), "The technological structure and performance of developing country manufactured exports, 1985–98", *Oxford Development Studies*, vol. 28, No. 3, Taylor & Francis.
___(1992), "Technological capabilities and industrialization", World Development, vol. 20, No. 2, Amsterdam, Elsevier.
Leamer, E. (1984), *Sources of Comparative Advantage: Theory and Evidence*, Cambridge, Massachusetts, The MIT Press.
Lewis, A. (1955), *The Theory of Economic Growth*, Homewood, Irwin.
McMillan, M. and D. Rodrik (2011), "Globalization, structural change, and productivity growth", *NBER Working Paper*, No. 17143, Cambridge, Massachusetts, National Bureau of Economic Research.
Netto, A. D. (2005), "Meio século de economia brasileira: desenvolvimento e restrição externa", *Economia Brasileira Contemporânea (1945–2004)*, F. Giambiagi and others (orgs.), Rio de Janeiro, Elsevier.
Prebisch, R. (1962), "The economic development of Latin America and its principal problems", *Economic Bulletin for Latin America*, vol. 7, No. 1, Santiago, United Nations.

Romero, J. P. and G. Britto (2018), "Sophistication, productivity and trade: a sectoral investigation", *Alternative Approaches in Macroeconomics*, P. Arestis (eds.), Cham, Palgrave Macmillan.

Serrano, F. and R. Summa (2011), "Política macroeconômica, crescimento e distribuição de renda na economia brasileira dos anos 2000" [online] http://www.excedente.org/wp-content/uploads/2014/11/Serrano-Summa-2011-AKB.pdf.

Woo-Cumings, M. (1999), "The state, democracy, and the reform of the corporate sector in Korea", *The Politics of the Asian Economic Crisis*, T. J. Pempel (ed.), Ithaca, Cornell University Press.

Older adults in the digital age in Latin America: bridging the digital age divide[1]

Guillermo Sunkel and Heidi Ullmann

Abstract

In recent decades, countries across Latin America have entered a stage of sustained population ageing. In parallel, changes associated with the rise of the digital society have profoundly transformed the way in which people in the region interact with each other and with their governments. This paper examines the use and appropriation of digital technologies among older adults in the region. In particular, it describes the evolution of Internet use by older adults in the region, using data from national household surveys; examines the determinants of Internet use among older adults, considering variables such as sex, ethnicity, education level and rural/urban residence using logistic regression analysis; and, lastly, highlights policies and programmes that are being implemented to promote the inclusion of older adults through the use of digital technologies.

Keywords

Ageing, Ageing persons, Internet, information technology, communication technology, digital divide, computer literacy, household surveys, programmes of action, ICT indicators, Latin America

JEL classification

I31, 035, J14

Authors

Guillermo Sunkel is a Social Affairs Officer in the Social Development Division of the Economic Commission for Latin America and the Caribbean (ECLAC) and holds a doctorate in cultural studies from the University of Birmingham. Email: guillermo.sunkel@cepal.org.

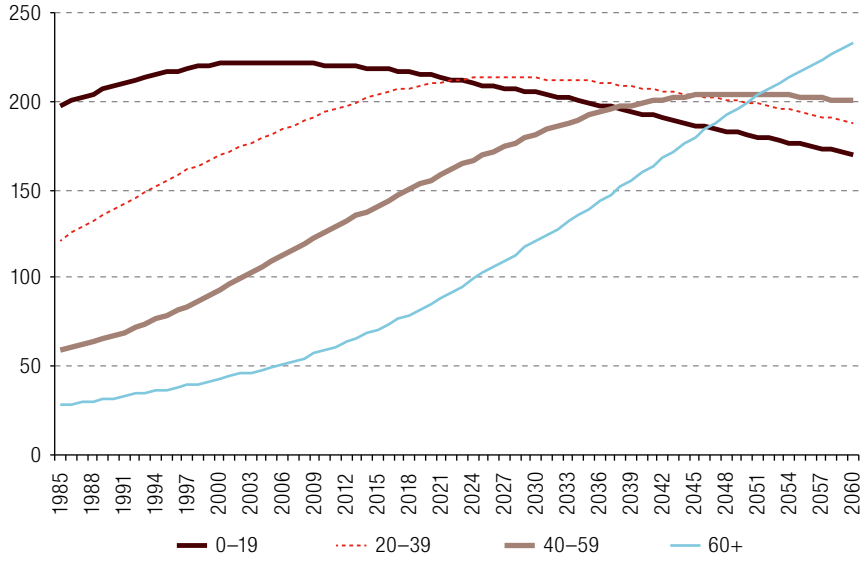
Heidi Ullmann is a Social Affairs Officer in the Social Development Division of the Economic Commission for Latin America and the Caribbean (ECLAC) and holds a doctorate in public affairs from Princeton University. Email: heidi.ullmann@cepal.org.

[1] The authors wish to acknowledge the contributions of Leydi Hernández, who completed an internship at the Economic Commission for Latin America and the Caribbean (ECLAC) in 2015 under the supervision of Guillermo Sunkel. This article draws heavily on the work Ms. Hernández did at ECLAC. The authors would also like to acknowledge Raymundo Mogollón for his support with data processing.

I. Introduction

In recent decades, countries across Latin America have entered a stage of sustained population ageing. Pronounced declines in fertility rates accompanied by improvements in life expectancy have significantly modified the population age structure with a significant increase in the proportion of older adults.[2] The United Nations estimates that by 2050, older adults will represent approximately one quarter of the whole population in the region (see figure 1). In accordance with the definition set forth in the Inter-American Convention on Protecting the Human Rights of Older Persons (OAS, 2015), for the purposes of this study, we define the older adult population as persons 60 years of age or over.

Figure 1
Latin America and the Caribbean: Population by age groups over time, 1985–2060
(Millions)



Source: Prepared by the authors, on the basis of United Nations, *World Population Prospects. The 2015 Revision* (ESA/P/WP.241), New York, 2015.

However, there is some regional heterogeneity in this trend, as the ageing process has not been equally intense everywhere in the region. Table 1 depicts four country groups. The first group (seven countries) has relatively high levels of fertility (more than 3.3 children per woman) and an ageing index of less than 17 older adults for every 100 children under 15 years of age. These countries are in what ECLAC has termed the incipient stage of the demographic transition process. The second group consists of 15 countries with lower fertility rates (between 2.3 and 3 children per woman) and ageing indices that range between 19.8 and 31.9, which means they are at the moderate stage of the ageing process. The three countries in the third group are at a moderate-to-advanced stage of ageing, as their fertility rates vary between 1.7 and 2.5 children per woman and their ageing indices range from 32.8 to 51 older adults per 100 children under the age of 15 (five countries). The fourth and final group (three countries) is in the advanced stage of ageing, with lower levels of fertility (below the replacement rate) and ageing indices over 65 (ECLAC, 2007).

[2] The World Health Organization (WHO) defines older adults as all persons aged 60 years or over in developing countries and, in developed countries, all persons aged 65 years old or over, taking into consideration life expectancy at birth, among other factors. However, each country is free to establish the age at which its population is considered older adult. This is the case with Costa Rica and Uruguay, which set 65 as the age at which a person starts to be considered an older adult.

Table 1
Latin America and the Caribbean: countries, by stage of population ageing process

Stage	Description	Countries
Incipient ageing	Countries that have relatively high levels of fertility (over 3.3 children per woman) and an ageing index of less than 17 older adults for every 100 children under the age of 15	Belize, Bolivia (Plurinational State of), Guatemala, Haiti, Honduras, Nicaragua, Paraguay
Moderate ageing	Countries with lower fertility rates (between 2.3 and 3 children per woman) and ageing indices that range between 19.8 and 31.9	Bahamas, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guyana, Jamaica, Mexico, Panama, Peru, Dominican Republic, Saint Lucia, Suriname and Venezuela (Bolivarian Republic of)
Moderate-to-advanced ageing	Countries with fertility rates varying between 1.7 and 2.5 children per woman and ageing indices ranging from 32.8 to 51 older adults per 100 children under the age of 15	Argentina, Chile, Trinidad and Tobago
Advanced ageing	Countries have lower levels of fertility (below the replacement rate) and ageing indices over 65	Barbados, Cuba, Uruguay

Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Report on the Application of the Regional Strategy for the Implementation in Latin America and the Caribbean of the Madrid International Plan of Action on Ageing* (LC/L.2749(CRE.2/3)), Santiago, 2007.

Despite the fact that the ageing process has not been equally intense, the trend will soon affect all countries in the region. The increase in the older adult population will also prompt proportional increases in the specific social, economic, political and cultural demands of this population, which must be addressed and resolved through public policies in order to ensure their social inclusion, quality of life and the protection and promotion of their rights (ECLAC, 2016a; Huenchuan, 2013). As policymakers seek to guarantee greater autonomy and social integration of older adults, they are increasingly looking to the creation and implementation of digital inclusion initiatives for older persons, with the aim of empowering them in the use and appropriation of information and communications technology (ICT) for their daily activities.

It is well known that the changes associated with the rise of the digital and information society have profoundly transformed the way in which people in the region interact with each other and with their governments. As ECLAC notes (ECLAC, 2016b), between 2003 and 2015 —just a little over a decade— the number of Internet users more than doubled to comprise 54.4% of the population. Mirroring global trends, Internet penetration (measured as the percentage of the total population that has Internet access) more than doubled in Latin America and the Caribbean, from 20.7% to 54.4% between 2006 and 2015. However, the latter figure remained well below the 79.6% average posted by the countries of the Organization for Economic Cooperation and Development (OECD).

