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Contents

Explanatory notes

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

Competitiveness and its determinants: a systemic analysis for developing countries

Victor Medeiros, Lucas Gonçalves Godoi
and Evandro Camargos Teixeira

Abstract

This paper seeks to make a comparative and econometric analysis of competitiveness in developing countries, identifying its determinants and sources of variation. It uses the data envelopment analysis methodology to generate measures of competitiveness. The determinants of competitiveness are obtained through a Tobit model based on the systemic competitiveness approach. As average competitiveness is low, the main results show that resource allocation could be improved in many of the countries in the sample. In addition to business factors such as innovation and the sophistication of the business environment, structural aspects such as market size and quality of demand, along with systemic factors such as infrastructure, health, education, workforce training and the macroeconomic environment, are all important for enhancing the competitiveness of emerging countries.

Keywords

Economic growth, competitiveness, productivity, industrial efficiency, developing countries, comparative analysis, econometric models

JEL classification

C24, O20, O57

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I. Introduction

According to Ferraz, Kupfer and Haguenauer (1996), competitiveness can be defined as a firm's capacity to create and implement competitive strategies and to sustainably maintain or increase its product share in the market. These capacities are associated with various factors, which may or may not be controlled by the firms, ranging from staff technical training and managerial-administrative processes, through to public policies, infrastructure supply and the specific features of demand and supply.

Competitiveness is important because it is positively related to long-term economic growth. A country can be considered competitive when it manages its resources and skills in such a way that, in addition to increasing the production of its firms, it improves its citizens' quality of life (IMD, 2012). According to a standard definition provided by the European Union (2001), competitiveness, at the regional and national levels, is the capacity of a region or country to achieve high and rising standards of living and high rates of employment on a sustainable basis.

Some authors have investigated the key determinants of competitiveness and how they relate to the process of economic growth and development in the different countries. According to the different theoretical approaches, the main determinants of competitiveness —and, consequently, economic growth— include: capital investments, the division of labour and trade, in classical theory; capital intensity, investment and government subsidy and tax policies, in the Keynesian approach; structural change, open trade and foreign direct investment (FDI), from the development economics standpoint; and the education level, expenditure on human capital, research and development (R&D) and incentives for innovation, in the "new growth theory".[1]

Endogenous growth theorists have also highlighted issues such as human capital (Lucas, 1988), innovations (Romer, 1990; Aghion and Howitt, 1992), infrastructure (Barro, 1990), institutions (Romer, 1986) and competition and trade openness (Grosmman and Helpman, 1991).

Ferraz, Kupfer and Haguenauer (1996) developed a dynamic process approach to competitiveness, in which a country's competitiveness is determined and constrained by a variety of business, structural and systemic factors. In this dynamic approach, competitive advantages stem from variables that are relevant for competitiveness at all levels of the system and from the interaction between them. It is thus concluded that competitiveness is systemic (Esser and others, 1996).

Empirical evidence has corroborated the aforementioned theoretical studies. Although the body of literature is not very extensive, the hypothesis of a positive relationship between competitiveness and economic growth has been demonstrated, as, for example, in the research by Kordalska and Olcyzk (2016).[2]

Using the data envelopment analysis (DEA) methodology, other studies have measured countries' levels of competitiveness and its determinants through a comparative analysis (Rocha, Rebelatto and Camioto, 2015; Ülengin and others, 2011; Charles and Zegarra, 2014). These authors treat competitiveness as an ex ante concept, such that a country would be considered competitive if it allocated its resources at least as efficiently as other countries. One of the main findings is that factors such as education, geography, income equality, good institutions and the provision of public goods can play an important role in enabling countries to use their resources efficiently and, thus, be more competitive.

This article aims to contribute to the specialized literature on competitiveness by providing additional evidence on its key determinants in developing countries, through a comparative and econometric analysis spanning 2011—2014, since no studies have considered these two aspects together. The choice of emerging countries is justified by the fact that they lag behind the rest of the

[1] For further details, see Kordalska and Olcyzk (2016).

[2] In this case a panel data model was used.

world in terms of competitiveness (as reported, for example, in the Global Competitiveness Index (GCI)), since improving factors that increase a country's competitiveness could be important in fostering its sustained economic growth.[3]

To achieve the objectives of this study, the DEA methodology will be used to generate country-efficiency measures based on an aggregate production function. These measures will then be used as a proxy for a nation's comparative competitiveness. In addition, the Malmquist index will be used to obtain variations in total factor productivity (TFP) and its decomposition into change factors (technical changes and changes in technical efficiency).[4] An econometric model will then be estimated to establish the determinants of competitiveness and thus provide additional evidence on policies that could be implemented to increase competitiveness and continue the process of economic growth in the sample countries. The determining factors will themselves be identified through principal components analysis, because of the high degree of multicollinearity that exists between the variables in question.

This article is divided into five sections, including this introduction. Section II outlines the theoretical framework, and section III describes the methods used in the study. Section IV sets out the results, and the fifth and final section summarizes the main conclusions.

II. Growth, competitiveness and their determinants: a systemic approach

The literature defines competitiveness through various concepts and indicators. As a performance concept, competitiveness is related to the country's industrial export earnings. According to this ex post approach, firms are competitive when they succeed in growing their share of the international market for certain products (Haguenauer, 1989). In addition to production conditions, the performance concept of competitiveness identifies factors that stimulate or discourage exports in specific products and countries, such as exchange-rate and trade policies, the efficiency of marketing channels and financing systems, international agreements, and business strategies.

Other authors see export performance as an immediate consequence of competitiveness, rather than the reverse. This concept of competitiveness is potential, ex ante, and traditionally linked to production conditions. In terms of efficiency, competitiveness is defined as a country's capacity to produce a given good in conditions that are at least as good as in other economies (Haguenauer, 1989).

Under the efficiency approach, the country that is able to generate the greatest output is considered competitive, relative to other countries, given the resources available to it. Accordingly, a simple aggregate production function can be considered, described by:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

where Y represents output, K the level of capital, and L the number of workers, while α is a positive parameter, between 0 and 1, representing the return on capital. A country would be considered efficient if it uses its capital and labour inputs to generate the greatest possible output, while holding technology constant. In this case, the country would be at the production technology frontier, so its factors of production would not be wasted, and its population would have the highest possible level of income.

[3] The choice is also justified by other shared characteristics of the countries analysed, such as lower levels of per capita income than developed countries, an export model consisting mainly of products of lower technological content, and worse human development indicators. In terms of methodology, the fact that these countries share similar characteristics also makes the analysis based on DEA and its comparative approach more realistic.

[4] Authors who have used this methodology to evaluate TFP for developing countries include Marinho and Bittencourt (2007) and Araujo, Feitosa and Da Silva (2014).

This article conceptualizes competitiveness in terms of efficiency, since its objective is to determine the relative efficiency of developing countries. However, since this measure alone is insufficient to encompass the breadth of the term "competitiveness", its determining factors also need to be analysed, following the approach of Ferraz, Kupfer and Haguenauer (1996). These authors seek a dynamic approach that provides a benchmark for competitiveness by analysing the competitive process. In this context, competitiveness is defined as a firm's capacity to create and implement competitive strategies and sustainably maintain or increase its market share.

The performance and productive efficiency of firms are likely to be related to the capacity accumulated over time, which would influence their competitive strategies. These, in turn, would vary according to the economic environment and the competitive process in which the firm operates. Competitiveness would thus be understood as a measure that encompasses more than one given firm, but that is directly related to the pattern of competition in a specific market.

Patterns of competition would be influenced by the composition of the firm's competitive environment, in other words by the structural and behavioural components of a given economic sector or system. These patterns stem from the interdependence that exists between competitive firms or sectors through technological complementarities, constraints and incentives to the flow of goods, in addition to the availability of infrastructure, laws, planning systems and industrial policies, among other factors. Competitiveness in this sense would be the capacity of companies to adapt their strategies to the pattern of competition prevailing in their sector.

The analysis of competitiveness thus needs to consider the diversity of factors that are capable of generating competitive advantages —such as sales efforts, training for production, access to sources of raw materials and to suppliers of parts and components, in addition to those directly linked to innovation and the dissemination of new techniques (Ferraz, Kupfer and Haguenauer, 1996). Thus, a dynamic approach to competitive performance is created by incorporating its business, structural and systemic determinants. In other words, competitiveness is essentially systemic (Esser and others, 1996).

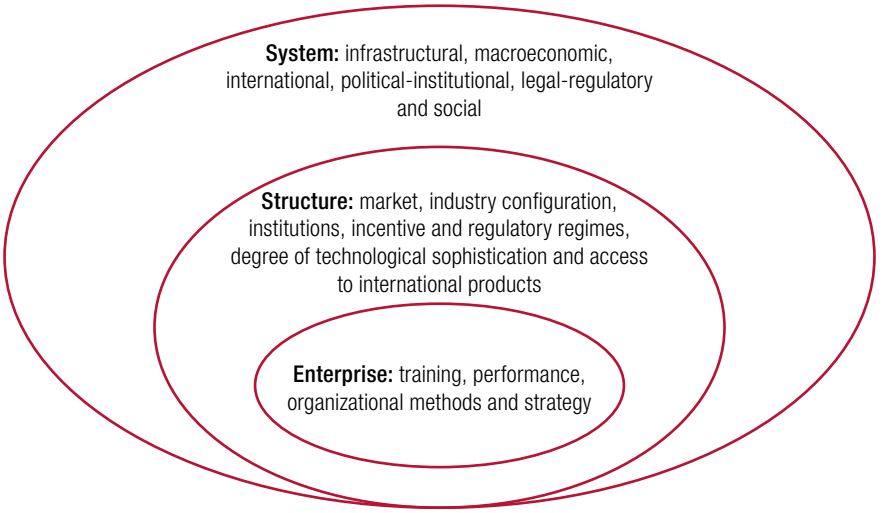
"Business factors" are those over which the enterprise has substantial control. These include the cumulative knowledge generated by the firm and its strategies and, more specifically, management effectiveness, training and performance, technological training in processes and products, organizational methods and human resources, among others.

"Structural factors" are those over which the enterprise does not have full control; that is, firms are constrained by the competition process itself and its specifics. Apart from the characteristics of demand and supply, these include the influence of non-market institutions that define the regime of incentives and regulation, geographical distribution, the degree of technological sophistication, growth rates, marketing systems and opportunities for access to international products, among others (Ferraz, Kupfer and Haguenauer, 1996).

"Systemic factors" are those over which the firm has little or no control. These generate conditions that are external to the firm but serve as parameters of the decision-making process. They include the following types of factors: infrastructural (availability, quality and cost of energy, transport, telecommunications, basic inputs and technological services; macroeconomic (exchange rate, tax burden, the growth rate of gross domestic product (GDP), credit supply and interest rates, and wage policy); political-institutional (tax policy, tariff policy, fiscal support for technological risk-taking, government purchasing power); social (labour training system, education policies and training of human resources, labour and social security); legal and regulatory (policies for industrial property protection, conservation of the environment, defence of competition and consumer protection); and international (trends in world trade, international capital flows, risk investments and technology, relations with multilateral organizations).

Diagram 1 illustrates the scope of the term competitiveness with the firm as the central element, which in turn is affected by the economic structure and system.

Diagram 1
Determinants of competitiveness



Source: Prepared by the authors, on the basis of J. Ferraz, D. Kupfer and L. Haguenauer, *Made in Brazil: desafios competitivos para a indústria*, Rio de Janeiro, Campus, 1996.

In the context illustrated in diagram 1, it would be important to define not only measures of relative efficiency (or competitiveness) between countries, but also the determinants of their competitiveness, to be better able to design public policies to improve the competitive environment of firms and expand their consequent benefits for the population in terms of economic growth and development.

III. Methodology

Two methodologies will be applied to achieve the objectives proposed in this study. In the first, data envelopment analysis (DEA), will be used to measure the efficiency of factors of production in developing countries. As this involves panel data, a further aim will be to assess the trend of TFP through the Malmquist index. Next, a Tobit model will be used with panel data to identify the key determinants of competitiveness in the sample countries, with the efficiency measures provided by the DEA methodology as dependent variable. However, as the explanatory variables of the Tobit model display a high degree of multicollinearity, principal components analysis will be used to construct indices to capture the importance of the different variables.

1. Efficiency differences between developing countries and their determinants: methodology

(a) Efficiency measures

The DEA methodology generates relative measures of efficiency between units of analysis, in other words within a given sample group. These measures are obtained through linear programming, and each production unit is treated as a decision-making unit (DMU).

In DEA, it is assumed that there are m outputs and k inputs for each of the n DMUs. From these data, input matrices (dimension $k\ x\ n$) and output matrices ($m\ x\ n$) are constructed to represent the various decision-making units. The methodology thus aims to measure efficiency as the ratio between outputs and inputs, as follows:

$$Efficiency\ of\ DMU_i = \frac{u'y_i}{v'x_i} = \frac{u_1y_{1i} + u_2y_{2i} + \ldots + u_my_{mi}}{v_1x_{1i} + v_2x_{2i} + \ldots + v_kx_{ki}} \quad (1)$$

where u is an ($m\ x\ 1$) vector of output weights and v is a ($k\ x\ 1$) vector of input weights. Since the values of the output and input variables may differ substantially across DMUs, the weights attributed for the scope of the efficiency measures will also vary. This makes it necessary to formulate a problem that generates appropriate sets of weights for each DMU relative to the others.

As Ferreira and Gomes (2009) explain, the problem must be formulated to take account of the values of u and v, in order to maximize the efficiency measure for each DMU, subject to the constraint that the measures of all DMUs are no greater than one. Assuming variable returns to scale,[5] the following maximization problem is obtained:

$$Max_{\theta,\lambda}\theta \quad (2)$$

subject to

$$-\theta y_i + Y\lambda \geq 0,$$
$$x_i - X\lambda \geq 0$$
$$N_1'\lambda = 1$$
$$\lambda \geq 0$$

$N_1'\lambda = 1$ is the convexity constraint and N_1 is an ($n\ x\ 1$) unit matrix; $1/\Theta$ is a scalar, whose value will be the efficiency measure of the i-th DMU. If Θ is equal to 1, the DMU is considered efficient; if Θ is less than 1 the DMU is inefficient. The parameter λ is an ($n\ x\ 1$) vector for which the values are calculated to obtain the optimum solution.

For an efficient DMU, all values of λ will be zero; and for an inefficient one, the values of λ will be the weights used in the linear combination of other efficient DMUs, which influence the inefficient DMU's projection on the calculated frontier. This means that, for every inefficient unit, there is at least one efficient unit, for which the calculated weights will provide the virtual DMU of the inefficient unit, through linear combination.

Accordingly, the DEA methodology seeks to generate country efficiency measures that represent each country's competitiveness relative to the others, since these measures will demonstrate the highest possible level of output, given the allocation of inputs (output orientation). The input variables $X1$ (number of persons employed) and $X2$ (capital stock, valued at purchasing power parity) will be used, together with the output variable $Y1$ (GDP at purchasing power parity).

(b) Malmquist index and total factor productivity

The Malmquist index is used to estimate the variation in TFP. As described in Coelli, Rao and Battese (1998), the Malmquist TFP index measures the variation in TFP between two periods, so it is a time-bound measure of productivity.

[5] For further details, see Charnes and others (1994) and Cooper, Seiford and Tone (2000).

The pioneering study by Malmquist (1953) finds that there are two effects that can influence factor productivity over time: (i) the recovery or catch-up effect, which determines the capacity of a DMU to approach the efficiency frontier, given an available technology; and (ii) the displacement effect, which captures the displacement of the efficiency frontier through time, in other words a change in the technology that alters productivity. The Malmquist index can be used to calculate the effects described, as follows:

$$Malmquist\ index = catch\text{-}up\ effect\ x\ displacement\ effect \tag{3}$$

In addition to obtaining efficiency measures for developing countries, this study seeks to identify any technological or technical efficiency developments in 2011–2014 and, consequently, track the behaviour of TFP in that period. The Malmquist index complements the efficiency analysis by more precisely identifying the sources of variation in the efficiency of developing countries. In this case, the application of the model includes the year 2010, in order to obtain productivity variations from 2011 onwards.

2. Econometric analysis

(a) Principal components analysis

Given the high degree of multicollinearity that exists between the explanatory variables used in the econometric approach, many of them contain the same information. To overcome this problem, it was decided to use principal components analysis, which consists of transforming one set of original variables into another set of variables of the same dimension, called principal components.

The principal components are a linear combination of all the original variables and are therefore mutually independent. They are estimated sequentially, such that each one contains as much as possible of the information present in the original data. Thus, principal components analysis is a means of reducing the dimensions of the data with the least possible loss of information.

According to Zivot and Wang (2003), denoting the covariance matrix of the variables by $\hat{\Omega}$ and the matrix of the original variables after normalization by Z, the first principle component is given by $x_1^* Z$, in which x_1^* is the solution to:

$$\max_{x_1} x_1' \hat{\Omega} x_1 \ \ s.t. \ \ x_1' x_1 = 1 \tag{4}$$

Thus, the solution x_1^* is the value associated with the highest eigenvalue of $\hat{\Omega}$. The second component is $x_2^* Z$; and x_2^* is the vector that solves the following expression:

$$\max_{x_2} x_2' \hat{\Omega} x_2 \ \ s.t. \ \ x_2' x_2 = 1 and\ x_1^{*\prime} x_2 = 0 \tag{5}$$

According to this solution, the K principal components are calculated for K original variables. In this way, the dimension of the dependent variables on the censored Tobit model will be reduced, by maintaining the components that account for 80% of the variance of the original variables in the problem.

Lastly, the elements of x_k^* are recovered to define the importance of each of the "original" variables in forming the components and, consequently, each variable's impact on competitiveness. This mechanism will be implemented through a simple ordinary least squares (OLS) estimation of x_k^* on Z.

(b) Regression model with censored data and resampling

A Tobit model will be estimated to evaluate the determinants of competitiveness in developing countries. This model was chosen because the efficiency measures calculated through the DEA consist of a censored sample, since they are restricted to the interval [0, 1]. In this case, when estimating through OLS, the parameters would be inconsistent and statistical inference on them would be infeasible (Wooldridge, 2011).[6]

Censoring may entail the loss or lack of data, and the sample may display censoring at the lower limit (on the left) or at the upper limit (on the right). With Y as the dependent variable, I as a constant that represents the minimum value assumed by Y, and S as its maximum value, then Y will be observed only in the interval $[I, S]$, so the observations are considered censored at the lower (I) and upper (S) points.

Using the notations defined in the previous paragraph, together Z' the vector of explanatory variables, β the vector of parameters to be estimated, Y^* the estimated vector of Y, and ε the random error term, the Tobit model can be described as follows:

$$\begin{aligned} Y^* &= Z'\beta + \varepsilon_i \\ Y &= I, \text{ if } Y^* \leq 1 \\ Y &= Y^*, \text{ if } I < Y^* < S \\ Y &= S, \text{ if } Y^* \geq S \end{aligned} \tag{6}$$

The model is estimated using the two-stage maximum likelihood method: the first stage uses a Probit model for the treatment of censored observations, and the second specifies a linear model for uncensored observations. The estimated coefficients can be interpreted as the effect of the regressors on the variable Y^*.

The Tobit model will use panel data, which makes it possible to examine the fixed or random effects of a given country or time periods on the efficiency measures (Park, 2005). However, according to Cameron and Trivedi (2005) and Da Silva and others (2015), there are a number of problems that make it difficult to use the Tobit model with fixed effects, such as the inconsistency of estimators for short panels, as is the case in this study, and in cases where individual effects are not uniform. As a solution, the authors propose using the random effects model.

In the random effects model to be used in this study, it is assumed that the random effect is identical for all periods and not correlated with the other regressors, that the angular coefficients are the same for all years and groups, and that the stochastic component of the model is not correlated between time periods (Greene, 2007).

Nonetheless, the Tobit estimator will only be consistent in the presence of homoscedastic and normally distributed errors (Gujarati and Porter, 2011). Otherwise, in the case of heteroscedasticity or non-normal errors, it would be better to use the bootstrap method, which estimates a given sample repeatedly to obtain the sample distributions of the parameters of interest and thus obtain robust estimates.

[6] The inconsistency of the parameters stems from violation of the following assumptions of the classical linear regression model: the error term would not be independent and identically distributed and would not have a zero mean.

3. Source and treatment of the data

The variables $X1$, $X2$ and $Y1$, used in the DEA methodology, will be obtained from the Penn World Table 9.0 database.[7] The countries considered in the sample correspond to the International Monetary Fund (IMF)[8] classification of developing countries. After excluding countries for which no information was available, the sample used for application of the DEA model consisted of 82 countries.

The efficiency measure generated in the DEA will be used as a proxy for national competitiveness in the estimation of the Tobit model. The vector of explanatory variables in the econometric analysis will describe the determinants of competitiveness, according to the analysis reported by Ferraz, Kupfer and Haguenauer (1996), subdivided into business, structural and systemic factors. The synthesis of the variables used in the study and the respective sources are described in tables A1.1, A1.2, A1.3, A1.4 and A1.5 of Annex A1. Further details can be found in World Economic Forum (2014).

The variables *Busin* and *Inov* capture business factors related to the environment that mediates between firms and their capacity to adopt competitive strategies, and the capacity of firms to innovate and implement innovative practices, respectively. In this way they ultimately address the capacity of firms in a given country to implement competitive strategies.

With respect to structural factors, the variables I*nst, Demand, Financ, Techn* and *Msize* encompass, respectively, the role played in national competitiveness by institutional quality, demand conditions, the level of development of the financial market and its institutions, the availability of advanced technology and the size of the market.

Lastly, the variables *Infra, Macro, Social, Train, Labour* and *Compet* capture aspects related, respectively, to the supply and quality of infrastructure, the macroeconomic environment, primary education and health, labour force training and higher education, labour market efficiency, financial market quality and efficiency in the market for goods and services. These are also related to systemic factors.

In both the application of DEA and the econometric analysis, the variables were chosen in accordance with the specialized literature. Authors using similar variables include Ülengin and others (2011), De Paula and Da Silva (2015), Rocha, Rebelatto and Camioto (2015), Charles and Zegarra (2014) and Lábaj, Luptáčik and Nežinský (2013).

IV. Results and discussion

1. Data envelopment analysis and Malmquist index

Application of the DEA model made it possible to observe the behaviour of developing countries in 2011–2014, considering an aggregate production function with capital and labour as inputs and GDP as output.

Table 1 reports the averages of efficiency, TFP variation and its respective decomposition into technical efficiency variation (ΔEfficiency), or catch-up effect, and technological variation (ΔTechnology), or displacement effect. The maximum efficiency measure (equal to 1) shows that the country is at the technology frontier; in other words, it allocates its resources without waste, given the most advanced technology used. The first result reported in table 1 shows that many developing countries could allocate their resources more efficiently and, as a result, become more competitive.

[7] Available [online] at https://www.rug.nl/ggdc/productivity/pwt/earlier-releases.

[8] See [online] http://www.imf.org/external/pubs/ft/weo/2014/01/pdf/text.pdf.

Table 1
Average measures of efficiency, catch-up effect, displacement effect and variation in total factor productivity (TFP): total sample, annual and average data for 2011–2014

Year/Measurement	Efficiency	ΔEfficiency	ΔTechnology	TFP
2011	0.571	0.858	1.193	1.023
2012	0.558	0.968	1.039	1.006
2013	0.578	1.068	0.918	0.980
2014	0.597	1.081	0.903	0.977
Average	0.572	0.996	1.013	0.999

Source: Prepared by the authors.

The variation in technical efficiency was negative in 2011 and 2012, a trend that is reversed in the ensuing years, with the variation becoming positive in 2013 and 2014. The opposite occurs with technological change, as the measure increases in 2011 and 2012 before dropping back in 2013 and 2014.

Overall, the cumulative TFP index shows that, on average, there was a slight decline (0.99) in productivity in developing countries. Following Young (1994), this would suggest that any economic growth in the countries analysed would be explained by an increase in the use of capital and labour inputs rather than by technological improvements. This result corroborates the study performed by Marinho and Bittencourt (2007), which explains the poor trend of TFP in developing countries, and specifically those in Latin America, owing to the lack of emphasis in those countries on policies promoting the systematic incorporation of technological innovations, the recognition of constraints on the formation of domestic savings, the high degree of infant industry protection and the inward-looking nature of the development process.

This moderate decline in TFP is mainly explained by negative variations in technical efficiency. This result seems to indicate that, on average, there was no convergence process in 2011–2014 between the countries analysed; in other words, the countries that were trailing in terms of productive efficiency failed to catch up with the more efficient countries.

The regional analysis (see table 2) shows that there were substantial differences between the regions analysed in 2011–2014. The average efficiency level, at 57.6%, shows that many countries could improve their resource allocation. Asian and European countries had, on average, the best results, with average efficiencies of 68.5% and 65.7%, respectively. In contrast, the African and Latin American countries had the worst indicators (averaging around 46.4% and 49.9%, respectively).

Table 2
Average measures of efficiency, catch-up effect, displacement effect and variation in total factor productivity (TFP), by region, averages for 2011–2014

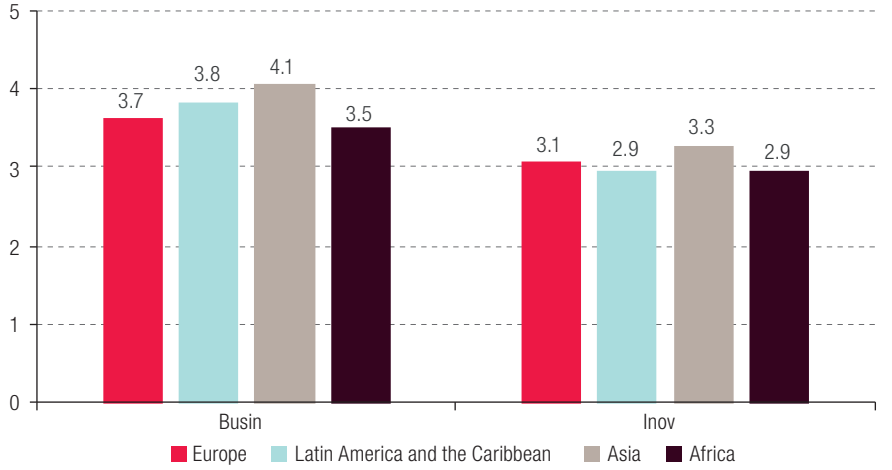
Sample	Efficiency	ΔEfficiency	ΔTechnology	TFP
Total	0.576	0.989	1.007	0.996
Europe	0.657	1.006	1.016	1.010
Latin America and the Caribbean	0.499	0.986	1.017	0.991
Asia	0.685	0.996	1.014	1.001
Africa	0.464	1.001	1.008	0.999

Source: Prepared by the authors.

In the case of TFP, only European countries recorded an average improvement in the period under review, while TFP in Asian and African countries remained practically constant. In contrast, the average for Latin American countries worsened, indicating a lag relative to the other countries in the sample during the period under analysis.

The weak performance of African and Latin American countries in terms of efficiency and its variation can be explained partly by indicators of business, structural and systemic factors that are worse than in European and Asian countries. In the case of business factors (market sophistication and degree of innovation), figure 1 shows that the African countries had the lowest values for the *Busin* and *Inov* indicators. The Latin American countries also recorded the worst innovation indicator *(Inov)*, identical to that of the African countries.

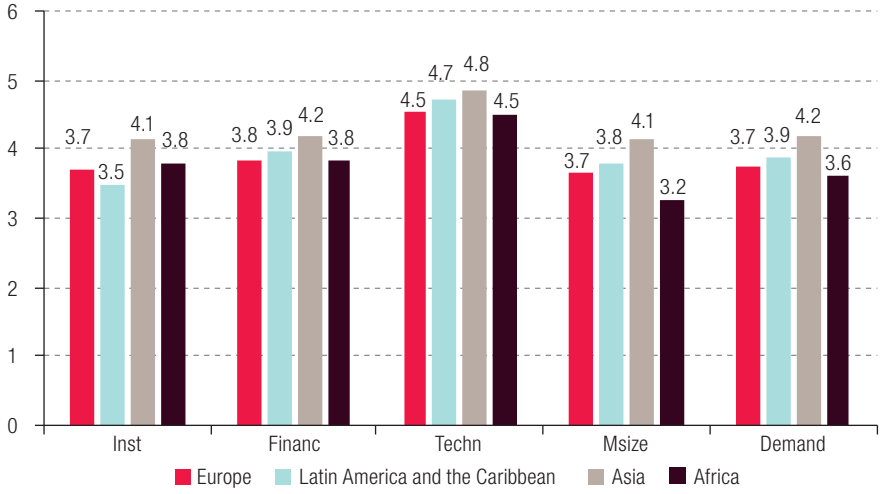
Figure 1
Business factors: average of values for 2011–2014



Source: Prepared by the authors, on the basis of World Economic Forum, "The Global Competitiveness Index", 2014.

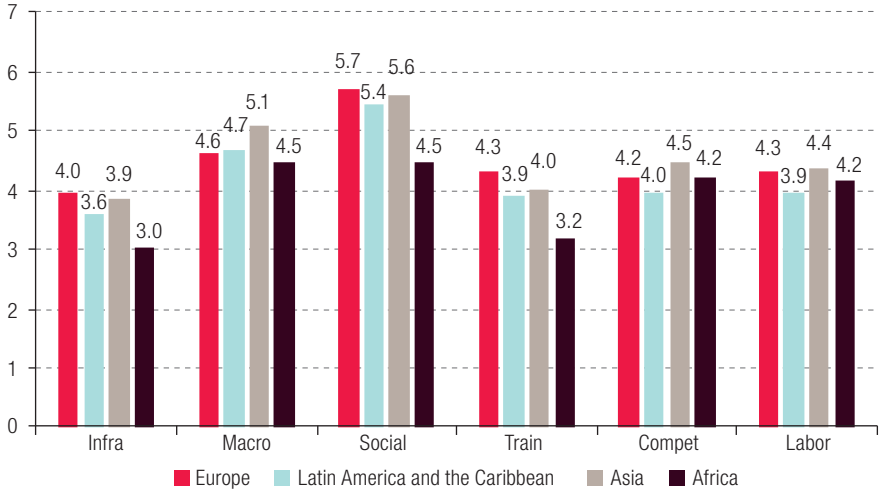
In the case of structural factors, figure 2 shows that Asian countries again have the best indicators, whereas African and Latin American countries have the worst in terms of the quality of institutions, demand conditions, the quality of the financial system, availability of advanced technology and market size. The results are similar for systemic factors (see figure 3), which show that the countries that achieved the best efficiency averages in the DEA approach are generally the same as those with the best indicators of infrastructure, macroeconomic environment, basic education and health, technical training and higher education, skill level and labour legislation.

Figure 2
Structural factors: average of values for 2011–2014



Source: Prepared by the authors, on the basis of World Economic Forum, "The Global Competitiveness Index", 2014.

Figure 3
Systemic factors: average of values for 2011–2014



Source: Prepared by the authors, on the basis of World Economic Forum, "The Global Competitiveness Index", 2014.

Lastly, the best-performing countries in terms of technical efficiency were, Azerbaijan, Brunei Darussalam, China, Kuwait, Montenegro, Qatar, the Russian Federation and Saudi Arabia, which had efficiency measures equal to 1 in all years analysed. In these countries all of the average business, structural and systemic indicators are above average for the total sample, as shown in table 3.

Table 3
Average of business, structural and systemic indicators: total sample and countries with best efficiency scores, 2011–2014

Business factors			Structural factors			Systemic factors		
Indicator	Total	Best	Indicator	Total	Best	Indicator	Total	Best
Busin	3.79	4.18	*Inst*	3.77	4.49	*Infra*	3.60	4.49
Inov	3.06	3.56	*Financ*	3.96	4.28	*Macro*	4.74	5.98
			Techn	4.65	4.86	*Social*	5.30	5.87
			Msize	3.72	4.16	*Train*	3.84	4.41
			Demand	3.87	4.28	*Compet*	4.23	4.48
						Labour	4.20	4.65

Source: Prepared by the authors, on the basis of World Economic Forum, "The Global Competitiveness Index", 2014.

As with the analyses conducted by Ferraz, Kupfer and Haguenauer (1996), IDM (2012) and the World Economic Forum (2014), the results described show that improved business, structural and systemic indicators can foster high levels of competitiveness and efficiency in developing countries.

In short, the results obtained through DEA indicate that the vast majority of the developing countries analysed have scope to improve the efficiency of their resource allocation, particularly the African and Latin American countries. Lastly, countries that achieved higher efficiency averages also display better business, structural and systemic indicators.

Nonetheless, some environmental factors or contextual variables can significantly influence the efficiency scores. Since competitiveness depends on structural, business and systemic factors, this diversity of factors needs to be assessed in relation to improved efficiency measurements. Thus, the following section uses a censored data model to estimate the impact of the different variables on the efficiency of developing countries.

2. Econometric analysis

The first procedure in the statistical analysis entailed reducing the mass of data through principal components analysis, given the threshold that was imposed of only retaining in the analysis components that met the Kaiser criterion, in other words those that had eigenvalues greater than one.[9] Accordingly, three of the 13 principal components were retained, as shown in table 4.

Table 4
Principal components analysis

Component	Proportion	Cumulative	Eigenvalue
Component 1 (PC1)	0.5730	0.5730	7.4491
Component 2 (PC2)	0.1270	0.7000	1.6512
Component 3 (PC3)	0.0793	0.7793	1.0308
Component 4 (PC4)	0.0630	0.8423	0.8192
No. of observations: 321			

Source: Prepared by the authors.

Following the principal components analysis, a Tobit censored data model was estimated, with the efficiency measures generated by the DEA methodology as dependent variable and the components as explanatory variables. The censored data model was estimated using the bootstrap method, which is appropriate for solving or minimizing problems arising from the difficulty of determining an asymptotic error pattern, which tends to underestimate the true variance. Thus, the model was estimated by the bootstrap method, using Tobit estimations with random and pooled effects.