Indeed, the diffusion of ICT may have several implications, not only in the economic field but also in the social and political ones. In this regard, the World Summit on the Information Society (WSIS) has sought "to achieve a common vision, desire and commitment to build a people-centric, inclusive and development-oriented Information Society where everyone can create, access, utilize and share information" (WSIS, 2016). Since the first Summit in Geneva in 2003, ICT has been highlighted as a key development tool, with direct impacts on education, health and government services as well as on strengthening democracy, reducing poverty and promoting innovation and economic growth (Balboni, Rovira and Vergara, 2011).

Nevertheless, it is increasingly clear that access to digital media is not evenly distributed within and between countries, which leads to the conclusion that potential benefits are not equally distributed among different populations. Indeed, potential impacts of the media are neither automatic nor extended to all individuals. This uneven access, as well as other economic and social differences, can be worsened if there are no adequate policies to guarantee digital access and benefits to all sectors of society (Balboni, Rovira and Vergara, 2011). Building on this perspective, this paper argues that *ICT* not only has great potential for reducing social and economic inequalities that affect older adults, but can also exacerbate pre-existing economic or social inequalities or even create new ones. Thus, in relation to the subject under discussion, public policies must promote the positive role of new technologies for what they are:

tools that can potentially create opportunities for promoting the inclusion of older adults in all spheres of daily life. Thus, digital inclusion is considered a way to promote social inclusion (Andreasson, 2015).

This work stresses the importance of integrating older persons in the digital world because, among other reasons, in the coming years they will represent a large proportion of the population. The main objective is to explore the use of digital media —particularly the Internet— among older adults in the region and to reflect on how those media can contribute to greater inclusion and better quality of life of this population. The paper seeks to examine whether (and to what extent) older persons are taking advantage of these opportunities. To this end, the following questions will be addressed:

What are the patterns of ICT use among older adults? Have these patterns of use changed over time? What individual-level characteristics are associated with ICT usage in the older adult population?

To answer these questions, this paper draws on data from national household surveys from eight countries in the region (Chile, Ecuador, El Salvador, Honduras, Mexico, Paraguay, Peru and Uruguay).[3] The countries considered are those that have a recently-conducted household survey that includes an ICT module.[4] In all cases, the surveys are nationally representative. Those countries with two recent waves that contain modules on ICT usage are used to examine the changes in ICT use among older adults. In order to make comparisons across surveys, the relevant variables were standardized.[5] The analytic strategy involved multivariate logistic regression analysis to identify the individual-level characteristics that are associated with ICT usage among older adults in the region.

The article is divided into six sections including this introduction. Section II compares Internet access between older adults and other age groups and discusses the notion of an age-related digital divide. Section III describes patterns and trends of ICT use by older adults in the region, using data from national household surveys from seven countries in the region. Section IV identifies the determinants of these types of Internet use among the older adult population, considering variables such as sex, ethnicity (belonging to an indigenous group), education level and rural/urban residence. Section V highlights policies and programmes that are being implemented to promote the inclusion of older adults through the use of ICT. Lastly, section VI draws conclusions and provides some recommendations for furthering the use of ICT in the older adult population.

II. The digital age divide

Historically, older adults have been considered to be persons whose capacities for carrying out productive activities related to the economic process are diminished. The tendency to undervalue the experience and knowledge of older persons has meant that they have come to be regarded as passive persons in the process of development of societies (Abusleme and others, 2014) and, therefore, as on the fringes of social progress.

[3] These surveys are: the National Socioeconomic Survey (CASEN) of Chile, 2015; the National Survey of Employment, Unemployment and Underemployment in urban and rural areas of Ecuador, 2015; the Multi-purpose Household Survey of El Salvador, 2015; the Permanent Multi-purpose Household Survey of Honduras, 2014; the Module on Availability and Use of Information Technologies in Households (MODUTIH) of Mexico, 2014; the Permanent Household Survey of Paraguay, 2015; the National Household Survey on Life Conditions and Poverty of Peru, 2015; and the Continuous Household Survey of Uruguay, 2015.

[4] Most household surveys from countries in the region contain household-level information on ICT availability, typically: whether the household has a cellular phone, a computer and an Internet connection. The eight surveys used in this analysis contain individual-level ICT usage information, which is deemed to be superior to household-level information, since general access to ICT for the household does not guarantee its use among all household members. The individual-level ICT modules contain questions about each household member's use of: cellular phones, computer, the Internet, as well as frequency and place of use. Given the growing interest in ICT usage among persons in the region, standardized modules have been developed and incorporated, which facilitates comparisons across surveys.

[5] For sample characteristics, please see annex A1.

At present, public policy seeks to modify this notion of older persons through campaigns that promote the culture of "active ageing", defined as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age". It applies to both individuals and population groups and allows people to realize their potential for physical, social and mental well-being throughout the life course and to participate in society, while providing them with adequate protection, security and care when they require assistance (WHO, 2002). Undoubtedly, promoting access to and use of digital media amongst older adults is invaluable for advancing the culture of active ageing.

However, one of the social effects of digital technologies in the modern world is that they have become a "new" factor that distinguishes older adults from younger population groups. Indeed, available ICT statistics for Latin America show that the older adult age group is the most isolated from digital technologies, reflecting a deep digital age divide.

The digital divide is a dichotomous concept that was first used in the 1990s to refer to the gap that was developing between countries, social groups and/or persons that had access to digital technologies and those that did not (Selwyn, 2004; Selwyn and Facer, 2007). The concept is particularly relevant when it refers to the reality of developing countries with an ageing population and where digital technologies can have a profound impact on the lives of older adults.

Prensky (2001) has argued that it is important to distinguish between digital natives and digital immigrants. He holds that the former —children and youth who were born and have grown up in the digital age— are characterized by a continuous and prolonged exposure to digital media and by the degree to which they (naturally) integrate them to their daily activities. The latter —"digital immigrants"— are those who were not born in the digital world and have had to adapt to the new environment (Prensky, 2001). This category includes older persons who come from a different cultural "environment" and have had to deal with technological innovations to try to adopt them in their daily lives (Piscitelli, 2009).

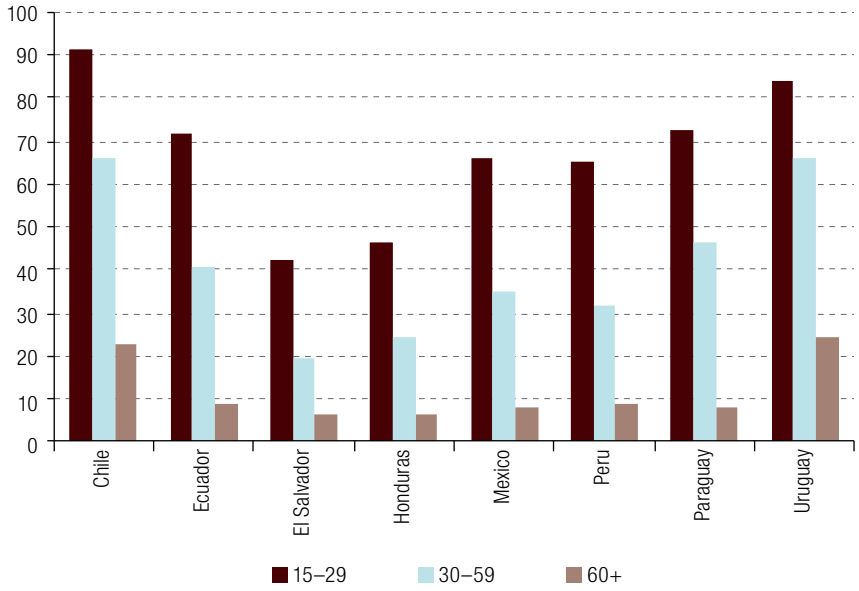
There is ample evidence of a digital divide between adults aged 60 and over and other population age groups in Latin America. Figure 2 shows that there is a lower level of Internet use among older persons than young people and adults in all the countries for which data are available and the gaps are quite striking. For example, reported Internet use among people aged 15–29 was more than seven times that of older adults in El Salvador and Honduras; that figure was eight times higher in Mexico and almost nine times higher in Ecuador.[6]

Patterns of use and access locations also differ across these population subgroups. Table 2 shows the most common locations of Internet access among the 15–29, 30–59 and 60 and over age groups in six countries. Clear differences are noted between the age groups. Most notably, as age increases, the percentage of users who access the Internet at home rises, while higher percentages of young people access the Internet from public locations and schools or other educational facilities.

The results of the analysis of the digital divide in the region show that, compared to other population age groups, older adults use the Internet the least, but they are the ones who access it most from the home. This trend may be attributable to mobility limitations or health problems that constrain their ability to leave the home. Alternatively, some older adults may choose not to leave their home. In contrast, the figures show that younger people rely primarily on Internet access outside of the home. While the data did not allow direct measurement of Internet access via mobile devices outside of the home, it is possible that an even larger proportion of young people access the Internet in this way.

[6] Disaggregated data for older adults aged 60–74 and adults aged 75 and over would have shed further light on the differences in Internet usage, but due to sample size limitations, this was not possible.

Figure 2
Latin America (selected countries): individuals using the Internet, by age group, around 2015[a]
(Percentages)



Source: Prepared by the authors, on the basis of data from national surveys.
[a] Surveys were conducted in 2015, except in Honduras and Mexico, where they were conducted in 2014.