Table 5 reports the results of the estimations. There were no substantial differences (only in the magnitude of standard errors) between the pooled and random-effects estimates; and the results were identical in terms of the significance and sign of the variables.

Table 5
Determinants of competitiveness in developing countries: Tobit and ordinary least squares estimation, 2013

Variable/Model	Random effect	Pooled
PC1	0.0240	0.0240
	(0.0048)***	(0.0042)***
PC2	0.0349	0.0349
	(0.0109)***	(0.0111)***
PC3	-0.0153	-0.0153
	(0.0164)	(0.0172)
Constant	0.6029	0.6029
	(0.0304)***	(0.0321)***
Observations	321	321
No. of left-censored observations	0	0
No. of right-censored observations	41	41
Wald chi-squared	28.30	35.53
Prob>chi-squared	0.000	0.000

Source: Prepared by the authors.
Note: (***) significant at 1%; bootstrapping standard errors in parentheses.

Table 5 shows that the first two components both had positive and significant effects in terms of influencing the competitiveness of a given developing country. Accordingly, from this point onwards this study sought to recover the weights used to form the components, in order to extract information on the influence of the original variables.

[9] For further information on component selection criteria, see Fávero and others (2009).

To that end, the weights of each variable in the formation of the principal components were normalized, and then a model was estimated through OLS, with the components as dependent variables. Since the components are merely linear combinations of the original model variables, R^2 must in fact be 1, so there is no standard error for the coefficients.

After applying the procedure described in the previous paragraph for the first component (PC1) —which generated a positive effect on the competitiveness of developing countries (see table 6)— all of the variables had a positive impact on competitiveness. The greatest weights are assigned to variables such as the business environment and the innovative capacity of the firms, and also to aspects such as infrastructure, demand conditions and quality, the competitive environment, health, basic education and the skill level of the workforce, institutions and the financial system, and access to advanced technologies.

Table 6
Weight of each main variable in the formation of the principal components

Original variable/component	Type of factor	PC1	PC2
Busin	Business	0.3382	0.0449
Inov		0.3163	0.0338
Inst	Structural	0.3079	-0.2498
Financ		0.2991	-0.1840
Techn		0.3133	-0.1225
Demand		0.3256	0.0289
MSize		0.1207	0.5248
Infra	Systemic	0.3148	0.1688
Macro		0.1986	0.1040
Compet		0.2838	-0.3664
Social		0.2164	0.3991
Train		0.2797	0.3366
Labour		0.1950	-0.4035
Observations		321	321

Source: Prepared by the authors.

The second component also has a positive effect on competitiveness. The variables with the greatest weight in this component are: *MSize*, *Social*, *Train*, *Compet* and *Labour*. The impact of the first three on competitiveness is positive and that of the last two negative.

To make it easier to analyse table 6, boxes shaded in dark grey indicate variables that weigh more heavily in determining the component, while those shaded in light grey indicate variables of minor importance in that regard. An analysis was made of the variables that obtained equivalent signs in relation to the competitiveness dependent variable and that were important in determining the components (that is, the variables *Busin, Inov, Demand, MSize, Infra, Macro, Social* and *Train*). The remainder of the variables (*Inst, Financ, Techn, Compet* and *Labour*) behave somewhat ambiguously, producing contrasting coefficients in components 1 and 2 (PC1 and PC2). Accordingly, a more in-depth analysis of their possible effects on efficiency will not be made.

The results obtained can be interpreted in three ways. Firstly, business factors are clearly important, as shown by the substantial weight of the variables *Busin* and *Inov* in PC1. Consequently, the competitiveness benefit derived from a sophisticated business environment —that is, an environment characterized by the large number and quality of local suppliers, breadth of the value chain, control of international distribution, sophistication of the production process, scope of marketing, among others— is proven; along with the innovative capacity of firms, in other words the quality of scientific research institutions, firms' R&D spending, R&D collaboration between universities and industries, government purchases of advanced technology products, the availability of scientists and engineers, patent applications and the protection of intellectual property, and others. These results corroborate the theoretical analysis performed by Romer (1990) and Aghion and Howitt (1992), for example.

Secondly, with respect to structural factors, aspects such as market size (*MSize*) and, to a lesser extent, the quality of demand (*Demand*), which is observed in the degree of customer orientation and sophistication of the buyer, are important. This result corroborates the theoretical analysis conducted by Romer (1986) and Ferraz, Kupfer and Haguenauer (1996), among others.

In addition, the *MSize* variable had considerable weight in PC2, which indicates that economies of scale generated by large domestic and export markets are important factors enabling countries to become more competitive. This result supports the theoretical analyses of authors such as Grossman and Helpman (1991), which highlight the importance of trade openness for the growth process through greater competitiveness.

Thirdly, in the case of systemic factors, the relevant variables explaining the principal components were *Infra, Social, Train* and, to a lesser extent, *Macro*. Thus, fundamental factors include improved means of transport, quality of energy supply and telecommunications services, in addition to the provision of health, basic and higher education and workforce training. These results corroborate theoretical work done by Lucas (1988) and Barro (1990), for example, which emphasizes the contribution of infrastructure and human capital to a country's development. Similarly, aspects related to the government's budget balance, gross national savings, control of inflation and the public debt, as well as the country's credit rating, would also be important for developing country competitiveness.

In short, the econometric analysis highlighted the importance of human capital, infrastructure, economies of scale, macroeconomic stability and the innovative capacity of firms to achieve a more competitive environment in developing countries. These results corroborate the theoretical analysis of Ferraz, Kupfer and Haguenauer (1996) and concur with the arguments made by endogenous growth theorists and others. In relation to other empirical evidence, the results are similar, albeit indirectly, to those reported by Rocha, Rebelatto and Camioto (2015), De Paula and Da Silva (2015), and Charles and Zegarra (2014), when indicating that environmental factors are important for a country's competitiveness.

V. Conclusions

The aim of this paper has been to measure the level of competitiveness and its main determinants in developing countries, with an approach that analyses competitiveness as an ex ante concept; in other words, a country is considered competitive relative to other countries if it uses its capital and labour inputs in such a way as to generate the greatest possible output.

The DEA methodology was used to obtain the level of technical efficiency and scale of developing countries. The results showed that most of the countries in the sample could allocate their resources more efficiently, given their low average level of efficiency. It was also noted that the countries and regions that have achieved higher efficiency averages and have improved their total factor productivity according to the Malmquist index, have better business, structural and systemic indicators.

In the econometric analysis, the Tobit model identified the following factors as important in enabling developing countries to become more competitive: business factors such as innovative capacity and the sophistication of the business environment; structural aspects such as the size of domestic and external markets and the quality of demand; as well as systemic factors such as the supply and quality of infrastructure, health, basic and higher education, workforce training and the macroeconomic environment. These findings are based on principal components analysis, since the variables in question played an important role in determining the components.

The importance of the political and economic authorities in these countries is also noted, since the provision of economic infrastructure services, health-care and education, and the maintenance of a favourable macroeconomic environment can help countries achieve high levels of competitiveness and,

consequently, reap benefits in terms of economic and human development. Accordingly, the business environment in which firms operate can be expected to be become more favourable, as a result of better-quality demand and increased market size. Ultimately, these factors can be expected to promote a business environment that is supportive of business decision-making, enabling firms to operate in a context that is conducive to innovation, thereby helping the country to become more competitive.

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Annex A1

Table A1.1
Variables used in the data envelopment analysis (DEA) model and the Malmquist index

Variable in the source	Source
Real GDP based on production at chained purchasing power parity (PPP) rates *(millions of dollars at 2011 prices)*	Penn World Table 9.0 (Feenstra, Inklaar and Timmer (2015))
Number of persons employed (millions)	
Capital levels at current purchasing-power parity *(millions of dollars at 2011 prices)*	

Source: Prepared by the authors.

Table A1.2
Variables used in the principal components and Tobit analysis

Index	Name	Variable	Variable in the source
Business	*Busin*	Business Sophistication Quality Index (1-7)	Pillar 11: Business sophistication
	Inov	Innovation quality index (1-7)	Pillar 12: Innovation
Structural	*Inst*	Institutional quality index (1-7)	Pillar 1: Institutions
	Financ	Financial market development quality index (1-7)	Pillar 8: Financial market development
	Techn	Technology adoption (1-7)	A. Technology adoption
	Msize	Market size quality index	Pillar 10: Market size
	Demand	Demand conditions quality index (1-7)	B. Quality of demand conditions
Systemic	*Infra*	Infrastructure quality index	Pillar 2: Infrastructure
	Macro	Macroeconomic environment quality index (1-7)	Pillar 3: Macroeconomic environment
	Social	Health and education quality index (1-7)	Pillar 4: Health and primary education
	Train	Training and advanced schooling quality index (1-7)	Pillar 5: Higher education and training
	Labour	Labour market efficiency quality index (1-7)	Pillar 7: Labour market efficiency
	Compet	Market competition level and quality	A. Competition

Source: Prepared by the authors, on the basis of World Economic Forum, *The Global Competitiveness Report 2013–2014*, Geneva, 2014.

Table A1.3
Variables related to the variables used in the principal components analysis: business factors

Variable	Related variables
Busin: Sophistication of the business environment	Quantity of local suppliers, quality of local suppliers, state of cluster development, nature of competitive advantage, breadth of value chain, control of international distribution, sophistication of the production process, scope of marketing, willingness to delegate authority, reliance on professional management.
Inov: Innovation capacity	Innovation capacity, quality of scientific research institutions, business R&D expenditure, R&D collaboration between universities and industries, government purchases of advanced technology products, availability of scientists and engineers, patent applications, intellectual property protection.

Source: Prepared by the authors, on the basis of World Economic Forum, *The Global Competitiveness Report 2013–2014*, Geneva, 2014.

Table A1.4
Variables related to the variables used in the principal components analysis: structural factors

	Public institutions	Private institutions
Inst: Institutional aspects	Property rights, intellectual property protection, embezzlement of public funds, public trust in politicians, irregular payments and bribes, judicial independence, favouritism in decisions by government officials, squandering of public expenditure, oversight of the government, efficiency of the legal framework in resolving disputes, efficiency of the legal framework in terms of regulations, transparency in government policymaking, commercial costs of terrorism, commercial costs of crime and violence, organized crime, reliability of police services.	Ethical behaviour of firms, sound auditing and reporting standards, effectiveness of boards of directors, protection of minority shareholders' interests, strong investor protection.
Demand: Qualitative aspects of demand	Degree of customer orientation, buyer sophistication.	
	Financial market efficiency	**Reliability and trust**
Financ: Institutional aspects of credit access	Availability of financial services, financing through the local stock market, easy access to loans, availability of venture capital.	Bank soundness, stock exchange regulation, legal rights index.
Techn: Availability of technology	Technology adoption Availability of recent technologies, technology absorption at the enterprise level, foreign direct investment (FDI) and technology transfer.	
	Domestic market	**External market**
Msize: Market size	Domestic market size index.	External market size index.

Source: Prepared by the authors, on the basis of World Economic Forum, *The Global Competitiveness Report 2013–2014*, Geneva, 2014.

Table A1.5
Variables related to the variables used in the principal components analysis: systemic factors

	Transport	Electricity and telephony	
Infra: Infrastructure aspects	Quality of overall infrastructure, quality of roads, quality of railways, quality of ports, quality of air transport.	Quality of energy supply, mobile and fixed telephony subscriptions.	
Macro: Macroeconomic aspects	Government budget balance, gross national savings, inflation, public debt, country credit rating.		
	Health	**Primary education**	
Social: Social aspects	Commercial impact of malaria, incidence of malaria, commercial impact of tuberculosis, incidence of tuberculosis, commercial impact of AIDS, prevalence of AIDS, infant mortality, life expectancy.	Quality of primary education, primary education enrolment rate.	
	Education quantity	**Education quality**	**On-the-job training**
Train: Social aspects	Secondary enrolment ratio, tertiary enrolment ratio.	Quality of the education system, quality of mathematics and science teaching, quality of school management.	Local availability of specialized research and training, extent of staff training.
	Domestic competition	**External competition**	
Compet: Legal and regulatory aspects	Intensity of local competition, extent of market dominance, effectiveness of antitrust policy, effect of taxation on investment incentives, total tax rate, number of procedures needed to set up a business, time needed to set up a business, costs of agricultural policy.	Prevalence of trade barriers, trade tariffs, prevalence of foreign ownership, trade impact of foreign direct investment (FDI) rules, burden of customs procedures, imports as a percentage of GDP.	
	Flexibility	**Efficient use of talent**	
Labour: Social aspects	Payments and productivity, reliance on professional management, country's ability to attract talent, country's ability to retain talent, women's participation in the workforce.		

Source: Prepared by the authors, on the basis of World Economic Forum, The Global Competitiveness Report 2013–2014, Geneva, 2014.

The gross domestic product (GDP) shares of the agriculture sector and the hydrocarbon and mining sector in the countries of South America between 1960 and 2014

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Abstract

This article analyses the GDP shares of the agriculture sector and the hydrocarbon and mining sector in the South American countries between 1960 and 2014. Although the share of the agriculture sector has been trending downward in South America, common features can be observed in three subgroups of countries. The first comprises the founding members of MERCOSUR, where agricultural and agro-industrial trade was in surplus and the share of the agriculture sector rose back up between 2002 and 2007. The second subgroup are the Andean countries, where the agriculture sector share of GDP declined from 1960 onward while that of hydrocarbon and mining production increased, especially during the 2000s. The third subgroup consists of Guyana and Suriname, where the historical series of the agriculture sector share of GDP takes the form of an inverted U.

Keywords

Agriculture, mining, hydrocarbons, industrial sector, industrial production, gross domestic product, agricultural statistics, industrial statistics, South America, MERCOSUR, Andean region, Guyana, Suriname

JEL classification

O13, O57, Q10

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I. Introduction

The theory of comparative advantage postulates that countries should devote their productive resources (land, labour and capital) to production and service activities in which they have comparative cost advantages relative to other countries. This idea is associated with the fact that foreign investors will decide what and where to produce and where to consume as their interests dictate. These two factors (comparative advantages and the role of foreign capital) determine an international division of labour that largely explains the production structure of the South American countries and the predominance in recent years of agricultural, hydrocarbon and mining activities in this production structure.

Between the sixteenth and nineteenth centuries, the countries of South America were exploited as Spanish and Portuguese colonies, whose main purpose was to supply foreign markets with agricultural and mining products. The role imposed on these colonies limited the development of industrial activity there, turning them into sellers of raw materials and buyers of industrialized products originating in the metropolises of the day (Baer, 2008; Furtado, 1989). This was clearly the international division of labour that existed at that time.

As independent countries, during the second half of the nineteenth century and the first half of the twentieth, the South American countries continued to pursue mining and agriculture as their main activities. In addition to selling these products on foreign markets, they allocated a portion to meeting the increased domestic demand resulting from incipient agro-industrialization. However, these activities were conducted directly or indirectly by foreign capital, primarily of British origin. The dynamism of production was determined by transnational mine-owning companies which also controlled international trade in both agricultural and mining products. This remains the situation to this day.

Between 1950 and 1970, the ideas of the Economic Commission for Latin America and the Caribbean (ECLAC) led South American countries to stimulate their industries. However, most of these stimuli were concentrated on natural resources and agricultural products. Those years were characterized by the implementation of protectionist policies that led to the creation of State monopolies in mining and hydrocarbon exploitation and limited the access of foreign capital, as in the case of Petrobras in Brazil (Baer, 2008). Even so, the role of transnational corporations as the main purchasers of these products was maintained.

According to Silva, Gómez and Castañeda (2012), the neoliberal model began to be adopted in most Latin American countries in the 1990s. In several of them (such as Brazil, Chile, Colombia and Peru), laws were relaxed to allow for increased participation by foreign capital in the direct exploitation of natural resources, and the bulk of these raw materials continued to be exported (Lagos and Peters, 2010). Since then, in addition to existing European and United States investors, new companies financed by capital from other countries interested in exploiting natural resources and carrying out agricultural production in South America, including China, have emerged (Ilyásova and Sérbinov, 2015). The intention behind this new investment is to receive raw materials in return for the financing provided. According to Ilyásova and Sérbinov (2015, p. 1), the funding received by the Bolivarian Republic of Venezuela from China since 2007 to develop its oil industry is being paid back in barrels of oil. In the case of Brazil, some lending to the agriculture sector is being channelled through foreign companies that grant loans in the form of inputs in exchange for the agricultural products to be exported (Bacha, 2012).

The 2000s have been characterized as a new, post-neoliberal phase. Foreign capital was invested in South America once again, both to produce raw materials, primarily for export, and to improve infrastructure to make these exports viable. A substantial proportion of these countries' GDP and exports continue to be based on primary commodities. According to data from Belloni and Wainer (2014, p. 106), these accounted for at least 68.8% of Argentina's exports from 2001 to 2011, while

the proportions for the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, the Plurinational State of Bolivia and Uruguay were 83.7%, 44.9%, 80.5%, 69%, 91.8%, 93.1%, 70.5% and 79.4%, respectively.

While Chile, Peru and Colombia opted to allow in more foreign capital for the exploitation of natural resources, which were previously in the hands of the State, Brazil, Argentina and Uruguay opted for State ownership but allowed foreign investment in agriculture and granted concessions for the exploitation of hydrocarbons and mining products. The Plurinational State of Bolivia, the Bolivarian Republic of Venezuela and Ecuador tended at times to restrict but not prohibit foreign investment in natural resource exploitation and agriculture. Although these three groups of countries can be differentiated by the scope allowed to foreign investors to participate in the exploitation of raw materials, such exploitation has not yet significantly altered the living conditions of South American populations (Belloni and Wainer, 2014).

Some studies argue that in the period from 2002 to 2008 (during the commodity price boom), South American countries suffered from Dutch disease, a situation in which revenues from raw material exports strengthen local currencies and stimulate imports of industrialized products (Bresser-Pereira and Marconi, 2008, for Brazil). Other authors, however, maintain that this did not occur (Puyana and Constantino, 2013, for Argentina).

It is important to point out that economies based on hydrocarbons and mining could have sustainability problems in future. Not only does the depletion of non-renewable natural resources jeopardize the future of these economies, but considerable environmental damage is being caused by the pollution of rivers and other water sources. Although agriculture also poses environmental challenges, its effects are less than those of mining and it plays an important role in food security.

While the present article will not focus on these topics, it will attempt to show the evolution of agricultural, mining and hydrocarbon activities, highlighting their different trajectories in the countries of South America. It will also argue that the allocation of production factors can give an idea of the differences in the dynamism of these activities in each of the countries. However, the main focus will be on the evolution of the agriculture sector, since although its GDP share has been in continuous decline in the South American countries, it is important to analyse how the patterns of this reduction vary between the different countries.

Specifically, the objective of this article is to analyse the evolution of the agriculture sector share of GDP in the South American countries and compare it with the share of mining and hydrocarbons there. It is expected that differences may be observed in the trajectory of these sectors' GDP shares between 1960 and 2014. Within the historical series analysed, special attention will be paid to the 2000s, since many countries in the region benefited greatly from the mining and agricultural commodity price boom during that period.

Agriculture competes with mining and hydrocarbon exploitation for land, infrastructure, capital investment and public policy attention. Even when an area may be better suited to mining than agriculture (such as Chile's arid north or rocky areas of Peru), State infrastructure investments in those areas divert possible resources that could be used to support other activities elsewhere (such as agriculture). There are also areas that can initially be used for mining and agriculture at the same time, but it is very likely that one of these activities will eventually expel the other. According to Lagos and Peters (2010, p. 3): "In Argentina, for example, mining was important in the mountainous provinces of Mendoza, San Juan, La Rioja, Catamarca, Salta, Jujuy and Neuquén. By the end of the nineteenth century, mining had already lost momentum in the face of the growing importance of agriculture and cattle ranching. Recently, in the last decade of the twentieth century, the establishment of a new legal structure facilitated substantial mining investment, leading to the emergence of mines such as Bajo de la Alumbrera (copper and gold), Cerro Vanguardia and Farallón Negro (gold and silver), Martha (silver), Salar del Hombre Muerto

(lithium), Andacollo and Veladero (gold) and San José (gold, silver and copper). The tension between agriculture and mining has not diminished, however, and in provinces such as Mendoza, for example, special laws have been drafted in the last decade to make mining more difficult." The same authors (Lagos and Peters, 2010, p. 5) cite the case of the area around Lima, where mining once coexisted with small-scale farming. As time went by, the latter gradually disappeared and the small farmers became the waged workforce needed to sustain mining expansion.

II. Literature review

The literature includes a number of studies on the importance of agriculture in the GDP of the South American countries.[1] Some of the studies analyse the countries separately, others together. There is also an extensive literature on the role of oil production and mining in the GDP of the South American countries. However, no document has attempted to jointly analyse these sectors' contribution to GDP or to compare them across the countries of the region.

In the first place, in view of the diversity of the territories of South America, this section divides the countries of the region into three blocs: those of the Andean Region, the Guianas[2] and the founding members of MERCOSUR. The countries of the Andean Region are: the Bolivarian Republic of Venezuela, Chile, Colombia, Ecuador, Peru and the Plurinational State of Bolivia. These are traversed by the Andes mountain range, which has enabled them to engage in mining and agriculture since Spanish colonial times. Farming is carried out mainly on plateaus and hillsides and in piedmont areas, but also on low-lying plains. The mining and hydrocarbon industries have attracted new multinational companies since the 1990s, particularly from China. The Guianas occupy what is still a little explored area of tableland, comprising two independent countries: Guyana and Suriname. Lastly, the founding members of MERCOSUR (Argentina, Brazil, Paraguay and Uruguay) share the plains watered by the system of rivers making up the River Plate basin, in which crop (mainly grain) production and cattle ranching are carried on extensively. Argentina and Brazil are the largest countries in MERCOSUR, and their vast territories serve for both agriculture and mining.

Among the Andean countries, the Bolivarian Republic of Venezuela is a particularly large producer of oil, this having been the leading sector in the Venezuelan economy since the 1920s. The country's oil exports were worth 40.7% of GDP in 2006 and represented almost 90% of the total that year (Souza, 2008). It is important to mention that few studies have been carried out on Venezuelan agriculture. One of these few is Morales (2002), which analyses maize, wheat and milk imports in the Bolivarian Republic of Venezuela.

One of the Latin American countries where the agriculture sector's share of GDP has fallen in recent decades is Colombia, with a decline from 20% in 1970 to 7.7% in 2010 (Fernández, Piñeros and Estrada, 2011; Romero, 2011). According to Rudas and Espitia (2013), mining and hydrocarbons accounted for about 7% of Colombian GDP in 2012.

As in the Bolivarian Republic of Venezuela, oil activity also accounts for a considerable proportion of the economy in Ecuador. Mateo and García (2014) show that oil is the leading sector in the Ecuadorian economy, since in 2012 it represented more than 12% of GDP and was one of the main export products (58%). Agriculture, conversely, is much less important to the Ecuadorian economy. According to Tandazo (2012), agriculture, including fisheries, accounted for about 10% of Ecuador's gross value added (GVA) that year.

[1] In this article, the term "agriculture" covers both crop and livestock production.

[2] For the purposes of this analysis, the Guianas comprise two independent countries, Guyana and Suriname, and do not include French Guiana.

In Peru, according to the Food and Agriculture Organization of the United Nations (FAO/CAF, 2006), both profits and competitiveness in agriculture are low. The emphasis of rural activities in the country is also on mining, since Peru is the world's leading producer of silver, with a 6.5% share of the global total in 2006. That same year, Peru was also the world's third-largest producer of copper and zinc, the fourth-largest producer of lead and the fifth-largest producer of gold (Dammert and Molinelli, 2007). Landa (2017) evaluates the impact of copper production on Peru's educational, health and road infrastructure between 2004 and 2013 and shows that this infrastructure improved more in extraction zones than elsewhere. However, the improvement was far below potential.

In the case of the Plurinational State of Bolivia, according to Urioste (2009), the GDP share of agriculture was 13% in 2008, the lowest rate since 1983. Montenegro and Guzmán (1999) found that the agriculture sector represented 15% of Bolivian GDP in 1995 and 1997, the lowest value observed in the 1970 to 1997 time series. On the other hand, minerals accounted for some 20% of the country's total exports in the period from 2005 to 2008, surpassed only by natural gas, exports of which increased substantially from 2003 onward, as Urioste (2009) points out.

The main product exported by the Chilean mining industry is copper, with exports worth almost US$ 18 billion in 2004 (Guajardo, 2007). The agriculture sector plays a secondary role in Chile's GDP, for although there has been a steady increase in the real value of production since 1962, it only represented 3.09% of GDP in 2007 (INE-Chile, 2009).

Guyana and Suriname are located in the north of South America and gained independence from Britain and the Netherlands, respectively, only in the 1970s. Although their economies are embryonic and infrastructure is very poor, Guyana and Suriname have great productive potential in the energy and mining sectors (Visentini, 2010). Guyana's economy continues to depend on the export of a few unprocessed commodities, such as gold and rice (Gold and Atoyan, 2007). In Suriname, agriculture remains unrepresentative, with a 9% share of GDP in 1992–1995 (Boye and Ramautarsing, 1997). According to Visentini (2010), there is scope for greater exploration of gold deposits in Suriname and, consequently, greater production of oil and gas.

In the southern part of South America are the River Plate countries, namely Argentina, Paraguay and Uruguay. The River Plate basin is very large and is formed by three rivers (the Paraná, the Paraguay and the Uruguay) that originate in Brazil. With very fertile soils, it is a region well suited to agriculture (Zarilli, 2013).

Regarding the importance of agriculture to the Argentine economy, we may cite, for example, Reca (2006), which analyses its development from 1875 to 2005. According to that study, Argentina's agriculture sector grew considerably during the period and the country became one of the world's leading exporters of grains, beef, wool and vegetable oils. However, there have been some fluctuations in recent years. Although agricultural value added decreased from 1999 to 2002 (because of the country's economic crisis in those years), between 2003 and 2005 the figure grew at an average annual rate of 5%, a level similar to that in the period 1875–1928, when the Argentine economy was dominated by cattle ranching. The country is one of the world's leading meat producers, and output of chicken and pork has increased by more than that of beef (Reca and Lema, 2016). According to Lence (2010), almost half of Argentina's exports between 2000 and 2007 were of agricultural products, which represented 8.4% of world agricultural production in the period. Puyana and Constantino (2013) analyse this expansion of agriculture and the dependence of Argentina's trade balance on agricultural commodities (especially soy), but find no evidence of Dutch disease in Argentina.

Agriculture also represents a large share of GDP and the trade balance in Paraguay and Uruguay, accounting for some 24% of Paraguayan GDP in the period 2000–2010 (Servín, 2011). According to Cresta and others (2014), agriculture represented 24.6% of Paraguay's GDP in 2013 and an average of

27.8% of its exports between 2000 and 2013. In Uruguay, data from INE-Uruguay (2009) indicate that agriculture represented 9.9% of GDP in 2010. Oyhantçabal and Sanguinetti (2017) analyse changes in Uruguayan agriculture between 2000 and 2015, assessing income distribution and pointing out that landowners have captured a large share of revenues.

Brazil is geographically the largest South American country and is currently one of the world's largest producers and exporters of agricultural products. In a study covering the period 1955–1996, Bacha and Rocha (1998) found a decrease in the agriculture sector's share of Brazilian GDP, from 23.5% in 1955 to 7.7% in 1989. Drawing on another set of data from Brazil's national accounts, Bacha (2012) analysed the period 1947–2010 and observed an increase in the contribution of agriculture to Brazil's GDP between 1998 and 2003. This was due to three main factors: (i) an increase in agricultural productivity combined with a decrease in industrial productivity; (ii) an improvement in the ratio of agricultural to industrial prices; (iii) an improvement in the ratio between prices charged and prices paid by ranchers and farmers. However, the years 2005 and 2006 were characterized by a decline in the GDP share of agriculture in Brazil, largely due to the strong appreciation of the real against the dollar and falling international agricultural commodity prices. This share recovered between 2007 and 2010.

In the 1990s, with increased economic liberalization, Brazil consolidated its position as the leading producer and exporter of several agricultural products, such as orange juice, sugar and chicken meat, in addition to the products of the soybean production chain (Jales, 2005). Bacha (2011) points out that rising agricultural output and commodity prices led to a large increase in Brazilian agricultural production and exports from 1998, which in turn drove a recovery in the country's agricultural GDP. The contribution of the agriculture sector to Brazil's GDP is also analysed by Brugnaro and Bacha (2009). Drawing on data for the period 1986–2004, the authors find that, despite the historical trend towards a declining share for agriculture in Brazil's GDP, that trajectory was reversed between 1993 and 2004.

Lastly, as mentioned earlier, while some studies in the literature focus on Latin America, other works analyse certain countries in the region individually. According to Pardey, Wood and Hertford (2009), there is a positive correlation between total GDP growth and agricultural GDP growth in Latin America during the period 1961–2002, especially in countries such as Belize, Brazil, Mexico and Paraguay. In spite of this, the period was characterized by a decline in the share of agriculture in the total GDP of the Latin American countries.

As regards trade, Latin America's agricultural trade surplus is due to the trade performance of a few countries, especially Argentina and Brazil, where the largest surpluses were recorded in 1999. In contrast, the Bolivarian Republic of Venezuela, Chile and Suriname, among others, have negative agricultural trade balances (Acosta, 2006). Valdés and Foster (2011) also point out the importance of agriculture in these countries' trade balances between 2000 and 2002. According to these authors, of the countries analysed, only Argentina, Uruguay, Brazil, Paraguay and the Plurinational State of Bolivia were net exporters of food, especially the first four.

Overall, the literature analysed has lost topicality, since much has changed over the last 10 years in the countries dealt with by the studies cited. Furthermore, the literature was not found to contain any analysis of compensation in the use of production factors (especially land use) between agriculture and the mining and hydrocarbon extraction industry in the South American countries.

The following section focuses on this compensation, analysing the period from 1960 to 2014, so that it covers a longer time span than the literature analysed.

III. Results

This document is based on a set of data from the World Bank (n/d) and the Food and Agriculture Organization of the United Nations (FAO). The two agencies provide similar information for South American countries on: (i) the use of production factors (such as land, capital and labour); (ii) the gross value and value added of agricultural production; and (iii) macroeconomic indicators, such as the trade balance and the GDP shares of agriculture and of hydrocarbon production and mining. These data are organized into tables and charts. Some data series are available from 1960 and others from 1990. The availability of a data series from 1960 facilitates comparison between the periods before and after the opening up of the South American economies in the 1990s.

1. Land availability, fixed capital investment and agricultural labour productivity in the South American countries

The ratio of farmland to total available land generally expanded in all the South American countries between 1961 and 2013 (see table 1). However, the three groups mentioned earlier (MERCOSUR, the Andean countries and the Guianas) have different patterns of land use.

Table 1
South America (12 countries): agricultural land as a proportion of total available land, 1961–2013
(Percentages, annual averages over each five-year period)

Country	Years					
	1961–1964	1970–1974	1980–1984	1990–1994	2000–2004	2010–2013[a]
Argentina	49.55	47.15	46.91	46.68	47.58	54.28
Brazil	18.96	24.26	27.21	29.53	31.86	33.00
Paraguay	26.65	29.37	35.13	42.83	49.88	53.93
Uruguay	92.60	87.99	85.83	85.28	85.25	82.21
Bolivia (Plurinational State of)	27.62	28.70	31.51	33.17	34.13	34.54
Chile	18.35	21.02	22.39	21.03	20.76	21.21
Colombia	37.05	40.26	40.85	40.51	38.33	38.68
Ecuador	17.03	18.02	24.96	28.77	30.70	30.06
Peru	13.51	14.18	14.66	17.08	17.93	18.90
Venezuela (Bolivarian Republic of)	21.92	22.78	24.01	24.61	24.48	24.49
Guyana	6.91	6.98	8.74	8.81	8.68	8.52
Suriname	0.27	0.34	0.47	0.57	0.52	0.50

Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.
[a] Data for 2014 are not available in the database used and a four-year average is taken.

Uruguay is the South American country that devotes the highest proportion of its total land area to agriculture. In the period under review, at least 82% of Uruguayan territory was given over to agriculture. In Paraguay, meanwhile, there have been large changes in land use. Between 1961–1964 and 2010–2013, the proportion of land used for agriculture doubled from an average of 26.65% to an average of 53.93%. Uruguay and Paraguay, like Argentina and Brazil, have climatic and geographical

conditions favourable to agriculture, particularly grain production and cattle ranching. At least half of Argentina's territory has been devoted to these activities since the mid-2000s, while they occupy a third of Brazil's.

Of the Andean countries, the Plurinational State of Bolivia and Colombia devote more than 30% of their territory to agriculture, while in Chile and Peru the proportion is less than 23%. Although Guyana and Suriname have increased the area devoted to agriculture, it represents no more than 9% and 1% of their territories, respectively (see table 1).

The data in table 2 show that most of the countries studied registered an increase in the capital employed in agriculture between 1990 and 2009, the exceptions being Argentina, Ecuador, Guyana and Suriname. This may indicate that most South American countries have invested more capital in the agriculture sector, undoubtedly accompanied by technological improvements.