Table 2
Latin America (selected countries): Internet use, by location of access and age group, around 2015[a]
(Percentages)

Country	Age	Home	Workplace	School	Public place
Chile	15–29	76.6	6.1	6.8	0.3
	30–59	77.0	15.3	0.1	0.2
	60+	86.6	9.5	0.0	0.2
Ecuador	15–29	52.8	12.5	23.7	48.1
	30–59	73.4	34.8	2.5	23.0
	60+	89.0	27.7	1.6	8.4
El Salvador	15–29	33.5	2.2	5.7	0.1
	30–59	53.8	10.0	0.3	0.0
	60+	83.7	5.5	0.4	0.0
Honduras	15–29	33.1	8.6	16.4	
	30–59	43.8	25.7	2.6	
	60+	67.4	15.2	0.6	
Mexico	15–29	48.9	8.1	7.9	31.5
	30–59	63.0	20.3	0.0	13.3
	60+	79.5	12.5	0.3	5.5
Peru	15–29	33.7	9.1	8.5	
	30–59	53.1	27.3	0.9	
	60+	75.4	23.6	0.7	

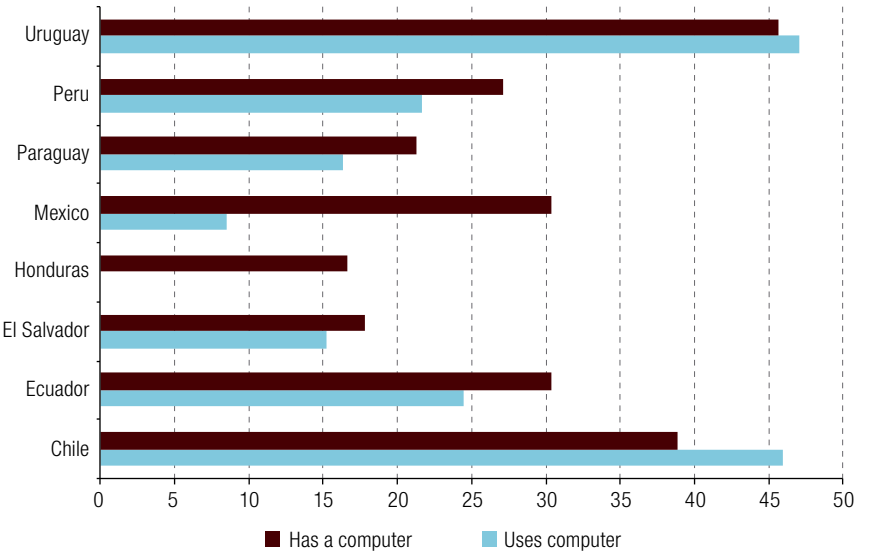
Source: Prepared by the authors, on the basis of data from national surveys.
[a] Surveys were conducted in 2015, except in Mexico, where they were conducted in 2014.

III. Patterns of ICT use by older persons in Latin America

This paper seeks to examine whether (and to what extent) older persons are taking advantage of opportunities in information and communications technology. To this end, it considers the patterns of ICT use among older adults and whether these patterns have changed over time, as well as the individual-level characteristics associated with ICT use in the older adult population. The aim is to provide a rich statistical portrait of ICT use by older persons and thereby offer evidence and recommendations that can help to guide policies that better incorporate older adults into the digital society.

The data on older adults' access to a computer show substantial variations between the countries studied (figure 3). While 45.7% of older adults in Uruguay live in a household with a computer, the number falls to 16.6% in Honduras. This diversity is not surprising, in view of the considerable gaps in economic and social development within the region. What is also clear from figure 3 is that household access to a computer does not equate with computer use by older adults. In five of the seven countries for which both indicators are available (Ecuador, El Salvador, Mexico, Paraguay and Peru), the proportion of this population using computers is lower than the proportion that has a computer in the home. Thus, there is a segment of the older adult population that has theoretical access to computers but does not use them.

Figure 3
Latin America (selected countries): adults aged 60 or over living in households with computers and using computers, around 2015[a]
(Percentages)



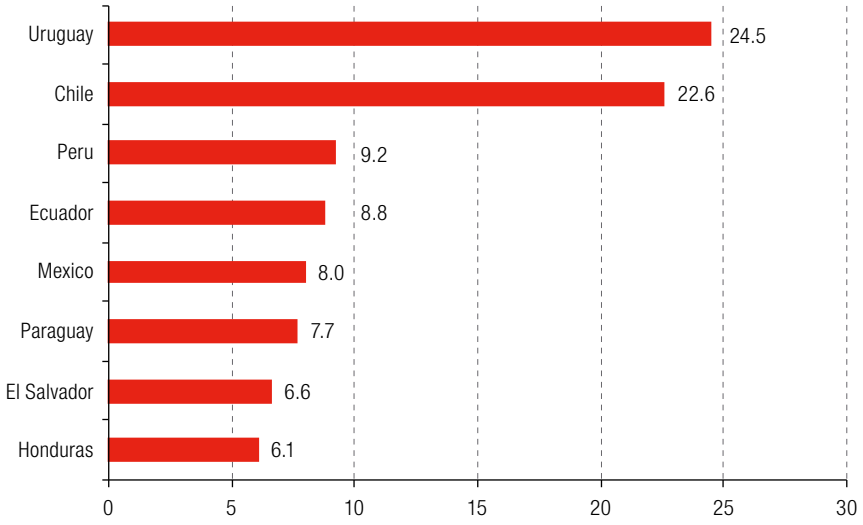
Source: Prepared by the authors, on the basis of data from national surveys.
[a] Surveys were conducted in 2015, except in Mexico, where they were conducted in 2014.

Correspondingly, the percentage of older adults using the Internet is also low (figure 4), ranging from 24.5% in Uruguay to 6.1% in Honduras. This variation not only reflects the uneven educational levels of the populations in each of the countries, but also, more generally, the levels of economic and social development and broadband and Internet connectivity.

The data therefore suggest that older adults are not active participants in the digital societies in which they reside and that there is significant room to expand Internet usage among older adults in the region. Selwyn (2003) argues that the access to and use of digital media is dependent on the

particular characteristics of the individual. The author discusses various factors that can influence non-users (or "offliners") in their decision not to use digital media. These include: discourses of material and cognitive deficiency, technophobia, ideological refusal and diffusion theory.

Figure 4
Latin America (selected countries): adults aged 60 or over using the Internet, around 2015[a]
(Percentages)



Source: Prepared by the authors, on the basis of data from national surveys.
[a] Surveys were conducted in 2015, except in Mexico, where they were conducted in 2014.

With regard to the first factor, he posits that discourses of material restrictions are related to economic and material resources. For some people —particularly those in less favourable conditions— the cost of a digital device might determine the quality of the device purchased or whether a device is even purchased at all. However, access to digital media is irrelevant if there are limitations regarding their use. The author states that discourses of cognitive deficiency are related to intellectual capabilities and to technological skills and that attitudes towards new technology become more positive as individuals gain more experience in using them (Selwyn, 2003).

On the second factor —technophobia, understood as an individual's fear (and apprehension) of technology, particularly the consequences of its use— Selwyn notes a significant correlation with individual characteristics such as gender and age. However, the feeling of anxiety commonly produced by technophobia may disappear as interaction with technology increases. In this regard, Van Deursen and Van Dijk (2014) state that motivation, access, skills and the use of digital media may be influenced by personal characteristics. It is for this reason that technology developers try to create user-friendly technology, that is, hardware and software specially designed for easy use. The third factor, ideological refusal, reflects an individual choice of those persons who do not want to relate to technology even though they are in a position to do so. Lastly, Selwyn (2003) argues that diffusion theory can explain the reluctance of non-use to purchase and adopt a technology that will be quickly replaced by a newer one on the market.

Following this line of thought, Castaño (2008) argues that although the digital divide may seem to be technological in character, it is, rather, a social one. This is because the digital divide —understood as the unequal access to and use of Internet amongst generations (Boonaert and Vettenburg (2011) quoted in Elwick and others, 2013)— is interconnected with other factors that influence s ocial exclusion, such as economic resources, availability of time, knowledge, skills, and cultural and linguistic background. The digital divide may be explained by the different interests, needs, experiences, attitudes and values

of each age group. The perception of the usefulness of a technology for a given activity will condition the degree of interaction an individual has with technology, including the reluctance to use it. In this sense, the extent of Internet use will depend on how, by whom and why it is used (Camacho, 2004).

In line with Murdock´s model, cited in Selwyn, 2003, and on the basis of the available data, young people and adults can be classified in general terms as "core users", while older persons can be classified as either "peripheral users" or "excluded users" of the Internet for the purposes of searching for information, communication and the production of materials (table 3).

Table 3
Types of ICT users

"Core" users	Continuous and comprehensive use of ICT for information seeking, communication and creation/production of materials
"Peripheral" users	Sporadic and limited use of ICT for information seeking, communication and creation/production of materials
"Excluded" users	Non-existent use of ICT for information seeking, communication and creation/production of materials

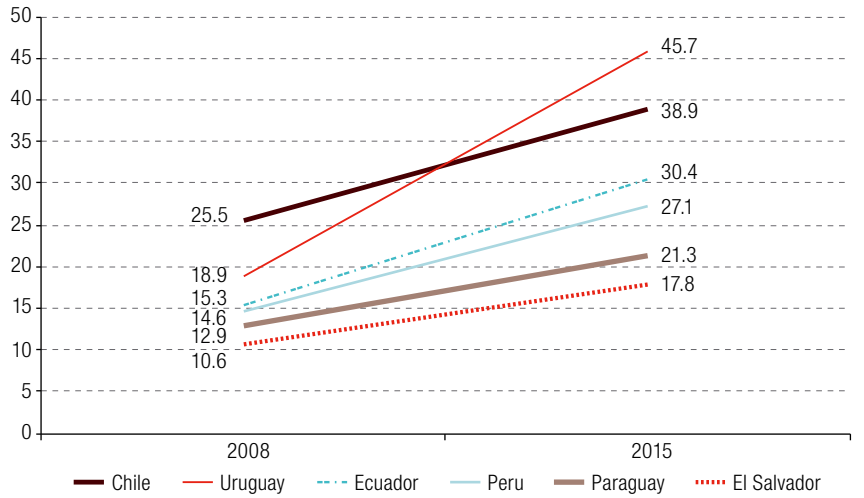
Source: Prepared by the authors, on the basis of N. Selwyn, "Apart from technology: understanding people's non-use of information and communication technologies in everyday life", *Technology in Society*, vol. 25, No. 1, Amsterdam, Elsevier, 2003.