Table 2
South America (12 countries): value of agricultural capital, 1990–2009
(Millions of 2005 dollars, annual averages over each five-year period)

Country	Years				Rate of growth between (D) and (A) *(percentages)*
	1990–1994 (A)	1995–1999 (B)	2000–2004 (C)	2005–2009[a] (D)	
Argentina	80 542.25	76 518.69	76 395.35	78 691.86	-2.3
Brazil	178 040.60	184 457.10	200 059.20	212 934.90	19.6
Paraguay	6 782.61	7 665.08	7 706.85	8 259.37	21.8
Uruguay	22 890.60	23 290.34	23 258.09	25 045.91	9.4
Bolivia (Plurinational State of)	6 470.62	7 189.41	8 157.64	9 072.33	40.2
Chile	20 305.29	22 627.82	22 995.87	22 872.66	12.6
Colombia	97 536.07	100 675.30	97 900.85	101 015.10	3.6
Ecuador	20 038.09	20 977.49	19 689.86	19 279.80	-3.8
Peru	19 824.48	21 258.93	22 601.76	23 442.91	18.3
Venezuela (Bolivarian Republic of)	26 399.50	27 168.88	28 563.28	29 442.64	11.5
Guyana	1 112.20	1 078.95	1 055.91	1 045.46	-6.0
Suriname	727.40	744.65	751.94	689.29	-5.2

Source: Prepared by the authors, on the basis of data from the Food and Agriculture Organization of the United Nations (FAO), "FAOSTAT" (n/d) [online database] http://faostat3.fao.org/.
Note: Forestry and fisheries are not taken into account in this calculation. The physical assets it includes are those used in production processes covering land use, irrigation works, structures, machinery and animals.
[a] Data for 2008 and 2009 are not available in FAOSTAT and a three-year average is taken.

Although agriculture is prominent in Argentina, its share of the country's GDP has declined in recent decades. Agricultural value added increased more quickly in the period after 2003, as Reca (2006) points out. Thus, the decline in the value of fixed capital stocks in Argentine agriculture in the 1990s and their increase in the following decade may be related to the performance of the Argentine economy in past decades. Ecuador, Guyana and Suriname, unlike Argentina, are not strongly oriented towards agriculture. These three countries have registered an increasing use of land in activities other than agriculture, a trend that in turn is related to a reduction in fixed capital stocks in that sector.

Despite the heterogeneous evolution of gross fixed capital formation, agricultural gross value added per worker (an indicator of agricultural productivity, see table 3) increased significantly over time in all the South American countries. On average, the founding countries of MERCOSUR experienced higher growth than the other countries studied. Two key factors explaining these differences are the global increase in agricultural commodity prices and the increased use of skilled labour in agriculture, especially in the 2000s and 2010s.

Table 3
South America (11 countries): gross value added per worker in the agriculture sector, 1990–2014
(2005 dollars, annual averages over each five-year period)

Country	Years					Rate of growth between (E) and (A) *(percentages)*
	1990–1994 (A)	1995–1999 (B)	2000–2004 (C)	2005–2009 (D)	2010–2014 (E)	
Argentina	7 670.36	9 203.27	9 918.16	11 638.02	12 293.46	60.3
Brazil	1 741.92	2 157.83	2 859.53	3 753.83	4 959.65	184.7
Paraguay	1 678.44[a]	1 846.01	1 910.79	2 207.43	2 807.21	67.3
Uruguay	5 852.37	7 310.11	7 201.98	8 215.57	9 410.55	60.8
Bolivia (Plurinational State of)	621.96	629.69	617.01	639.41	643.99	3.5
Chile	3 303.21	3 615.41	4 717.61	5 697.36	6 371.00	92.9
Colombia	3 509.61	2 959.87	2 889.40	3 308.13	3 657.16	4.2
Ecuador	2 086.87	2 405.62	2 792.12	3 398.61	4 000.32	91.7
Peru	1 029.24	1 230.21	1 401.20	1 625.90	1 848.03[c]	79.6
Guyana	3 248.93	4 473.55	4 781.87	4 291.03	4 761.84[b]	46.6
Suriname	3 172.20	2 753.69	2 955.24	3 009.33	3 848.04[b]	21.3

Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.
[a] Data for 1990 are not available in the database used and a four-year average is taken.
[b] Data for 2014 are not available in the database used and a four-year average is taken.
[c] Data for 2013 and 2014 are not available in the database used and a three-year average is taken.

2. Agricultural output and trade balances in the countries of South America

Between 1990 and 2013, the value of agricultural production increased in all the South American countries examined except Suriname (see table 4). In the case of crop production, the increase was greater in the founding countries of MERCOSUR than in the Andean countries, while the reverse was true of livestock production. The growth in the value of both agriculture and livestock production was due to the expansion of farmland, the growth of fixed capital and rising labour productivity, as shown in tables 1 to 3, respectively. The greater abundance of flatlands in the MERCOSUR countries as compared to the Andean ones gave the former a comparative advantage that allowed them to increase grain production more rapidly. In some Andean countries, many rocky areas are better suited to livestock than to crops.

Table 4
South America (11 countries): average annual crop and livestock production by value, 1990–2014
(Millions of averaged 2004 to 2006 dollars, annual averages over each five-year period)

Country	Years					Rate of growth between (E) and (A) *(percentages)*
	1990–1994 (A)	1995–1999 (B)	2000–2004 (C)	2005–2009 (D)	2010–2013[a] (E)	
Crop production						
Argentina	8 874.81	11 373.72	13 651.46	16 209.11	18 539.29	108.9
Brazil	25 035.17	28 377.74	35 894.12	44 052.61	52 712.74	110.6
Paraguay	722.51	979.77	1 258.33	1 678.40	2 383.56	229.9
Uruguay	495.03	672.16	655.72	955.22	1 395.96	182.0
Bolivia (Plurinational State of)	622.71	810.15	970.40	1 097.04	1 308.49	110.1
Chile	2 196.95	2 480.69	2 766.46	2 835.81	3 070.25	39.8
Colombia	5 501.58	5 366.71	5 570.88	6 048.33	5 933.28	7.8
Ecuador	1 583.48	1 808.60	1 835.06	1 959.33	2 219.07	40.1
Peru	1 373.71	2 040.93	2 648.63	3 165.37	3 826.75	178.6
Guyana	3.91	6.47	5.85	7.57	6.54	67.3
Suriname	96.97	84.71	71.71	79.39	94.08	-3.0

Table 4 (concluded)

Country	Years					Rate of growth between (E) and (A) *(percentages)*
	1990–1994 (A)	1995–1999 (B)	2000–2004 (C)	2005–2009 (D)	2010–2013[a] (E)	
Livestock production						
Argentina	1 973.98	2 652.88	2 593.54	3 257.18	3 808.27	92.9
Brazil	14 500.07	19 312.28	24 662.94	30 528.29	34 738.48	139.6
Paraguay	550.54	634.27	742.11	853.53	980.12	78.0
Uruguay	1 105.10	1 304.70	1 202.65	1 488.01	1 519.57	37.5
Bolivia (Plurinational State of)	281.28	334.53	376.09	512.23	575.43	104.6
Chile	1 437.30	1 842.72	2 100.24	2 603.46	2 816.52	96.0
Colombia	3 427.38	4 002.99	4 466.68	5 461.96	5 926.12	72.9
Ecuador	1 077.27	1 542.32	1 843.95	2 183.43	2 589.97	140.4
Peru	1 173.61	1 483.15	1 859.20	2 478.74	3 194.89	172.2
Guyana	7.89	11.67	14.03	19.60	18.93	139.9
Suriname	45.61	31.65	29.62	34.76	40.78	-10.6

Source: Prepared by the authors, on the basis of data from the Food and Agriculture Organization of the United Nations (FAO), "FAOSTAT" (n/d) [online database] http://faostat3.fao.org/.
Notes: Following FAO, these values are calculated by multiplying the physical quantity of gross output by farm gate prices.
[a] Data for 2014 are not available in FAOSTAT and a four-year average is taken.

It is well known that Brazil and Argentina are, in that order, the largest producers of crops and livestock in South America, owing to the size of their territories and their climatic diversity. However, it is also important to highlight the strong growth of crop production in Uruguay and Paraguay and of livestock production in Ecuador, the Plurinational State of Bolivia, Peru and Guyana. Much of the agricultural output of the South American countries goes to foreign markets. All the South American countries surveyed except Peru and Suriname run trade surpluses in agricultural and agro-industrial products (see table 5).

Table 5
South America (12 countries): agricultural and agro-industrial trade balances, 1990–2014
(Millions of dollars, annual averages over each five-year period)

Country	Years				
	1990–1994	1995–1999	2000–2004	2005–2009	2010–2013[a]
Argentina	6 363.68	9 652.60	11 552.21	23 730.49	37 329.78
Brazil	6 575.05	8 749.22	15 146.18	38 089.01	66 825.63
Paraguay	413.94	181.39	572.85	1 794.50	3 789.57
Uruguay	515.90	751.19	784.64	2 163.76	4 160.88
Bolivia (Plurinational State of)	49.10	180.44	233.04	427.60	869.54
Chile	883.35	1 355.97	2 112.28	3 287.58	5 037.82
Colombia	1 999.20	1 903.14	1 305.79	2 465.39	1 206.92
Ecuador	797.19	1 178.10	1 144.55	1 799.00	2 777.61
Peru	-491.55	-642.97	-271.63	-153.53	79.79
Venezuela (Bolivarian Republic of)	-810.06	-1 126.56	-1 701.49	-5 378.88	-8 617.49
Guyana	108.75	156.83	88.40	122.77	129.62
Suriname	-20.44	-58.85	-68.01	-125.70	-148.54

Source: Prepared by the authors, on the basis of data from the Food and Agriculture Organization of the United Nations (FAO), "FAOSTAT" (n/d) [online database] http://faostat3.fao.org/.
[a] Four-year average.

The founding countries of MERCOSUR have the strongest trade balances. Both production and exports of agricultural and agro-industrial products have increased considerably in this group of countries. In Brazil, for example, average annual agricultural output grew by 110.6% from 1990–1994 to 2010–2013. At the same time, the average value of the South American giant's annual livestock production increased by 139.6%. As a result, Brazil's trade surplus in these products grew by 916.4% over the same period. Paraguay, Uruguay and Argentina also recorded substantial growth, with their

trade surpluses in agricultural and agro-industrial products increasing by 815.5%, 706.5% and 486.6%, respectively. These figures clearly position them as agro-exporting countries.

Acosta (2006) points out that the Bolivarian Republic of Venezuela and Suriname have run agricultural and agro-industrial trade deficits since 1990, a trend that continued in the 2000s (see table 5). Like these two countries, Peru has a poor agricultural and agro-industrial trade balance.

A general review of tables 5 and 6 shows that the countries with the highest agricultural production are also those with the largest agricultural and agro-industrial trade surpluses.

Table 6

South America (12 countries): gross domestic product (GDP) shares of the agriculture sector and the mining and hydrocarbons sector and gross value added (GVA) of the agriculture sector, 1990–2014

(Percentages and millions of 2004 dollars, annual averages by five-year period)

Country	Indicator	Years				
		1990–1994	1995–1999	2000–2004	2005–2009	2010–2014
Argentina	GDP share of agriculture	6.37	5.61	8.16	7.68	7.59
	Agricultural GVA	11 254.63	13 577.04	14 543.08	16 787.16	17 174.24
	GDP share of mining and hydrocarbons	1.50	1.40	3.84	3.79	3.43
Bolivia (Plurinational State of)	GDP share of agriculture	16.66	16.06	15.18	13.69	12.91[a]
	Agricultural GVA	765.24	894.69	1 010.77	1 181.96	1 298.41[a]
	GDP share of mining and hydrocarbons	3.12	2.20	3.97	8.50	9.24
Brazil	GDP share of agriculture	8.20	5.45	6.29	5.29	5.29
	Agricultural GVA	24 596.07	29 563.82	37 251.28	44 503.25	51 646.47
	GDP share of mining and hydrocarbons	1.35	0.95	2.91	4.22	4.78
Chile	GDP share of agriculture	9.45	6.71	5.31	3.87	3.37
	Agricultural GVA	3 155.41	3 513.86	4 560.25	5 543.57	6 094.67
	GDP share of mining and hydrocarbons	7.46	5.90	7.31	14.98	16.58
Colombia	GDP share of agriculture	15.98	14.21	8.96	7.87	6.77
	Agricultural GVA	12 063.42	10 317.34	10 351.11	11 776.02	12 720.00
	GDP share of mining and hydrocarbons	5.00	3.48	5.17	5.75	8.49
Ecuador	GDP share of agriculture	22.02	20.32	12.87	9.91	9.60
	Agricultural GVA	3 911.27	4 918.57	3 237.96	4 969.26	7 885.81
	GDP share of mining and hydrocarbons	9.62	7.51	13.36	16.99	17.48[a]
Guyana	GDP share of agriculture	38.07	36.96	30.99	24.57	18.56
	Agricultural GVA	185.69	249.53	260.05	223.16	234.45[a]
	GDP share of mining and hydrocarbons	8.82	4.57	3.35	5.36	12.94[a]
Paraguay	GDP share of agriculture	17.57[a]	18.18	16.83	20.47	26.34[a]
	Agricultural GVA	1 028.04[a]	1 250.36	1 415.09	1 763.59	2 385.50
	GDP share of mining and hydrocarbons	0.00	0.00	0.00	0.00	0.00[a]
Peru	GDP share of agriculture	9.30[a]	9.38	8.39	7.62	7.39[b]
	Agricultural GVA	2 980.95	3 917.06	4 818.63	5 877.49	6 966.64[a]
	GDP share of mining and hydrocarbons	3.74	1.57	2.03	9.41	10.91[a]
Suriname	GDP share of agriculture	13.01	12.65	8.63	8.12	7.43[a]
	Agricultural GVA	91.37	79.28	89.85	97.00	126.99[a]
	GDP share of mining and hydrocarbons	20.01	8.07	11.00	12.68	25.93[a]
Uruguay	GDP share of agriculture	8.36	7.82	9.24	10.34	9.49[c]
	Agricultural GVA	1 105.86	1 408.38	1 361.97	1 562.28	1 771.87
	GDP share of mining and hydrocarbons	0.00	0.00	0.03	0.10	0.12[a]
Venezuela (Bolivarian Republic of)	GDP share of agriculture	5.44	5.02	4.29	4.54	5.56[b]
	Agricultural GVA	4 105.58	4 267.59	4 764.72	5 595.08	5 875.18[a]
	GDP share of mining and hydrocarbons	25.79	20.24	24.96	23.12	24.94[a]

Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

[a] Data for one of the years are not available in the database used and a four-year average is taken.

[b] Data for 2013 and 2014 are not available in the database used and a three-year average is taken.

[c] Data for 2012, 2013 and 2014 are not available in the database used and a two-year average is taken.

3. The GDP shares of the agriculture sector and the mining and hydrocarbons sector in the South American countries

Table 6 shows the evolution of the GDP shares of agriculture and of mining and hydrocarbons (the latter two being taken together) in the South American countries from 1990 to 2014. These shares are calculated as annual averages over five-year periods, and the gross value added of the agriculture sector is measured in millions of dollars at constant 2004 prices.

The data suggest that the importance of mining and hydrocarbon exploitation increased during the period under review in all the South American countries surveyed except Paraguay and the Bolivarian Republic of Venezuela. In Paraguay, the data indicate that these sectors make no contribution to GDP. In the Bolivarian Republic of Venezuela, mining and hydrocarbon exploitation (and especially oil production) has been very important since the beginning of the data series, and the fact that its share of GDP changed so little between 1990 and 2014 reflects the rigidity of the country's production structure and its historical dependence on oil. In Chile, Ecuador, Guyana, Peru and Suriname, the GDP share of mining and hydrocarbons also increased. Similarly, and despite the predominance of the agriculture sector, the GDP share of mining and hydrocarbons in Argentina and Brazil likewise rose over the course of the series.

An examination of the data set in table 6 reveals that the importance of mining and hydrocarbon exploitation in the South American economies has increased overall in recent years, even as the GDP share of the agriculture sector has declined sharply in most of the countries. This pattern was expected because the share of value added in the economy contributed by the industrial and service sectors has grown faster than that of the agriculture sector since the mid-twentieth century.

Despite the downward trend in the contribution of agriculture to the GDP of the South American countries, the gross value added of this sector has continued to rise in most of them. In Peru, for example, the average GVA of agriculture rose by 133.71% between the five-year periods 1990–1994 and 2010–2014. The increase was 110% in Brazil, 101.62% in Ecuador and 93.15% in Chile, to name just a few.