The different degrees of interaction with ICT are related to what Castaño (2008) has termed the "second digital divide", which affects the type of use (in terms of intensity and variety) and is determined by people's computer and Internet access and skills. In this regard, Van Deursen and Van Dijk (2014) argue that digital skills are the "key to the entire process of the appropriation of these new technologies" and that continuous effort and motivation are required to develop those skills.

1. Evolution of ICT usage among older adults

Despite the generally low access to computers and Internet usage among older adults in the region documented above, it must be noted that there has been an important increase in ICT usage among this population in the past five years, which occurred in a larger context of Internet and ICT penetration in the region (ECLAC, 2016b). In terms of household-level access to a computer (figure 5), the expansion was greatest in Uruguay, where just under 19% of older adults lived in a household with a computer in 2008, compared to over 45% in 2015, a more than two-fold increase in just seven years.

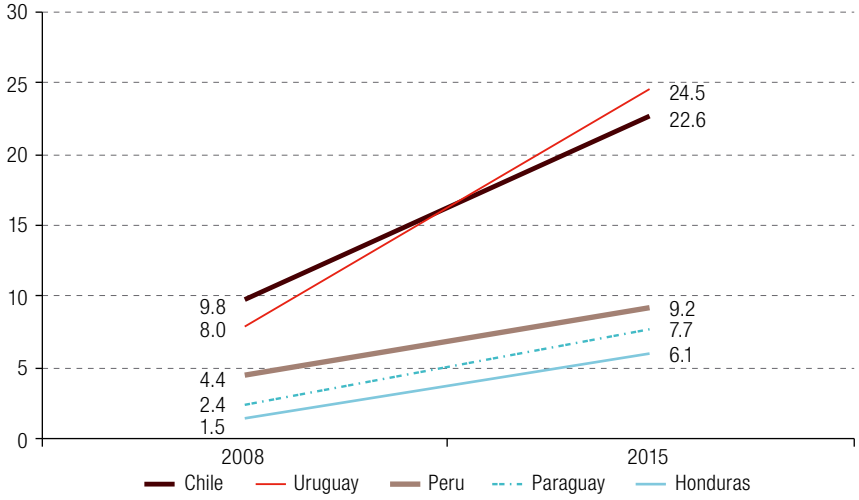
Figure 5
Latin America (selected countries): adults aged 60 or over living in households with computers, 2008 and 2015
(Percentages)



Source: Prepared by the authors, on the basis of data from national surveys.

The data show corresponding increases for Internet use among older adults (figure 6), although these levels are still quite low in some countries, with under 10% of older adults in three of the five countries examined responding that they use the Internet.

Figure 6
Latin America (selected countries): adults aged 60 or over using the Internet, 2008 and 2015
(Percentages)

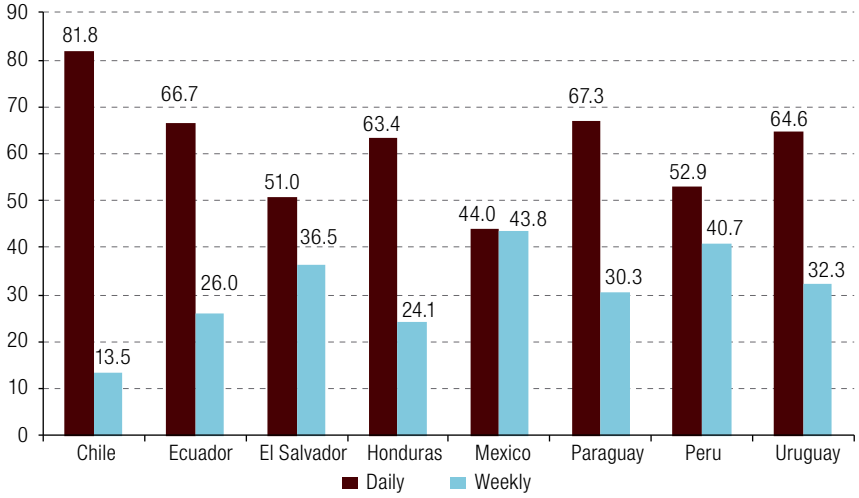


Source: Prepared by the authors, on the basis of data from national surveys.

2. Characteristics of Internet use by older adults

Although, in general, only a small percentage of older adults in Latin America use the Internet, those who do are frequent users, with a majority of them going online every day (figure 7). This suggests that the Internet serves a daily purpose for those older adults who have adopted it. The high level of Internet access and use in a segment of the older adult population in Latin America suggests that they are "core users", as per the classification presented in table 3. Nonetheless, these data do not indicate how much of their Internet usage is dedicated to searching for information, communicating or producing content.

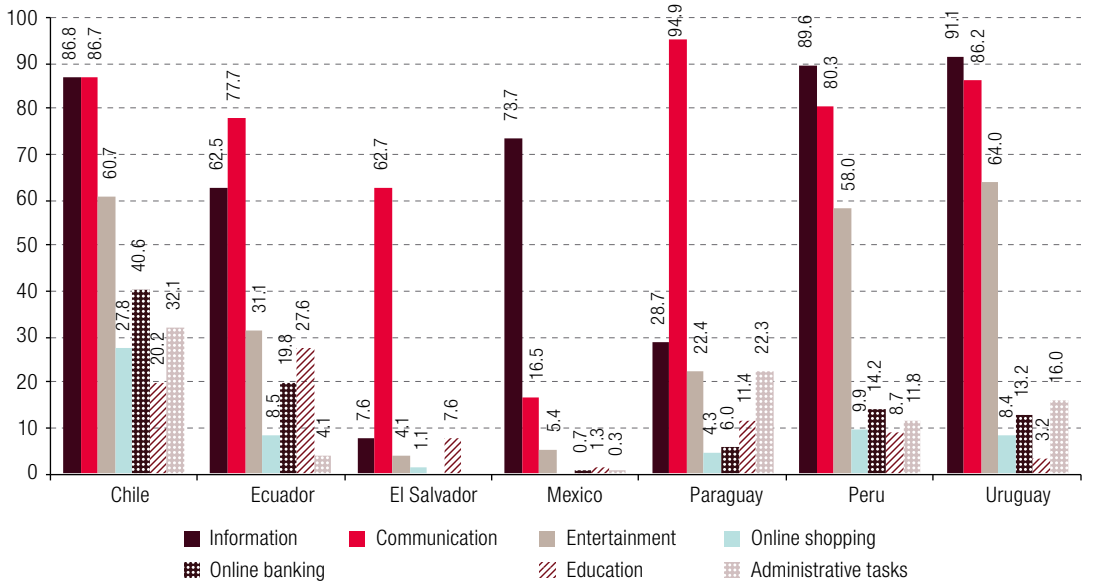
Figure 7
Latin America (selected countries): frequency of Internet use by adults aged 60 or over, around 2015[a]
(Percentages)



Source: Prepared by the authors, on the basis of data from national surveys.
[a] Surveys were conducted in 2015, except in Mexico, where they were conducted in 2014.

To ascertain the main online activities of older adults in the region, this article examines the activities included in the household surveys, namely: information seeking, communication (including email and chatting), education (and training), entertainment, online banking, shopping and carrying out administrative tasks. Despite the above-mentioned heterogeneity in Internet use among older adults in the countries under analysis, the types of activities are somewhat consistent across countries. The Internet is primarily used to search for information and for communication (figure 8).

Figure 8
Latin America (selected countries): adults aged 60 or over using the Internet, by type of activity, around 2015[a]
(Percentages)



Source: Prepared by the authors, on the basis of data from national surveys.
[a] Data for Mexico taken from Module on Availability and Use of Information Technologies in Households (MODUTIH), 2010.

Among older adults, use of the Internet for communication is especially important. Videotelephony software such as Skype or FaceTime make it possible to hold virtual meetings with persons in any location, providing, along with other communication tools, an avenue for older adults to stay in touch with family and friends in an age when it is common for families to live far apart. Moreover, online communication tools allow older adults with limited mobility or hearing to maintain social and interpersonal bonds without having to leave the home. While one might reasonably expect mobility and/or communication difficulties to render other transactions such as Internet shopping or banking more common among older adults, these registered low levels in most of the countries considered.

The fear of using technology (owing to a perceived lack of mastery) together with the security threats and distrust associated with conducting financial transactions on digital devices are possible factors that contribute to older adults' reluctance to use electronic banking or to purchase online. Moreover, in Latin American societies, trips to the bank or shops may represent opportunities for interaction and socialization with others and, in that regard, may be valued by older adults, even those with mobility or communication limitations.

The data also show that a high percentage of users connect to the Internet for entertainment activities, such as viewing and downloading videos, music and movies. In Chile, 60.7% of older adults report using the Internet for entertainment, while that figure stands at 64% in Uruguay. Digital media are not only a pastime for older adults, but can also be a means of combating loneliness. Nonetheless, traditional forms of entertainment and social interaction remain firmly rooted among older persons in these societies.

Lastly, it is interesting to note that in countries such as Chile and Uruguay where Internet usage is more widespread in general, older adults seem to engage in a wider set of online activities, particularly for the administrative procedures of public institutions.

IV. Determinants of Internet use among older adults

In this section, multivariate logistic regression models are used to identify predictors of computer ownership and Internet use. This highlights the sociodemographic factors associated with these two indicators, which can help to pinpoint particular social groups that could benefit from targeted action to expand access to ICT.

The odds ratios from multivariate logistic regression analyses to identify predictors of computer ownership (table 4) and using the Internet (table 5) among older adults in the region are presented below. An odds ratio of 1 means that the variable does not affect the outcome —in this case, one of the two indicators of ICT usage. Values below 1 indicate lower odds of ICT use, whereas values above 1 indicate higher odds of ICT use.

Table 4
Latin America (selected countries): odds ratios from multivariate logistic regression analyses predicting computer ownership among adults aged 60 or older

	Chile	Ecuador	El Salvador	Mexico	Paraguay	Peru	Uruguay
Mean age	0.98 **	1.00	1.01 ***	1.01 **	1.01 *	1.02 **	0.97 **
Male	0.42 **	0.83 **	0.75 **	0.83 **	1.00	0.73 **	1.12 **
Urban	1.30 **	2.95 **	2.88 **	3.85 **	4.43 **	6.54 **	1.64 **
Years of education	1.09 **	1.23 **	1.18 **	1.23 **	1.21 **	1.19 **	1.25 **
Indigenous ethnicity	0.87 **	0.71 **	1.00	0.72 **	1.00	0.94 ***	0.97
With children	2.00 **	5.95 **	3.17 **	3.56 **	5.27 **	5.84 **	5.95 **

Source: Prepared by the authors, on the basis of data from national surveys.
Note: Results are statistically significant at the ** 0.01, * 0.05, and *** 0.10 level.

Table 5
Latin America (selected countries): odds ratios from multivariate logistic regression analyses predicting Internet use among adults aged 60 or older

	Chile	Ecuador	El Salvador	Peru	Uruguay
Mean age	0.93 **	0.91 **	0.96 **	0.92 **	0.91 **
Male	1.10 **	1.24 **	1.09	1.32 **	1.00
Urban	2.31 **	2.23 **	2.58 **	5.09 **	1.62 **
Mean years of education	1.36 **	1.44 **	1.40 **	1.43 **	1.37 **
Indigenous ethnicity	0.80 **	0.95	1.00	0.74 **	0.81 **
With children	1.13 **	0.82 *	0.93	0.99	0.81 **

Source: Prepared by the authors, on the basis of data from national surveys.
Note: Results are statistically significant at the ** 0.01, * 0.05, and *** 0.10 level.

The results in table 4 indicate that in all of the seven countries, older adults living in urban areas have higher odds of owning a computer than those living in rural areas, ranging from 1.30 higher odds in Chile to 6.54 in Peru. Similarly, the likelihood of computer ownership is higher among older adults with higher levels of education and those who have had children. Lastly, older adults belonging to ethnic minorities have a lower likelihood of owning a computer.

The relationship between computer ownership and the variables of age and sex is not consistent in the seven countries in table 4. In some countries, the odds of owning a computer are lower with each additional year of age, whereas in others they are higher. Patterns are also mixed when disaggregated by sex— while, in Uruguay, men are more likely than women to live in a household with a computer, in the other countries, they are less likely than women to live in a household that owns a computer.

The patterns are more consistent when Internet usage among older adults (table 5) is examined. As age increases, the odds of using the Internet decreases in the five countries examined. In three of the five countries (Chile, Ecuador and Peru), men are more likely than women to use the Internet. Older adults belonging to an ethnic minority have lower odds of using the Internet than older adults who do not belong to such groups in Chile, Peru and Uruguay. As with computer ownership, there is a statistically significant association between urban residence and Internet use among older adults in the region. Each additional year of education increases the odds of using the Internet. Lastly, having children in the household is associated with higher odds of using the Internet in one of the five countries (Chile), whereas this is associated with lower odds of using the Internet in Ecuador and Uruguay.

In sum, despite increases over the past few years, computer ownership and use and Internet usage remain low among older adults in the region. However, a majority of those older adults who do use the Internet have incorporated it into their daily routines, the main uses being searching for information and communication. The factors that are most consistently associated with computer ownership and Internet usage are urban residence and educational attainment. On the other hand, older adults belonging to an ethnic minority, in particular indigenous populations, are less likely to have access to a computer at home and to use the Internet.

The relationship between ICT usage in the region and education has been documented by other research (Gutiérrez and Gamboa, 2010) and can be explained in two ways. First, as educational attainment is a proxy for socioeconomic status, those with higher levels of education likely have higher socioeconomic status and are, therefore, more likely to have the financial resources to access ICT. It is also true that ICT usage requires a certain level of literacy and skills, so that those with higher levels of education are more able to engage in these activities.

The association between urban residence and ICT usage is feasibly related to the greater availability of technological goods and wider Internet connectivity in cities. In the four countries that measure ethnicity, adults belonging to ethnic minorities are systematically less likely to use the Internet. This is consistent with a generalized pattern of exclusion and marginalization of these groups that may also be related to linguistic and cultural issues.

One last finding is that, as age increases, the odds of Internet use declines —it is the younger older adults who have an advantage in Internet usage. The relationship between ICT usage (particularly having a computer) and having children suggests that younger generations are instrumental in introducing and exposing their parents to the potential uses of ICT. That said, there is clearly a wide margin for increasing ICT access and use for older adults in the region.

Although much has been written about the digital divide between generations, these results suggest that there is another digital divide: one within the older adult population. ICT penetration is heavily concentrated among specific groups of older adults: those who are educated, reside in urban areas, and do not belong to indigenous groups. Thus, the diffusion of technologies seems to replicate other socioeconomic inequalities.

V. Programmes that promote the digital inclusion of older adults

To complement the picture drawn in the previous sections, it is important to examine what the different countries of the region are doing to bridge the digital age gap. Therefore, this section highlights some of the policies and programmes that are being implemented to promote the inclusion of older adults through the use of ICT. The aim is to provide an initial mapping of how the problem of the digital age divide is being addressed in the region. These experiences (or practices) have been identified through a web search for programmes targeting older adults implemented by various institutions in the different countries of the region.

It should be recognized that there are some regional instruments on the rights of older adults which enshrine the right to ICT access.[7] For example, the San José Charter on the Rights of Older Persons in Latin America and the Caribbean, adopted by government representatives at the Third Regional Intergovernmental Conference on Ageing in Latin America and the Caribbean in 2012, specifically refers to the need to "promote actions to guarantee access by older persons to information and communication technologies, in order to reduce the technological divide" (ECLAC, 2012).

More recently, in 2015, the member States of the Organization of American States (OAS) adopted the Inter-American Convention on Protecting the Human Rights of Older Persons (OAS, 2015), which specifically mentions access to ICT in relation to the right to education and the right to accessibility and personal mobility. Under the Convention, the States Parties undertake to "promote education and training for older persons in the use of new information and communication technologies (ICTs) in order to bridge the digital, generational, and geographical divide and to increase social and community integration" (article 20 (d)) and to "promote access for older persons, at the lowest possible cost, to new information and communication technologies and systems, including the Internet" (article 26 (e)).

In addition to this normative framework, since the mid-2000s, Latin American and Caribbean countries have embraced the notion of ICT for development, adopting the Plan of Action for the Information Society in Latin America and the Caribbean (eLAC), which underlines the importance of information and communication technologies (ICT) as tools for economic development and social inclusion. In 2005, during the preparatory meetings for the second phase of WSIS, the countries of the region agreed on the Plan of Action eLAC 2007. Subsequent Plans, namely eLAC 2010, eLAC 2015 and, most recently, eLAC 2018 guarantee the continuity of this engagement.

In the Mexico City Declaration, the outcome of the fifth Ministerial Conference on the Information Society in Latin America and the Caribbean, the countries of the region renewed the agreements of the eLAC process through the and adopted the new digital agenda eLAC 2018, which sets out 23 policy objectives in five areas of action: (i) access and infrastructure; (ii) digital economy, innovation and competitiveness; (iii) e-government and citizenship; (iv) sustainable development and inclusion; and (v) governance for the information society. In order to advance towards the policy objectives laid out in the eLAC regional framework for ICT, many countries in the region have adopted digital agendas, many of which make specific mention of the inclusion of older adults (see table 6).

[7] Countries of the region adhere to the Madrid International Plan of Action on Ageing (2002) which, in "Objective 1: Equality of opportunity throughout life with respect to continuing education, training and retraining as well as vocational guidance and placement services", calls on governments to "ensure that the benefits of new technologies, especially information and communication technologies, are available to all, taking into account the needs of older women" and, in Objective 2: Full utilization of the potential and expertise of persons of all ages, recognizing the benefits of increased experience with age, to "encourage older volunteers to offer their skills in all fields of activities, in particular information technologies" (United Nations, 2002).