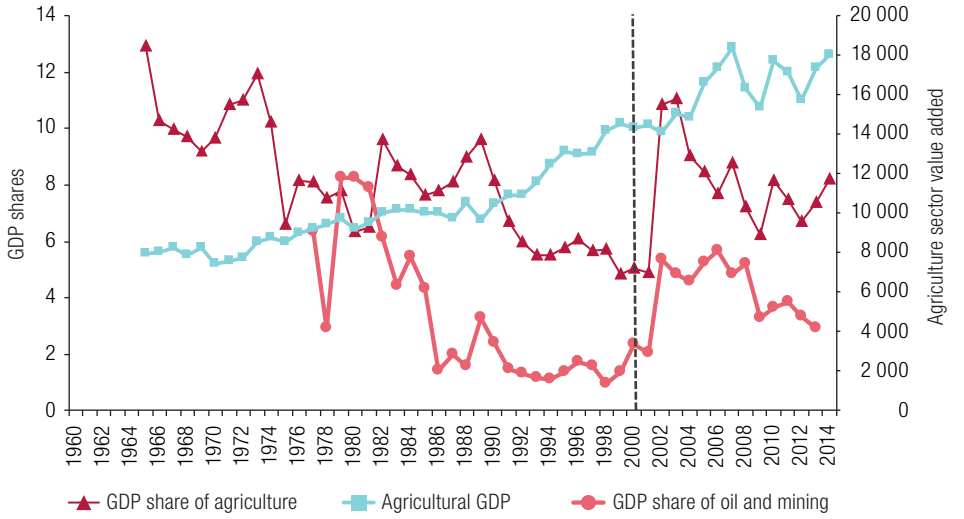
Argentina, the Bolivarian Republic of Venezuela, Paraguay and Uruguay are exceptions to the continuing downward trend in the agriculture sector's share of GDP over time. In these countries, although the GDP share of agriculture declined between 1990 and 1999, that trend was reversed in the 2000s. The agricultural commodity price boom in 2002–2007 was probably partly responsible for this turnaround. However, as with the Bolivarian Republic of Venezuela and oil, this situation may indicate how heavily these countries depend on agricultural exports (with the exception of the Bolivarian Republic of Venezuela).

The information provided by the series allows the countries to be classified into three different groups, the first of which comprises Argentina, Brazil, Paraguay and Uruguay. The GDP share of agriculture increased in all these countries except Brazil between 1990–1994 and 2010–2014. Nonetheless, agriculture's share of GVA remains higher in Brazil than in any of the other countries analysed. The second group comprises the Bolivarian Republic of Venezuela, Chile, Colombia, Ecuador, Peru and the Plurinational State of Bolivia. Agriculture's share of GDP declined in this group during the 2000s. Even so, the sector's value added also increased in all these countries except the Bolivarian Republic of Venezuela. In the latter, although the size of the agriculture sector as a percentage of GDP declined between 1990 and 2009, it increased slightly from 2010 onward. The third group consists of the Guianas, where the series for the agricultural share of GDP took the form of an inverted U in the 2000s while the GDP share of mining and hydrocarbons increased, as will be seen further on. These three groups of countries are analysed in detail below.

(a) Argentina, Brazil, Paraguay and Uruguay

In the case of Argentina, the agriculture sector's share of GDP grew considerably from 2000 onwards (see figure 1). Part of this increase was due to the economic crisis the country faced at the beginning of the twenty-first century (Reca, 2006). Argentina's agriculture sector relied mainly on exports and as a result was little affected by the domestic economic crisis, except during the last few years of Cristina Kirchner's second administration, which sought to ban agricultural exports.

Figure 1
Argentina: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)

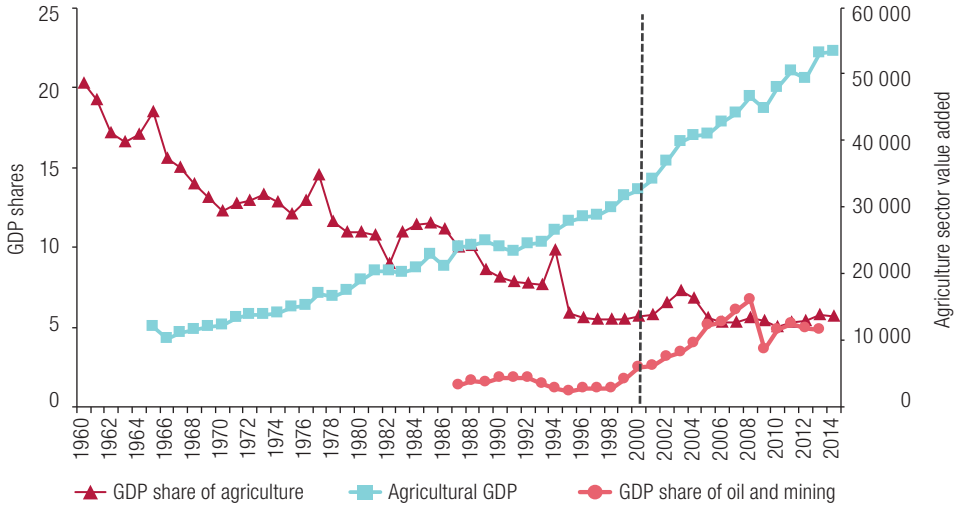


Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

What is most striking in figure 1 is the upward trend of Argentina's agricultural GDP at factor cost (or GVA). At 2005 prices, its monetary value increased from about US$ 14 billion in 2010 to about US$ 18 billion in 2014. Moreover, Argentina's agriculture sector has modernized considerably since the 1990s, generating economies of scale thanks to the opening up of the economy and the comparative advantages of its agriculture (Lema, 1999). Although the combined share of mining and hydrocarbon production in Argentina's GDP has increased in the twenty-first century, it is still lower than that of the agriculture sector.

Figure 2 shows the substantial increase in Brazil's agricultural GVA since the 1960s. This growth has been mainly due to productivity improvements in relation to land availability and the increase in the area given over to agriculture, especially in regions such as the centre-west and north of Brazil and, recently, the region known as MATOPIBA, formed by the states of Maranhão, Tocantins, Piauí and Bahia (Bacha and Carvalho, 2014). However, the share of agriculture in Brazil's GDP declined from about 20% in 1960 to 5% in 2014. During the commodity price boom, this figure exceeded 7% (as in 2003). Between 2007 and 2014, following the price crisis caused by the appreciation of the Brazilian currency in 2005 and 2006 especially, the GDP share of Brazil's agriculture sector ranged from 5% to 6%.

Figure 2
Brazil: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

According to figures 1 and 2, the share of GDP represented by mining and hydrocarbon revenues increased in both Argentina and Brazil in the first 14 years of the twenty-first century. These two nations are known to be very diverse in terms of climate and geological formations, which creates the conditions for large-scale agriculture and provides comparative advantages both in agriculture and in mining and hydrocarbon production.

Although Paraguay and Uruguay do not have large expanses of land, both devote a large part of their territory to agriculture (see table 1). The GDP share of mining and hydrocarbon revenues is practically zero in both Paraguay and Uruguay (see figures 3 and 4).

Figure 3
Paraguay: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)

Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

Figure 4
Uruguay: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)

Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

The GDP share of agriculture in Uruguay was 7% in 2000, increasing to 8.6% in 2014 (see figure 4). In Paraguay, these figures were about 15% and 21%, respectively (see figure 3). As can be seen in table 4, the agricultural commodity price boom between 2002 and 2007 allowed Uruguay to double the annual value of its agricultural production between the periods 2000–2004 and 2010–2013. In the case of Paraguay, the increase was almost 90%.

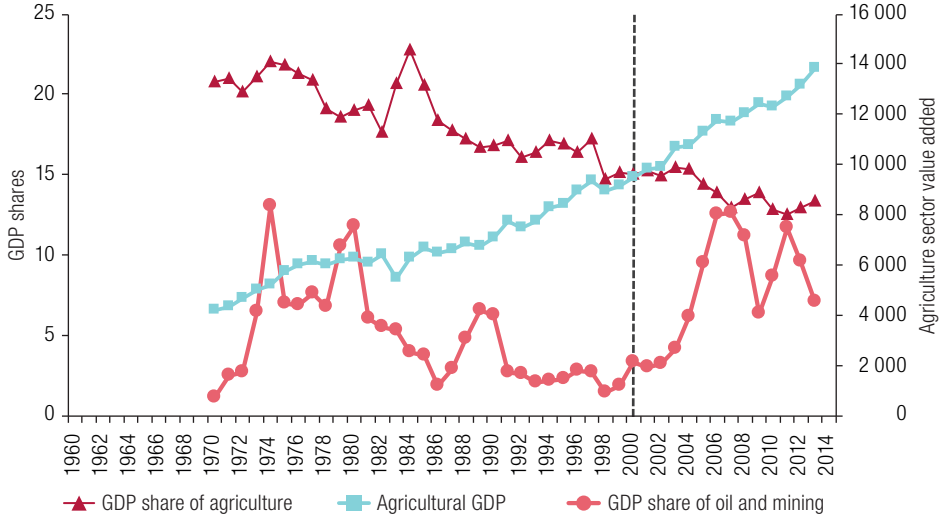
The four countries mentioned above are all part of MERCOSUR. Throughout the first decade of this century, about 50% of all Paraguayan exports went to the member countries of that bloc. In Uruguay, the share was some 30% during the same period (Graf and Azevedo, 2013). It can be concluded that agriculture plays an important role in the economies of these four countries, especially in income generation and in the supply of agricultural products to many other countries.

(b) The Plurinational State of Bolivia, Chile, Ecuador, Peru, Colombia and the Bolivarian Republic of Venezuela

The GDP share of agriculture has declined steadily in this group of countries since the 1960s, falling even in the agricultural commodity price boom years from 2002 to 2007 (except in the Bolivarian Republic of Venezuela). Even so, the sector's gross value added has grown.

In the case of the Plurinational State of Bolivia (see figure 5), although the inflation-adjusted value of agricultural GDP has been on an upward trend since 1970, the GDP share of agriculture declined during the period of rising agricultural prices (2002 to 2007), while that of the mining and hydrocarbons sector increased.

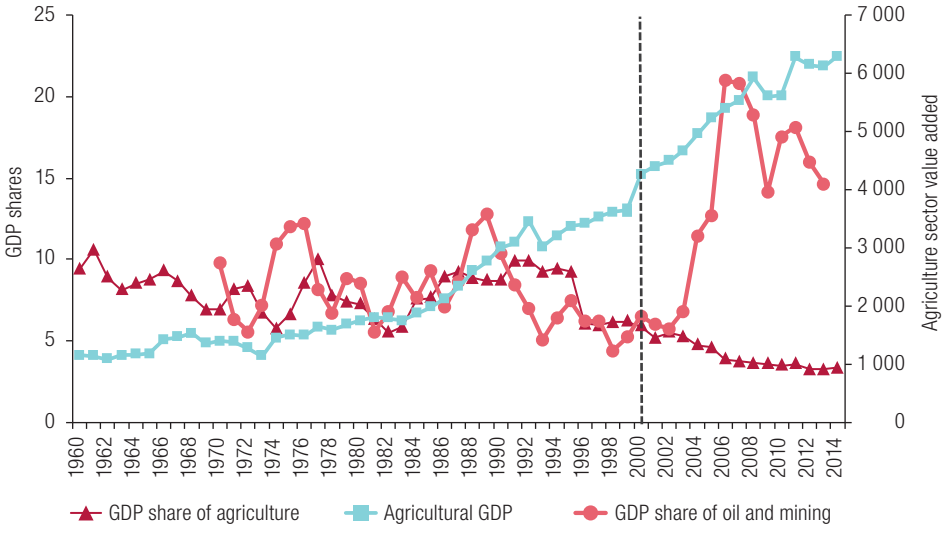
Figure 5
Plurinational State of Bolivia: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

The situation in Chile (see figure 6) is not very different from that in the Plurinational State of Bolivia. In contrast to countries such as Brazil, Chile's cool climate precludes the cultivation of tropical products. In the twenty-first century, the GDP share of the mining and hydrocarbons sector in Chile has increased even as that of agriculture has declined. In 2014, the mining and hydrocarbons sector in Chile generated three times the GVA of agriculture.

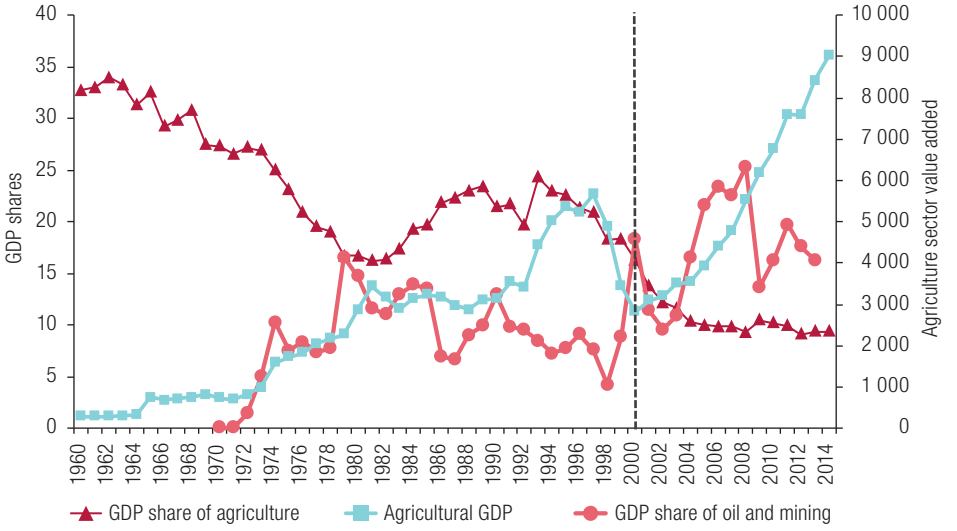
Figure 6
Chile: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

In Ecuador (see figure 7), the agricultural sector's contribution to GDP declined greatly between 1960 and 2014 despite a considerable increase in the value of production. According to Mateo and García (2014) and Tandazo (2012), the GDP share of mining and hydrocarbons in Ecuador is high, and the importance of this sector is confirmed by the large increase in its share of GDP, which reached 25% in 2008 before dropping back to 20% in 2012.

Figure 7
Ecuador: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)

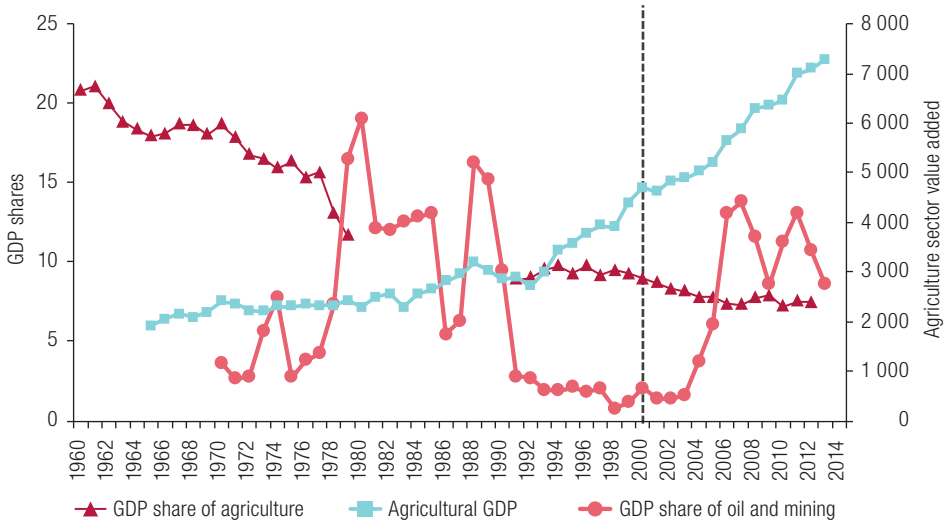


Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

According to a study by FAO/CAF (2006), Peru is also characterized by the low profitability of its agriculture sector. The leading land use in Peru is for mining, especially silver and copper mining (Dammert and Molinelli, 2007). Figure 8 shows that, at just over 5%, the GDP share of agriculture in Peru in 2012 was extremely low compared to earlier figures in the data series. In contrast, the share of mining and hydrocarbon revenues in Peru's GDP more than tripled during the agricultural price boom between 2002 and 2007, from about 1.3% to about 8%.

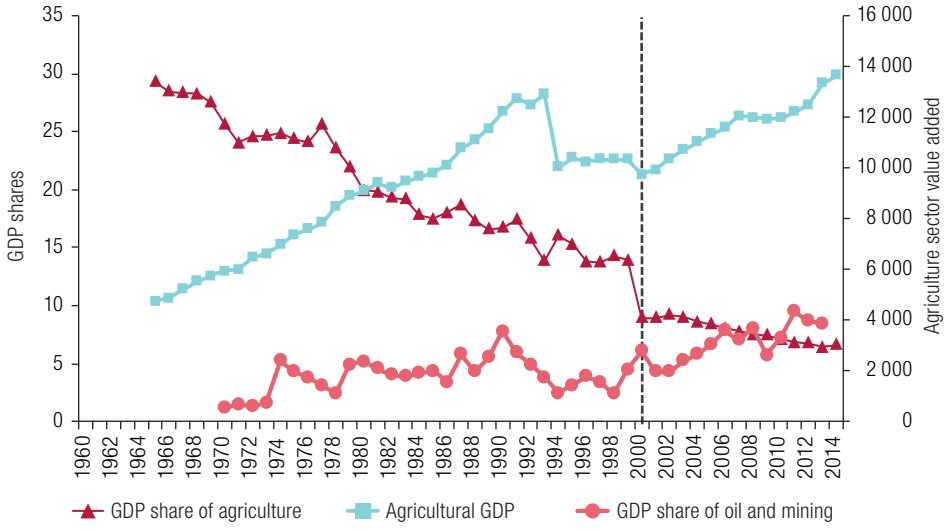
The data presented in figure 9 show that agricultural value added in Colombia has been unchanged in recent years from the values observed in the early 1990s. In addition, while the GDP share of the agriculture sector in Colombia has declined, the share of mining and hydrocarbons has increased. It seems, then, that Colombia has been developing its mining sector as well this century. According to Muñoz (2014), the Colombian government has adopted policies to attract foreign direct investment into the mining sector since the late 1990s.