Table 6
Latin America (selected countries): national digital agendas and plans with specific mention of older adults

Country	Agenda/Plan	Mentions of and references to older adults
Costa Rica	National Telecommunications Development Plan 2015–2021 *"Costa Rica: Una sociedad conectada"*	(Projects) should be inclusive, serving the general population, including vulnerable populations, that is those who are economically disadvantaged, and with an emphasis on persons with disabilities, children and young people, older adults, indigenous peoples, female heads of households and microentrepreneurs, as well as the public institutions that attend to them. All persons (including persons with disabilities) shall be guaranteed access to broadcasting services of high technical quality, on equal terms and without discrimination. In addition, the production of software and content and applications development shall promote accessibility, with a view to offering innovative products and services.
Guatemala	National Agenda for the Information and Knowledge Society of Guatemala	Implement an "education for life" system, with the participation of older adults and persons with disabilities.
Honduras	Digital Agenda of Honduras 2014–2018: connectivity, transparency, and efficiency	Promote the digital inclusion of indigenous peoples and communities, persons with disabilities and older adults. Establish broadband internet access centres for rural and urban communities and accessible to all users, and the installation of screen reader software for persons with visual disabilities. Promote the labour inclusion of persons with disabilities through teleworking.
Mexico	National Digital Strategy, 2013–2018	Enhance the National Digital Inclusion Campaign with special emphasis on indigenous peoples, older adults, persons with disabilities and groups that are marginalized and living in extreme poverty.
Peru	Plan for the Development of an Information and Knowledge Society in Peru - the Peruvian Digital Agenda 2.0	The developments necessary to move towards the information and knowledge Society in Peru must include actions that adequately address disability and diversity from the perspective of equal rights and opportunities, non-discrimination, universal accessibility and the removal of barriers for various vulnerable groups. The foregoing is not limited to promoting policies to increase access to computers and the Internet, and/or ensure that points of access such as public Internet kiosks and telecentres are equipped to welcome different categories users, including persons with disabilities, older persons, children, indigenous peoples and Afrodescendants, among others. It also implies creating digital literacy and capacity-building projects, developing applications and content that reflect multiculturality and identity, and addressing disability issues.

Source: Prepared by the authors, on the basis of information contained in national plans and agendas.

Many of these digital strategies exist under the framework of laws that explicitly recognize the rights of older adults to information and communication technologies, and in particular, the Internet (table 7). However, it is clear that the existence of these laws is a necessary but not sufficient condition to guarantee the right of older adults to ICT.

Table 7
Latin America (selected countries): national laws that recognize the rights of older adults to information and communication technologies

Country	Law	Mention of older adults
Argentina	Digital Argentina Act (2014)	Service providers have an obligation to ensure that specific social groups, persons with disabilities, among them users with serious vision impairment or visual disabilities, the hearing impaired and speech impaired, older persons and users with special social needs have access to services in conditions comparable to other users, pursuant to the provisions of the applicable legislation (article 62, para. c).
Bolivia (Plurinational State of)	General Law No. 164 of 8 April 2011 on telecommunications and information and communication technologies	The service contract must guarantee that persons with disabilities have adequate access to services (article 26, para. II (3)); users with disabilities and older adults have the right to be provided with accessible telecommunications and information and communication technology, as specified in the implementing regulations (article 54, para. 18); providers must facilitate access to telecommunications and information and communication technology for users with disabilities and older adults, as specified in the implementing regulations (article 59, para. 14).
Brazil	Ordinance No. 16 (2012)	Guarantee access to the network of ICT services to minority and marginalized groups, people living in poverty, indigenous groups, persons with disabilities, the Afrodescendent population and older adults.
Colombia	Law 1221 of 2008 establishing the rules for the promotion and regulation of teleworking and other provisions	The Ministry of Social Protection, within six (6) months of the enactment of this law, will formulate a public policy to mainstream telework for vulnerable populations (persons with disabilities, forcibly displaced populations, geographically isolated populations, female-headed households, prisoners, and persons whose lives are threatened (article 3, para. 1).
Costa Rica	General Telecommunications Law No. 8642	Provide quality, timely and efficient telecommunications services at affordable and competitive rates to institutions and to persons with special social needs, including shelters for children, older persons, persons with disabilities, indigenous peoples, public schools, and public health centres (article 32, para. (c)).

Source: Prepared by the authors.

With regard to the outline of programmes promoting ICT use among older adults presented below, it is important to note, first, that the practices described are not exhaustive or representative of what is being done in the different countries of the region, neither can they be considered "best practices". They merely provide a snapshot of some of the programmes that are currently in existence in the region. Second, what follows should be taken as a preliminary approach since the lack of the necessary information made it impossible to examine key aspects of the programmes, such as coverage, performance, results, impact and financing, among others. —These, then, may be identified as priorities for future research.

Table 8 summarizes some of the basic characteristics of the digital inclusion programmes for the older adults that are being implemented in the region. Two points are worth highlighting in this regard. The first is that digital inclusion amongst older adults is promoted by providing access to digital technologies and, at the same time, by developing digital skills (particularly, those related to digital literacy) through computing workshops. In their most recent work, Van Deursen and Van Dijk (2014) argue that the concept of "access" is multifaceted and includes four different aspects: motivation to use computers and the Internet ('motivational access'); physical access —be it private or public— to computers and the Internet, ('material access'); digital skills ('skills access'); and, usage opportunities ('usage access'). According to Van Dijk, access problems gradually shift from physical to the usage access (which, as mentioned in Section III, has been termed the 'second digital divide').

Table 8
Latin America (selected countries): examples of programmes for the digital inclusion of older adults

Country	Initiative	Implementation period	Form	Implemented by
Argentina	*Postas Digitales* programme		Computing workshops	Buenos Aires City Government
	University for Older Adults (UPAMI) programme		Digital and technology literacy courses for everyday life	Universities offering courses for older adults and the elder care programme
Costa Rica	Courses in technology		Basic computing courses	The Costa Rican Gerontology Association (AGECO) and Gerontological Training Institute (IGEF)
	Ciudadano de Oro programme		Basic computing courses	National Council for Older Persons (CONAPAM), the Costa Rican Social Security Fund and the Latin American University for Science and Technology (ULACIT) of Costa Rica
	ED-1498 project: Digital technologies for older adults under the *Tecnologías Educativas Avanzadas* (PROTEA) programme	2005	Internet courses	University of Costa Rica
Chile	*Chile Mayor Digit@l 2.0*	2013–present	Installation of Digital Citizen Plazas	National Service for Older Adults of Chile and the Rural Training Foundation of the Catholic University of Chile
Mexico	Digital education courses by Universidad Autónoma de Nueva León	In progress	Free computer courses	University for Older Adults, as part of the University of the Third Age network
	Biblioteca digital TELMEX	In progress	Digital inclusion courses	Teléfonos de México (TELMEX) and the Carlos Slim Foundation
Peru	*Campaña Gratuita de Alfabetización Digital*	2013	Computer and Internet courses	Peruvian Association of Professional Engineers
Uruguay	*Plan Ibirapitá*	2015	Provides electronic tablets to retirees and pensioners and basic courses	*Plan Ceibal*

Source: Prepared by the authors.

The programmes considered offer "material access" for the digital inclusion of older adults in the region. This is the case, for instance, with the *Postas Digitales* programme implemented by the Government of the City of Buenos Aires which aims to bring older adults closer to digital technology by setting up

public centres, equipped with computers and an Internet connection, in different neighbourhoods. These centres also serve as meeting places where older adults can socialize.

The *Chile Mayor Digital 2.0* programme offers digital literacy training workshops, albeit in a somewhat broader sense than the examples above. The idea is to acquaint older adults with platforms that can help them in their daily lives, enabling them to maintain communication with loved ones, interact with older adult groups across the country through social networks and learning about web sites. The programme also provides courses and thematic seminars that aim to promote Internet use by raising awareness of the opportunities that digital networks offer, for example, local government web portals which give information on the different programmes, workshops, benefits and the like available to older persons or which allow them to carry out administrative tasks online.

It should be noted that such spaces offering "material access", particularly to the poor and the vulnerable, presuppose that older adults have the motivation to use computers and the Internet. However, these technological spaces are established with the aim of developing digital skills, particularly those related to digital literacy. In the strict sense, and following Van Dijk's model, "digital literacy" refers to digital skills which are medium-related, that is, operational skills (knowing the actions required to operate a digital medium) and formal skills (knowing how to handle the formal structures of the medium: browsing, searches). Some of the programmes in existence seek to go further and develop content-related skills.[8]

For example, under the *Postas Digitales* programme, digital literacy workshops are provided for older adults, twice a week for a period of six months. To complement the training received, participants are given a guidebook of medium-related skills, including both operational and formal skills. Thus, the programme seeks to contribute to the Government's commitment to integrate 100,000 older adults in the digital world.

Another example is the *Alfabetización digital para el adulto mayor* programme in Lima, which is designed for older adults with little or no knowledge of communication technologies. The aim of the programme —which is sponsored by the Peruvian Association of Professional Engineers and is in its initial stage— is to give older adults the opportunity to learn medium-related digital skills so that they can use digital technologies in their daily lives. At the end of the training, the participants are expected to be able to use web tools such as search engines, browsers, email services and personal websites or blogs.

A different method for the promotion of digital inclusion among older adults has been implemented in Uruguay through the *Plan Ibirapitá* programme, which the Government of Uruguay launched in 2015 to complement training courses in digital technologies given by different institutions. Within the framework of *Plan Ceibal*, the programme aims to contribute towards equal access to knowledge and the social inclusion of retired persons.

Under the programme, electronic tablets are provided to introduce older persons and retirees of low socioeconomic level to the digital world. After a pilot test carried out in mid-2015 to assess and make adjustments to the software, the mass delivery of the devices began, with the planned delivery of 100,000 tablets in 2016. The tablets, specifically designed to be intuitive and user-friendly (simple access, large text and icons), are provided during a workshop in which the beneficiaries learn how to operate the hardware and the software. For many of them, this is their first contact with an electronic device. The workshop not only familiarizes them with the main features of the devices, but also provides an opportunity to relate to their peers and overcome any possible technophobia. Device content is grouped into four categories: health, entertainment, administrative tasks and communication. According to Novaresse (2015), the health category should be one of the most useful to beneficiaries,

[8] "The medium-related skills account for the technicalities of media use, apparent in the operational and formal skills, whereas the content-related skills account for the aspects that relate to the content provided by the media, apparent in the information, communication, content creation, and strategic skills. The distinction has a sequential and conditional nature. In other words, the skills come after and on top of each other. For example, performing content-related skills requires the command of medium-related skills". See Van Deursen and Van Dijk (2014, p. 7).

as it includes the *Caléndula* app which allows them to manage medication intake through a calendar in which users can enter personalized medication routines. The *Ibirapita* web page also provides tutorials on the technology.[9] Interestingly, the programme includes a campaign that aims to help the children and grandchildren of the beneficiaries to use and adopt the technology.

The second aspect worth highlighting with regard to digital inclusion programmes for older adults in the region is that they are being implemented through different institutional arrangements. For example, *Chile Adulto Mayor Digital 2.0* is administered by the National Service for Older Adults (which is a public service) in collaboration with the Rural Training Foundation of the Catholic University of Chile. This public-private initiative complements the Government's digital agenda to reduce the digital gap in the country. In the *Plazas Digitales Ciudadanas* programme, various public organisms and private enterprises show the many actions that can be done through the Internet to improve the quality of life of older adults. The initiative also requires the coordination of the national and local governments. The *Postas Digitales* programme is implemented by the Government of the City of Buenos Aires in coordination with the Ministry of Social Development and the Undersecretariat for Older Adults. This is a public initiative that works in connection with civil society organizations, associations and institutions catering to older adults.

In Lima, the digital literacy programme for older adults is coordinated by the Peruvian Association of Professional Engineers in collaboration with the University of Sciences and Humanities (through its Faculty of Engineering), through agreements signed with local governments, as was the case in the northern district of Comas. In Costa Rica, the *Ciudadano de Oro* programme is a joint initiative of the Latin American University of Science and Technology (ULACIT) of Costa Rica, the National Council for Older Persons (CONAPAM) and the Costa Rican Social Security Fund. The programme seeks to create a culture of respect for persons aged 65 or older, in recognition of their life of effort and work, by offering various free benefits, discounts and preferential treatment to older adults in possession of the card that identifies them as "golden citizens". Included in these benefits are digital literacy courses which aim to enhance the social contact, independence and development of older adults.

In short, a number of institutional arrangements are being explored to implement digital skills programmes for the social inclusion of the elderly population. However, the countries of the region must make greater efforts to further promote the use of digital media among older adults. These efforts should, at least, consider the following elements:

1. Strengthen the coordination among the different public sector, private sector and civil society entities that organize programmes to promote ICT usage among older adults to ensure that the programmes are mutually reinforcing.
2. Promote intergeneration skills development, whereby the younger generations assist older adults in becoming familiar with digital tools that are of use to them.
3. Promote opportunities for peer-to-peer training, where older adults who are actively engaged in the digital society help to train older adults who have not yet embraced digital technologies (as is the case in the *Plan Ibirapitá* programme).
4. Develop apps or other technological tools that respond directly to older adults' needs have and that can foster their inclusion in society and raise awareness on these technologies among older adults.
5. Expand access to the Internet in the home or via mobile devices for older adults, particularly for those residing in rural areas, those belonging to indigenous groups and those of low socioeconomic status.

[9] See [online] http://ibirapita.org.uy.

6. Improve data on ICT usage at the individual level —as this analysis reveals, few countries in the region have data that can be used to measure ICT usage among older adults, which makes it difficult to identify patterns and monitor policies.
7. Ideally, qualitative data should also be used, as they could further understanding of the barriers and factors that promote ICT use among older adults in Latin America and the Caribbean and provide insight on the most relevant issues that condition the use of ICT by this population (low levels of literacy, non-accessible formats, cost, lack of familiarity, individual perceptions of ICT, among others).
8. Promote greater participation of older adults in ICT development so that these tools better meet their needs and promote participation in the drafting of plans and strategies to expand ICT access and use among older adults.

VI. Conclusions

This analysis provides a regional overview of ICT usage among older adults, a subject heretofore not examined fully despite its relevance in ageing societies. This study provides valuable evidence to guide policy and programme design and specific policy recommendations to expand access to ICT for older adults in the region and thus promote their inclusion. Despite this important contribution, some limitations should be kept in mind. For example, in 2014, 14.9% of users in Latin America utilized devices other than personal computers to access the Internet, opting instead for mobile telephones or tablets (ECLAC, 2016b). Owing to the sources of data used for this study, it has not been possible to explore this type of Internet use. The authors were also limited by the number of household surveys in the region that include ICT modules. Although common patterns between the countries have been identified, given the extremely heterogeneous nature of Latin America, it is important to consider the specificities of each country and bear in mind that the data presented here may not apply to all contexts. Lastly, the fact that the study considers mainly public sector (and some civil society) initiatives promoting ICT usage among older adults although the private sector is clearly a key player as well may constitute a methodological flaw.

Despite these limitations, this study represents an important contribution. First, the results confirm the existence of a marked digital age divide —not only between countries, but also within them. Although the use of the Internet has increased for persons aged 60 or over across all countries, their usage levels are still quite low when compared to the 15–29 and the 30–59 age groups. Another interesting finding pertains to the fact that while many older adults in the region live in households with access to the Internet, a large percentage of them do not use it. This suggests that access is not the sole determinant in the use of ICT among older adults, but that motivation and skills, in other words the desire and the capacity to take advantage of these tools, are also necessary. For older adults, a lack of awareness of how these tools can address everyday needs may be an important barrier to ICT use. It is therefore important to raise awareness about the potential benefits of using ICT and develop ICT skills among older adults and those close to them.

The findings of this research also corroborate previous studies showing that in Latin America, household access to ICT is determined by the availability of infrastructure and other economic, social and demographic variables, such as housing location (ECLAC, 2016).

Certain social groups are also being excluded from the digital revolution that is under way in the region. As this analysis demonstrates, older adults belonging to indigenous groups are less likely to use the Internet than non-indigenous older adults, all else being equal. It must therefore be borne in mind that although ICT can help to reduce social inequalities, the current uneven access to these technologies may exacerbate these inequalities, as some reap the benefits while others remain behind.

With the adoption of the 2030 Agenda for Sustainable Development, all countries in Latin America and the Caribbean pledged to leave no one behind. This means, among other things, taking decisive steps to reduce the persistent disparities that plague the region. The digital divide between generations and within the older adult population alike is a cause for concern because it could serve to widen gaps which must instead be reduced.

Bibliography

Abusleme, M. T. and others (2014), *Inclusión y exclusión social de las personas mayores en Chile*, Santiago, National Service for Older Adults/Faculty of Social Sciences at the University of Chile/Latin American Faculty of Social Sciences (FLACSO)-Chile.

Andreasson, K. (ed.) (2015), *Digital Divides: the New Challenges and Opportunities of e-Inclusion*, Boca Raton, CRC Press.

Balboni, M., S. Rovira and S. Vergara (eds.) (2011), *ICT in Latin America: A Microdata Analysis* (LC/R.2172), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Boonaert, T. and N. Vettenberg (2011), "Young people's internet use: divided or diversified?", *Childhood*, vol. 18, No. 1, SAGE.

Camacho, K. (2004), "Retos para evaluar el impacto de la internet: el caso de las organizaciones de la sociedad civil centroamericana", Acceso Foundation [online] https://revistas.um.es/analesdoc/article/view/1721/1771.

Castaño, C. (2008), "La primera y la segunda brecha digital", *La segunda brecha digital*, C. Castaño (coord.), Madrid, Cátedra.

ECLAC (Economic Commission for Latin America and the Caribbean) (2016a), *The Social Inequality Matrix in Latin America* (LC/G.2690(MDS.1/2)), Santiago.

___(2016b), *The New Digital Revolution: From the Consumer Internet to the Industrial Internet* (LC/L.4029/Rev.1), Santiago.

___(2012), *San José Charter on the Rights of Older Persons in Latin America and the Caribbean* (LC/G.2537), Santiago [online] http://repositorio.cepal.org/bitstream/handle/11362/21535/S2012897_en.pdf?sequence=1&isAllowed=y.

___(2007), *Report on the Application of the Regional Strategy for the Implementation in Latin America and the Caribbean of the Madrid International Plan of Action on Ageing* (LC/L.2749(CRE-2/3)), Santiago.

Elwick, A. and others (2013), *Beyond the Digital Divide: Young People and ICT*, CfBT Education Trust [online] https://www.educationdevelopmenttrust.com/~/media/EDT/Reports/Research/2013/r-beyond-the-digital-divide-perspective-2013.pdf.

Gutiérrez, L. H. and L. E. Gamboa (2010), "Determinants of ICT usage among low-income groups in Colombia, Mexico, and Peru", *The Information Society*, vol. 26, No. 5, Taylor & Francis.

Huenchuan, S. (2013), "Perspectivas globales sobre la protección de los derechos humanos de las personas mayores, 2007–2013", *Project Documents* (LC/W.566), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Novaresse, C. (2015), "Así funcionan las tabletas para jubilados" [online] https://www.cromo.com.uy/asi-funcionan-las-tabletas-jubilados-n654160.

OAS (Organization of American States) (2015), "The Inter-American Convention on Protecting the Human Rights of Older Persons" [online] http://www.oas.org/en/sla/dil/inter_american_treaties_a-70_human_rights_older_persons.asp.

Piscitelli, A. (2009), *Nativos digitales: dieta cognitiva, inteligencia colectiva y arquitecturas de la participación*, Buenos Aires, Santillana.

Prensky, M. (2001), "Digital natives, digital immigrants", *On the Horizon*, vol. 9, No. 5 [online] http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf.

Selwyn, N. (2004), "Reconsidering political and popular understandings of the digital divide", *New Media Society*, vol. 6, No. 3, SAGE.

___(2003), "Apart from technology: understanding people's non-use of information and communication technologies in everyday life", *Technology in Society*, vol. 25, No. 1, Amsterdam, Elsevier.

Selwyn, N. and K. Facer (2007), *Beyond the Digital Divide: Rethinking Digital Inclusion for the 21st Century*, Futurelab [online] https://www.nfer.ac.uk/publications/FUTL55.