Figure 8
Peru: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

Figure 9
Colombia: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)

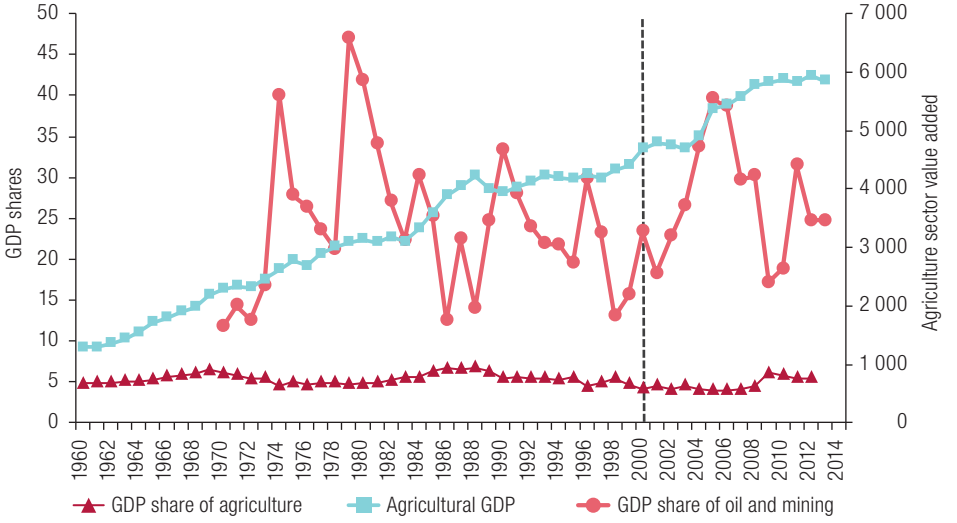


Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

The Bolivarian Republic of Venezuela is characterized by large-scale oil production and export, this having been an important sector of its economy since the 1920s (Souza, 2008). Value added in agriculture is low, and its share of Venezuelan GDP is therefore also small, at around 5% throughout the period under consideration (see figure 10). On the other hand, revenues from oil production and

mining fluctuated around 30% of Venezuelan GDP in the period from 1970 to 2013. The Venezuelan economy has suffered from swings in the price of a barrel of oil (Bresser-Pereira, 2008), but the political crisis affecting Maduro's government means that more recent data are not available.

Figure 10
Bolivarian Republic of Venezuela: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

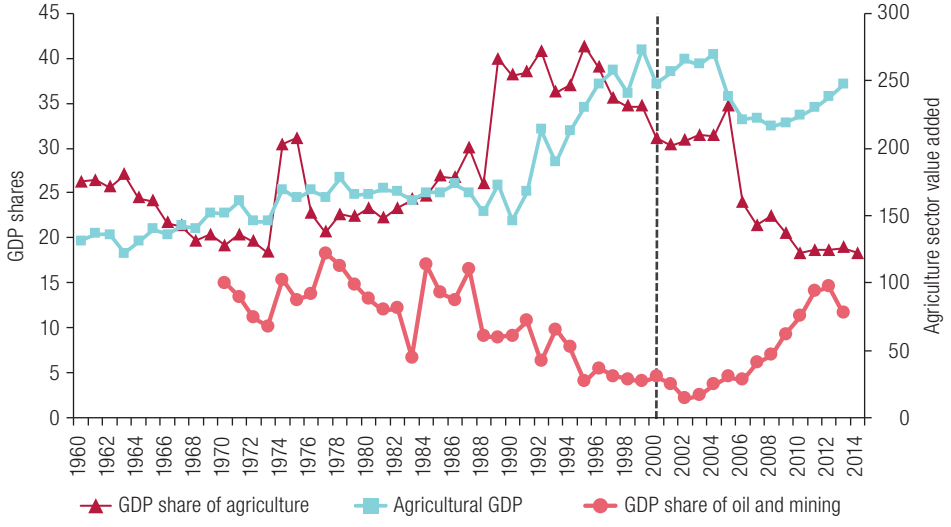
(c) Guyana and Suriname

Figures 11 and 12 show the GDP shares of the agriculture sector and the mining and hydrocarbons sector in Guyana and Suriname, respectively. The percentage of GDP represented by agriculture is higher in Guyana than in Suriname. Although the GDP share of agriculture in Guyana increased between 1970 and 1995, this trend has gradually weakened since 1996. The same has happened in Suriname, where the increase was substantial only until 1993, after which the representativeness of agriculture began to decline. The historical series for the GDP share of agriculture in Guyana and Suriname clearly takes the form of an inverted U.

In any event, the GDP share of agriculture in both countries was lower in 2014 than in 1960. In addition, the declining trend in the GDP share of agriculture since the mid-1990s was followed by an increase in the share of mining and hydrocarbons.

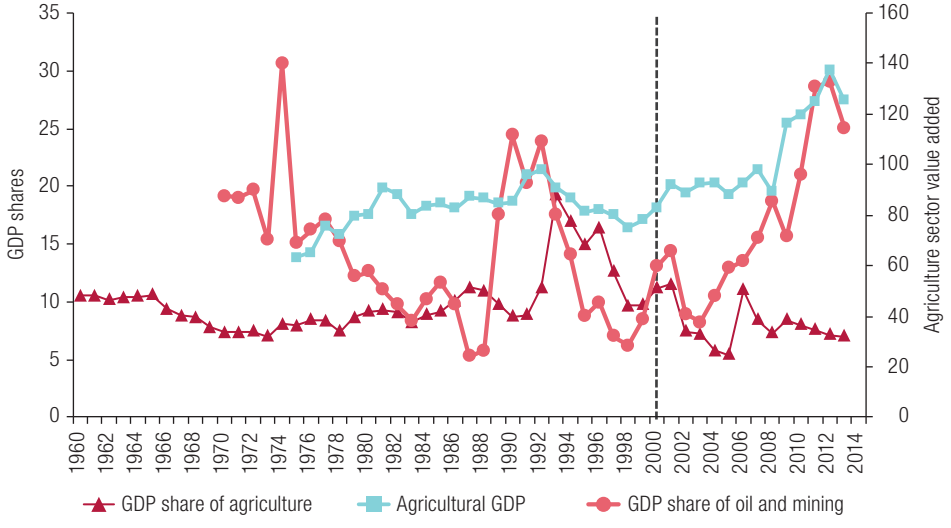
Because agriculture occupies less than 10% of Guyana's territory and less than 1% of Suriname's (see table 1), suitable land is available to expand it in both countries. However, it may not be easy to initiate such an expansion given the lack of a strong institutional framework to secure the process. These countries have infrastructure deficiencies that need to be addressed. As relatively young republics, it is also important for the two economies to consolidate a hegemonic sector, be it agriculture or something else. As figures 11 and 12 show, the sectors acquiring this hegemony in both countries are mining and agriculture.

Figure 11
Guyana: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

Figure 12
Suriname: gross domestic product (GDP) shares of the agriculture sector and the mining and oil sector and agricultural value added, 1960–2014
(Percentages and millions of 2005 dollars)



Source: Prepared by the authors, on the basis of data from World Bank, "World Development Indicators (WDI)" (n/d) [online database] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.

IV. Conclusions

This article has set out to present an overview of the trade-off between agricultural production and mining and hydrocarbon exploitation in the countries of South America. The results of this study indicate that agriculture is, in general, an important sector for the region, even though its share of GDP in the South American countries evinces a constant downward trend. Agricultural production has expanded in most South American countries since 1960, and the region as a whole runs an agricultural and agro-industrial trade surplus. When it comes to the importance of agriculture and of mining and hydrocarbons in each country's GDP, however, patterns are uneven.

Argentina, Brazil, Paraguay and Uruguay are founding members of MERCOSUR and net exporters of agricultural and agro-industrial products. Although the share of mining and hydrocarbons in Brazil's and Argentina's GDP has increased, it remains lower than the share of the agriculture sector. Meanwhile, mining and hydrocarbons do not seem to be important in the GDP of Paraguay and Uruguay. A major feature of all four countries is the good performance of the agriculture sector during the agricultural price boom of 2002 to 2007, reflected in the increase in its contribution to GDP during the period.

The economies of the Bolivarian Republic of Venezuela, Chile, Ecuador, Peru and the Plurinational State of Bolivia are more oriented towards mining and hydrocarbon extraction than agriculture. Their climates and soil partially explain this. Although agricultural production increased in all of them during the period under review, the sector's share of GDP declined throughout, even between 2002 and 2007. On the other hand, the GDP share of mining and hydrocarbons has increased since the 2000s.

Guyana and Suriname are the only countries in which the GDP share of agriculture increased until the mid-1990s, before declining. It is assumed that mining and hydrocarbon extraction will grow faster than agriculture in the two countries despite the availability of land suitable for farming. However, it should be stressed that both of them are taking their first steps in today's globalized world and trying to solve other structural problems in their economies besides that of the production and sale of goods and services.

Soil and climate types and the availability of production factors such as land partially explain the above findings. International investors have been exploiting the potential they represent, and this, as mentioned in the introduction, has given a particular pattern to the international division of labour.

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Green jobs in Argentina: opportunities to move forward with the environmental and social agenda

Christoph Ernst, Ana Sofía Rojo Brizuela
and Daniele Epifanio

Abstract

The Argentine economy has been becoming greener because of a new political orientation, international commitments (the Paris Agreement and the 2030 Agenda for Sustainable Development) and private sector initiatives. This transition is having economic and social impacts. The aim of the present article is to determine the potential of the economy to create green jobs that protect workers and the environment. In 2015, 7% of formal jobs were green and presented better average employment conditions than the rest. They were predominantly in goods production and the provision of urban services, such as sanitation and transport. Regulations and public policies seem to be the main factors driving green job creation, with consumption still playing a minor role. For the transition to a green economy to be fair, policies must take account of the employment dimension in order to initiate a virtuous circle leading to a more productive, inclusive and environmentally friendly economy.

Keywords

Employment, environment, climate change, environmental economics, employment creation, decent work, environmental protection, sustainable development, employment statistics, Argentina

JEL classification

J01, Q01, O01

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I. Introduction

Climate change is one of the main challenges facing humanity in the coming decades. Its economic, social and environmental consequences threaten vast sections of the planet's population, particularly in the poorest regions. In response, countries have set an environmental policy agenda that may have both positive and negative effects on their societies and economies.

Argentina's geographical position and production structure mean that it is particularly affected. Natural disasters such as river and coastal flooding, droughts, extreme temperatures and fires are becoming more and more frequent. Agriculture, which is fundamental to the country's development and the global food supply, is the most vulnerable to these phenomena. Energy security is another sensitive issue, as it is being affected by the increasing intensity and duration of heat waves. Urban activities in general are being permanently impacted by the negative effects (MAyDS, 2017b).

In view of the need to adapt the most vulnerable systems and sectors to the international environmental agenda and a growing awareness of the need to respect the environment, policies for a greener economy are being implemented in Argentina. Different factors are driving this paradigm shift: political will at the different levels of government; the production sector, often prompted by the demands of external markets; and society in general, where responsible consumption practices are still incipient (Voices Research and Consultancy, 2016).

The transition to a green economy brings many opportunities and challenges. Incorporating technological change, stimulating innovation, investing in infrastructure and developing value chains associated with the emergence of new sectors are processes that provide the opportunity to create jobs with new employment profiles, while adapting the occupational skills of current profiles (Altenburg and Assmann, 2017; OECD, 2017). To capitalize on this potential, there is a need to formulate policies, create incentives and establish institutional frameworks that improve resource management and contribute to the transition. The nature of the challenges means that some sectors will inevitably have to be transformed. The transition to a green economy will be fair to the extent that it is inclusive. Creating decent work in the new activities and implementing social protection policies to mitigate the effects on the sectors that need transforming are the main channels for ensuring this inclusiveness.

By green jobs are meant those that meet the requirements of decent work and help preserve and restore the environment. They may be in traditional sectors, such as manufacturing or construction, or in new emerging sectors, such as renewable energy and energy efficiency (Jarvis, Varma and Ram, 2011). Green jobs are crucial for a fair transition.

The study on green employment in Argentina focuses on the jobs being created as a result of this transition and notes among its findings that the country had some 650,000 such jobs in 2015, employing 7% of formal wage earners (ILO, 2017). The study is part of the Green Jobs Programme initiative of the International Labour Organization (ILO), which has carried out similar research in different countries, notably Argentina, Brazil, Mexico and Uruguay in Latin America (ILO, 2009, 2013a, 2016 and 2017). The present article is based on the aforementioned study on green employment in Argentina and examines aspects such as the sectors in which green jobs are being created, the worker profiles benefiting and the quality of that employment, while showing the interdependence between the environmental, production and labour dimensions. It also seeks to demonstrate that in countries with production structures like Argentina's, a shift towards greater environmental sustainability is compatible with greater production development and the creation of decent work, particularly if environmental, production and labour policies are coordinated.

The article is structured as follows. First, it presents the main issues in the debate on a fair transition to a more sustainable economy, while highlighting the role of green jobs in the transition and

defining the concept of green employment. Second, estimates of green employment in the country are presented by means of a sectoral analysis. Third, the link between environmental, production and labour policies is discussed. Lastly, the conclusions are presented.

II. Sustainable development and the creation of decent jobs

International concern about climate change goes back almost half a century. The 2030 Agenda for Sustainable Development, adopted by the United Nations General Assembly in September 2015, and the 17 Sustainable Development Goals (SDGs) associated with the Agenda have given a fresh impetus to global strategies to eradicate poverty, protect the planet and ensure prosperity for all.

In this new paradigm, public policies and institutions are organized around an environmental big push that is transforming the production and consumption structure and pursuing the incorporation of technical progress, sustainability and equality. This situation offers the opportunity to create high-quality jobs, increase productivity (which would make social policies more sustainable) and strengthen universal minimum income systems, unemployment insurance and mechanisms to protect workers and reintegrate them into the labour market. A fair transition for the workforce towards sustainable economies and societies can thus be sought (ILO, 2011 and 2016; ECLAC, 2016).

III. The effects of climate change and environmental policy on employment: the need for a fair transition

Climate change has many effects on the labour market. The high frequency of extreme weather events affects urban employment, with damage to transport systems, infrastructure and settlements impairing workers' ability to switch or find employment, for example. Agriculture, tourism, insurance, forestry, fisheries, infrastructure and energy are some of the sectors most vulnerable to the direct effects of climate change, as they depend on the weather (ILO, 2010). The concept of vulnerability is closely associated with the lack of adaptation strategies, something that is common among the poorest.

Adaptation policies can initiate a virtuous circle that drives local employment: they prevent job losses by altering forms of production threatened by climate change, and they create jobs by preparing the country for climate change (particularly through infrastructure projects). Mitigation efforts aimed at reducing greenhouse gas (GHG) emissions change certain sectors of the economy, mainly those associated with fossil fuel energy production and those requiring a great deal of energy. The latter include the steel, iron and aluminium and road transport industries.

Changes in commercial standards also have an impact on employment, as growing consumer awareness can lead to shifts in consumption patterns and thus in labour markets. Another effect is the displacement of jobs because of carbon leakage, as the diversion of investments to territories where environmental standards are less stringent is termed. Climate change can also produce migratory flows from rural areas, where production capacity has been affected, to cities.

Environmental policy has clear effects on the production fabric, in some cases merging with green industrial policy. Indeed, some measures induce process innovations, with energy policy measures in particular seeking to transform the production structure to make it low-carbon, resource-efficient and more productive (Altenburg and Rodrik, 2017).

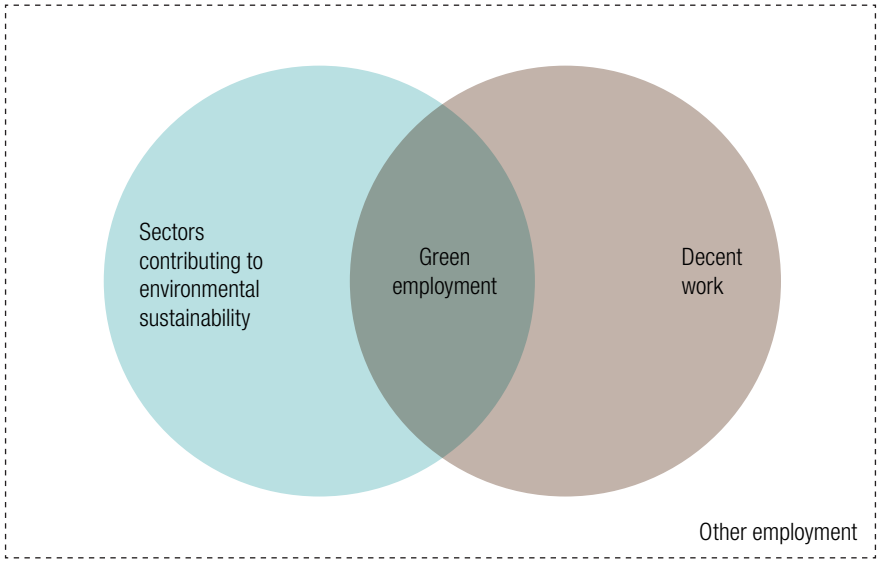
From the above, it is possible to say that the transition to a greener economy will affect employment in four ways: (i) jobs will be created in new emerging green sectors, such as renewable energies, where demand for goods and services is expanding; (ii) certain jobs will be destroyed and not directly replaced, for example because certain methods are banned or discouraged; (iii) some jobs will be replaced as a result of industrial transformation; and (iv) most of today's jobs will be transformed and redefined in accordance with the new working methods and profiles required (UNEP and others, 2008).