United Nations (2015), *World Population Prospects. The 2015 Revision* (ESA/P/WP.241), New York.

___(2002), *Political Declaration and Madrid International Plan of Action on Ageing*, New York [online] http://www.un.org/en/events/pastevents/pdfs/Madrid_plan.pdf.

Van Deursen, A. and J. van Dijk (2014), *Digital Skills: Unlocking the Information Society*, Basingstoke, Palgrave Macmillan.

WHO (World Health Organization) (2002), *Active Ageing: A Policy Framework* [online] http://www.who.int/ageing/publications/active_ageing/en/.

WSIS (World Summit on the Information Society) (2016), "WSIS background" [online] https://www.itu.int/net4/wsis/forum/2016/About/Background.

Annex A1

Table A1.1
Latin America (selected countries): characteristics of older adults who use ICT
(Percentages and years)

	Mean age *(years)*	Male *(percentage)*	Urban *(percentage)*	Mean education *(years)*	Indigenous ethnicity *(percentage)*	Marital status *(percentages)*			
						Married	Single	Widowed	Divorced
Chile	70.8	42.7	85.3	8.2	6.0	56.9	22.7	2.0	6.7
Ecuador	70.5	47.6	65.3	5.9	14.6	58.2	7.3	22.6	12.0
El Salvador	71.1	45.0	65.5	4.1		50.2	7.3	26.7	15.8
Honduras	70.2	46.1	56.9	4.7		56.4	19.2	18.6	5.9
Mexico	70.3	46.1							
Paraguay	69.8	48.4	59.5	5.7		59.5	11.6	22.5	6.4
Peru	70.8	46.7	75.2	6.2	49.1	60.9	5.3	23.8	10.1
Uruguay	71.6	42.0	94.3	7.7	7.1	56.3	4.7	24.9	10.8

Source: Prepared by the authors, on the basis of the National Socioeconomic Survey (CASEN) of Chile, 2015; the National Survey of Employment, Unemployment and Underemployment in urban and rural areas of Ecuador, 2015; the Multi-purpose Household Survey of El Salvador, 2015; the Permanent Multi-purpose Household Survey of Honduras, 2015; the Module on Availability and Use of Information Technologies in Households (MODUTIH) of Mexico, 2014; the Permanent Household Survey of Paraguay, 2015; the National Household Survey on Life Conditions and Poverty of Peru, 2015; and the Continuous Household Survey of Uruguay, 2015.

Guidelines for contributors to the *CEPAL Review*

In order to facilitate the submission, consideration and publication of articles, the editorial board of the *CEPAL Review* has prepared the following information and suggestions to serve as a guide for future contributors.

The submission of an article implies an undertaking by the author not to submit it simultaneously to other publications. The copyright to all articles published in the *Review* shall be owned by the United Nations.

Each article will be reviewed by the editorial board, which may decide to submit it to external referees.

Papers should be submitted in the original language (English, French, Portuguese or Spanish). They will be translated into the appropriate language by the relevant eclac services.

Each article must be accompanied by a summary, no more than 150 words in length, giving a brief description of its subject matter and main conclusions.

Each article must also carry three jel (Journal of Economic Literature) classification codes. The JEL Classification Codes Guide is available online at www.aeaweb.org/jel/jel_class_system.php.

Papers should be no longer than 10,000 words, including the summary, notes and bibliography. Shorter papers will also be considered.

Articles should be sent by e-mail to *revista@cepal.org* in Word format. Papers in pdf format will not be accepted.

Style guide:

Titles should not be excessively long.

Footnotes

- It is recommended that footnotes be kept to a minimum.
- It is recommended that footnotes not be used to cite bibliographical references; such references should preferably be incorporated into the text.
- Footnotes should be numbered consecutively using superscript Arabic numerals.

Tables, figures and equations

- It is recommended that tables and figures be kept to a minimum, avoiding any redundancy with the text.
- Equations should be written using the Office equation editor "MathType"; they should not be inserted as "pictures".
- Tables, figures and other elements should be inserted at the end of the text in the format in which they were designed; they should not be inserted as "pictures". Figures in Excel should include the corresponding worksheets.
- The location of tables and figures in the body of the article should be indicated in the appropriate place as follows:

  Insert figure 1

  Insert table 1
- Tables and figures should include an explicit and complete reference to their sources.
- Tables should indicate the period covered at the end of the title, and should indicate the units in which the data are expressed in a subtitle (in italics and between brackets).
- The symbols referred to in the "Explanatory notes" which appear on the page preceding the table of contents should be taken into account in the preparation of tables and figures.
- Footnotes to tables and figures should be ordered consecutively using superscript lower-case letters.
- Figures should be prepared bearing in mind that they will be printed in black and white.

Acronyms and abbreviations

- Acronyms and abbreviations should not be used unless absolutely necessary, in which case the full name should be written out the first time it occurs in the article.

Bibliography

- Bibliographical references should be directly related to the content of the article and should not be excessively long.
- At the end of the article, under the title "Bibliography", all the necessary information should be included accurately and in alphabetical order by author: name of author(s), year of publication, full name of article (if any) and publication (including any subtitle), city of publication, publisher and, in the case of a periodical, month of publication.

The editorial board of the *Review* reserves the right to make any necessary editorial changes in the articles, including their titles.

Authors will receive a one-year courtesy subscription to the *Review*, plus 30 offprints of their article in Spanish and 30 in English, at the time of publication in each language.

Publicaciones recientes de la CEPAL
ECLAC recent publications

www.cepal.org/publicaciones

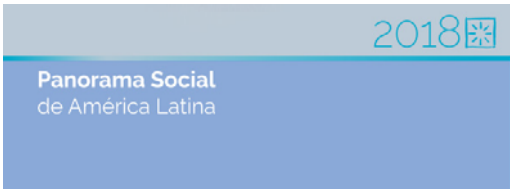
Informes Anuales/*Annual Reports*
También disponibles para años anteriores/*Issues for previous years also available*

Estudio Económico de América Latina y el Caribe 2018
Economic Survey of Latin America and the Caribbean 2018

La Inversión Extranjera Directa en América Latina y el Caribe 2018
Foreign Direct Investment in Latin America and the Caribbean 2018

Balance Preliminar de las Economías de América Latina y el Caribe 2018
Preliminary Overview of the Economies of Latin America and the Caribbean 2018

Anuario Estadístico de América Latina y el Caribe 2018
Statistical Yearbook for Latin America and the Caribbean 2018



Panorama Social de América Latina 2018
Social Panorama of Latin America 2018

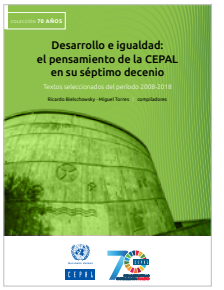
Perspectivas del Comercio Internacional de América Latina y el Caribe 2018
International Trade Outlook for Latin America and the Caribbean 2018

El Pensamiento de la CEPAL/*ECLAC Thinking*

Desarrollo e igualdad: el pensamiento de la CEPAL en su séptimo decenio. Textos seleccionados del período 2008-2018

La ineficiencia de la desigualdad
The Inefficiency of Inequality

Horizontes 2030: la igualdad en el centro del desarrollo sostenible
Horizons 2030: Equality at the centre of sustainable development
Horizontes 2030: a igualdade no centro do desenvolvimento sustentável



Libros y Documentos Institucionales/*Institutional Books and Documents*

Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe
Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean

Hacia una agenda regional de desarrollo social inclusivo: bases y propuesta inicial
ATowards a regional agenda for inclusive social development: bases and initial proposal

Libros de la CEPAL/*ECLAC Books*

Logros y desafíos de la integración centroamericana: aportes de la CEPAL

Envejecimiento, personas mayores y Agenda 2030 para el Desarrollo Sostenible: perspectiva regional y de derechos humanos

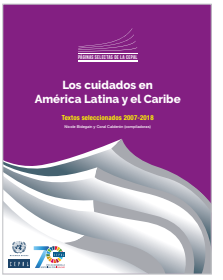
La inclusión financiera para la inserción productiva y el papel de la banca de desarrollo

Páginas Selectas de la CEPAL/*ECLAC Select Pages*

Los cuidados en América Latina y el Caribe. Textos seleccionados 2007-2018

Empleo en América Latina y el Caribe. Textos seleccionados 2006-2017

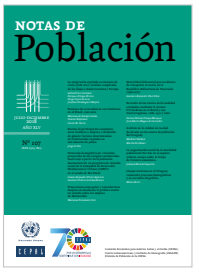
Desarrollo inclusivo en América Latina. Textos seleccionados 2009-2016



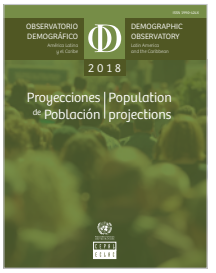
Revista CEPAL/*CEPAL Review*

Series de la CEPAL/*ECLAC Series*

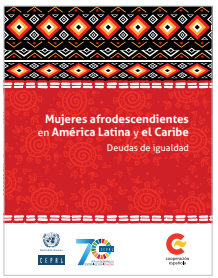
Notas de Población



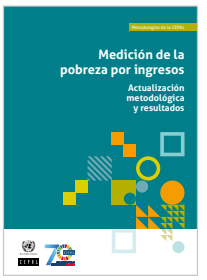
Observatorio Demográfico
Demographic Observatory



Documentos de Proyectos
Project Documents



Metodologías de la CEPAL



Coediciones/*Co-editions*

Copublicaciones/*Co-publications*

Miguel Torres
Editor

www.cepal.org/en/review

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

ECLAC

United Nations Publication • S.18-01046 • April 2019 • ISSN 0251-2920