The above considerations clearly illustrate that these processes provide opportunities, but also carry major risks for some sectors of employment. The concept of a just transition, which originated in the trade union movement and has now been adopted by the specialized agencies of the United Nations and governments, posits that a shift to a greener economy must consider all the actors involved. Social dialogue must be at the heart of the process, and governments, besides regulating GHG emissions, must play the fundamental role of promoting the kind of industrial and social policies that lead to the creation of productive and decent employment (ILO, 2015).

IV. Green employment

In recent years, a number of policymakers, advocacy groups and researchers have held debates on the potential of climate policies to create green jobs. These are defined as jobs that, by meeting decent work standards, contribute to the preservation and restoration of the environment in traditional sectors, such as manufacturing and construction, or in new emerging sectors, such as renewable energy and energy efficiency (Jarvis, Varma and Ram, 2011). Diagram 1 illustrates this concept.

Diagram 1
Definition of green employment



Source: A. Jarvis, A. Varma and J. Ram, *Assessing Green Jobs Potential in Developing Countries: A Practitioner's Guide*, Geneva, International Labour Organization (ILO), 2011.

"Decent work" is a concept developed by ILO that establishes the characteristics an employment relationship must have for work to be carried out "in conditions of freedom, equity, security and human dignity". For work to be decent, workers must have: (1) productive jobs with a fair wage, (2) good working conditions, (3) social protection, (4) labour rights, (5) equal opportunities between genders and (6) a say in decisions which will affect their lives (ILO, 2012).

At the company level, green jobs may be in the production of goods or services that benefit the environment, such as water sanitation or reforestation. Again, firms may apply more environmentally friendly production processes without necessarily producing environmental goods or services, for example by reducing water consumption or improving their recycling systems. These are the jobs that reduce the environmental impact of companies and economic sectors, ultimately to sustainable levels (UNEP and others, 2008).

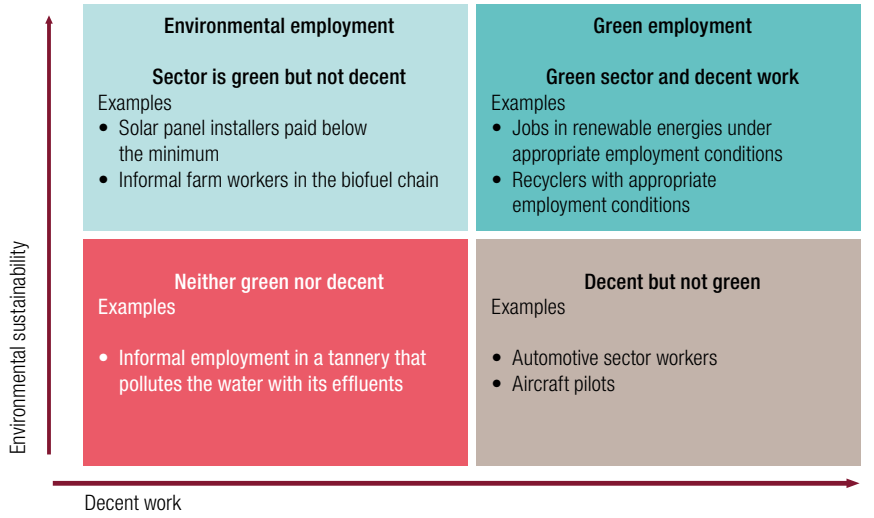
The universe of employment can be classified into four broad situations depending on whether the two attributes, decent work and environmental sustainability, are present.

Green employment, as already mentioned, meets the conditions of decent work and environmental sustainability (see diagram 2).

Environmental (non-green) employment is found in sectors that follow sustainable environmental practices but do not meet high enough labour standards for employment there to qualify as green. Examples of non-green environmental jobs are: informal and seasonal jobs and those carried out without the application of mandatory safety measures in some sectors of organic agriculture; the work of urban ragpickers and recyclers, when carried out under inappropriate conditions; and the work of informal workers who build small structures for better water management. This type of employment has immense potential to become green if productivity and working conditions are improved.

The remaining two situations are that of sectors where work is decent but environmental sustainability conditions are not met (lack of environmental policies) and that of sectors where both labour and environmental conditions are inadequate.

Diagram 2
The relationship between decent work and environmental sustainability



Source: A. Jarvis, A. Varma and J. Ram, *Assessing Green Jobs Potential in Developing Countries: A Practitioner's Guide*, Geneva, International Labour Organization (ILO), 2011.

While the definition of green employment used by the International Labour Organization (ILO) and the United Nations Environment Programme (UNEP) is widely accepted, there is much debate about how to apply it in practice. Should green employment be estimated at the occupational, enterprise or sector level? Should it be restricted to industries that produce environmental goods and services, or should it be extended to other sectors of the production fabric that follow good environmental practices? Should direct employment or all employment generated in the value chains of green sectors be considered? These are the main points at issue.

Some studies focus on occupations that have a clearly environmental objective (Keivani and others, 2010). However, these can be difficult to identify when they are traditional occupations performed in environmental activities (a metallurgy worker producing turbines for wind power). Other studies focus on production activities, restricting green employment to the environmental goods and services industry or, if they set out from the logic of greening the production fabric, including subsectors and companies that follow good environmental practices in traditional sectors (OECD/Eurostat, 1999; UNEP and others, 2008).

The focus on occupations offers great advantages, as it makes it possible to quantify the green jobs created in brown sectors, most of which (constrained by regulations or the markets) are making great efforts to improve their environmental performance. It thus seems to be the most appropriate criterion. However, it requires methodological efforts and sources of information on occupations that are not usually available.

Following the methodology proposed by the ILO Green Jobs Programme (Jarvis, Varma and Ram, 2011), the best match for the information sources available, green employment in Argentina was estimated by sector and company. This aspect is discussed in detail in the annex.

For this reason, the estimate for Argentina underestimates total green employment, as it does not include green occupations in brown sectors because of the impossibility of quantifying them from the information sources available.

1. Green employment in Argentina: sectoral patterns and implications for employment quality

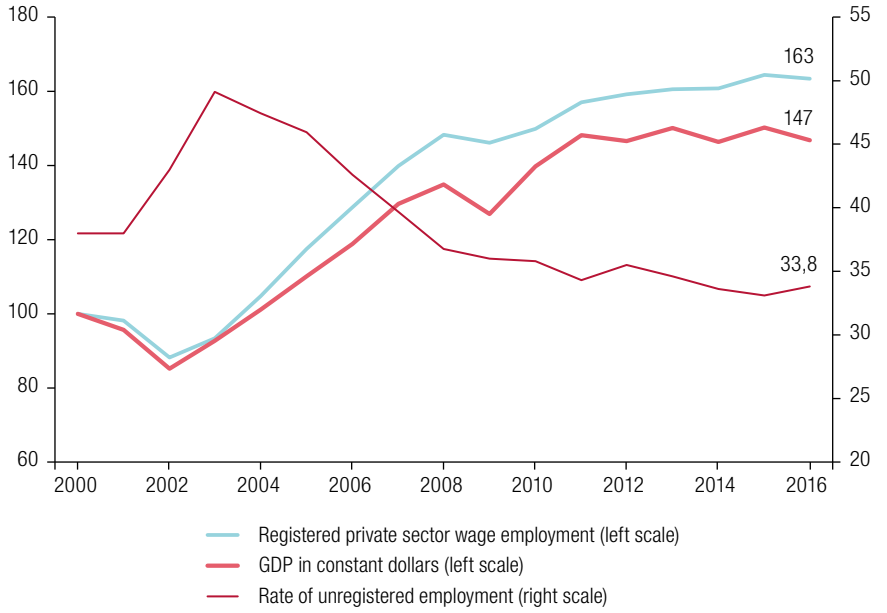
With gross domestic product (GDP) of US$ 546 billion (2016), Argentina is one of the largest economies in Latin America. It has abundant natural resources in energy and agriculture, is a leader in food production and has opportunities in some manufacturing subsectors and in innovative high-technology services.

In 2016, agriculture, livestock, forestry and fisheries accounted for 9% of GDP and manufacturing for 21% (of which food and beverages accounted for 25%). The population was 44 million, with an unemployment rate of 8.5%[1] and an underemployment rate of 10%. Informal employment (the proportion of unregistered wage earners) was 33.8% (MTEySS, n/d a).

During the last 15 years, Argentina has gone through a process of economic growth driven by the primary and industrial sectors that has brought more people into the consumer market, mainly through formal employment. The institutional framework, being characterized by policies aimed at promoting the formalization of employment, social dialogue and the consolidation of the minimum, living and mobile wages and collective bargaining, helped ensure that this stage of economic growth would be accompanied by a process of social inclusion (Bertranou and Casanova, 2013). Indeed, registered wage employment increased by 63% between 2000 and 2016, outstripping GDP growth in constant money terms (47%), partly owing to the creation of new jobs and the formalization of unregistered jobs (see figure 1).

[1] Third quarter of 2016.

Figure 1
Gross domestic product (GDP), registered private sector wage employment and rate of unregistered employment, 2000–2016
(Index: 2000=100)



Source: Prepared by the authors, on the basis of the Permanent Household Survey of the National Institute of Statistics and Censuses (INDEC) and information from the Ministry of Labour, Employment and Social Security (MTEySS).

The strength and type of growth, driven by the expansion of agricultural and manufacturing activities, also had adverse environmental consequences. Perhaps the main problem was the deforestation that took place in the north of the country because of the advance of the agricultural frontier. In 2014, 39.6% of greenhouse gas emissions came from energy production, followed by agriculture and livestock (26.9%) and land use change and forestry (25.7%). Although to a lesser extent, waste management (4.4%) and industrial processes (3.3%) also generated GHGs (SAyDS, 2015).

The loss of huge tracts of forest not only increased GHG emissions but also contributed to an increase in the frequency and intensity of the floods that affect people year after year (FAO, 2014; World Bank, 2016). Air pollution, waste management and water pollution have also become serious problems, particularly in urban centres (World Bank, 2016).

Since 2000, increasing efforts have been made to bring about a transition towards more environmentally sustainable growth paths, in the form of both public policies and private initiatives, often prompted by the requirements of export markets. Among these efforts, mention can be made of Law No. 25675, known as the General Environment Act (2002), which establishes the minimum prerequisites for achieving sustainable and appropriate management of the environment and encompasses different sectoral regimes. The result of these efforts has been lesser growth in GHG emissions (0.4%) than in GDP (2.8%), considering average annual rates for the period 2000–2014. This process has become more evident since 2009, when emissions fell (in a context of stagnant GDP), mainly owing to a slower rate of deforestation, falling livestock production and reduced emissions in the energy sector.

Efforts towards greater environmental sustainability have intensified since the change of government in 2016. A more active energy policy has been adopted, energy and fuel price subsidies have been cut and investment in renewable energy sources has been encouraged (RenovAr Programme). The implementation of flood prevention infrastructure works and the development of disaster monitoring

systems (National Water Plan) are reducing the vulnerability of vast sectors of the population while creating green jobs. An effort is also being made to improve the environmental efficiency of the urban passenger transport system by expanding metro networks and urban infrastructure.

The transition to more socially and environmentally sustainable growth patterns is creating new activities and occupations in addition to the traditional ones. Many of these jobs are considered green, i.e. decent work in environmentally sustainable activities.

2. The sectoral configuration of green employment

Green jobs are found in practically all sectors of the Argentine economy. Some sectors are considered green by definition, such as sanitation and environmental protection, while in the rest of the production fabric green jobs are found in activities involving sustainable environmental practices, such as organic agriculture, energy-efficient industrial processes and research activities focused on environmental issues.[2]

It is estimated that there were between 486,000 and 650,000 green jobs in Argentina in 2015, representing 4% and 7% of registered wage earners, respectively. The difference between the two estimates depends on whether or not employment in public road passenger transport is considered green.

It should be noted that this estimate does not include environmental jobs in the informal sector of the economy, which are not considered green because of poor working conditions. The challenge for this type of employment is to improve productivity and guarantee access to labour rights.

Registered employees in "non-green" sectors and enterprises are shown in table 1. It was not possible to quantify green employment within these non-green enterprises from the sources available, so there is an underestimation bias.

Table 1
Argentina: sectoral composition of green employment, two estimation hypotheses, 2015

	Registered employees 2015		Green employment (broad estimate[a])			Green employment (narrow estimate[b])		
	thousands	*percentage of total*	*thousands*	*percentage of total*	*percentage of sector*	*thousands*	*percentage of total*	*percentage of sector*
Agriculture, livestock, forestry and fisheries	366	4	58	9	16	58	12	16
Agriculture, livestock, hunting and allied services	341	3	53	8	16	53	11	16
Forestry and timber extraction	11	0	3	1	30	3	1	30
Fisheries and aquaculture	15	0	2	0	11	2	0	11
Mining and quarrying	97	1	-	0	0	-	0	0
Manufacturing	1 274	13	245	38	19	245	50	19
Supply of electricity, gas, steam and air conditioning	71	1	11	2	15	11	2	15
Supply of water, removal of waste water, waste management	59	1	48	7	83	48	10	83
Construction	475	5	23	3	5	23	5	5
Transport and storage	476	5	188	29	39	24	5	5
Accommodation and catering activities	278	3	16	2	6	16	3	6
Commerce and other personal and business services not analysed	6 844	69	62	10	1	62	13	1
Total	9 939	100	650	100	7	486	100	5

Source: Prepared by the authors, on the basis of International Labour Organization (ILO), *Estimación del empleo verde en Argentina*, Buenos Aires, 2017.

[a] Includes employment in road passenger transport.

[b] Excludes employment in road passenger transport.

[2] The methodological aspects of estimating green employment in Argentina are detailed in the annex to this article.

Taking the larger estimate (650,000), most green jobs are in manufacturing (38%), transport (29%), the agriculture, livestock, forestry and fisheries sector (9%) and water supply and waste management (7%). Services and commerce linked to environmental protection account for 10%. On the narrower estimation hypothesis (486,000), the relative importance of sectors changes, with manufacturing (50%) and agriculture, livestock, forestry and fisheries (12%) even more to the fore (ILO, 2017).

To expedite the analysis, economic activities were then organized into four main groups or subsystems by the central issues common to them: (i) the exploitation of renewable resources, (ii) the production of energy and fuels, (iii) manufacturing and (iv) urban systems. The sectoral analysis presented below is based on Estimación del empleo verde en Argentina (ILO, 2017).

(a) Exploitation of renewable resources

The first subsystem that will be analysed is the exploitation of renewable resources, comprising agriculture, livestock, fisheries and forestry. In 2015, these activities represented 9% of GDP, 7% of formal employment and 23% of Argentina's exports. If agro-industrial linkages are considered, the incidence of the primary sector in the national economy is even greater (Rodríguez, 2005). They also contribute greatly to the subsistence of poor rural populations, this being particularly the case with fisheries, forestry and small-scale agriculture. Employment conditions for workers in these sectors tend to be worse than the average for the economy: work is informal and not permanent (temporary and seasonal), and occupational hazards are greater than in other activities (Ohaco, 2012; CIFRA, 2011).

Alongside organic agriculture and livestock husbandry, technology-based conservation practices are among the good environmental practices of the agricultural sector, mainly in the form of precision agriculture, control of erosion by means of no till systems and control of soil and water pollution and the impact on biodiversity. Mention should also be made of waste management, with waste increasingly being used for energy production (Viglizzo and Frank, 2010; World Bank, 2016).

Meanwhile, the protection of forests and fishing resources requires the development of appropriate governance regimes and the institutions to implement them. Argentina has a highly sophisticated resource management model for both resources that creates a significant number of green public and private sector jobs in monitoring and oversight. In addition, producers oriented towards the external market use special seals of quality that certify good environmental practices.

Three strategies are used to identify producers following good environmental practices in these sectors. In the export sector, good agricultural, forestry and fisheries practices are identified by specific seals certifying them, mainly GlobalG.A.P. (Good Agricultural Practice), RTRS (Roundtable on Responsible Soy), FSC (Forest Stewardship Council) and MSC (Marine Stewardship Council).

This type of certification, which usually has a high cost for the producer, is not yet generally required in Argentina's domestic market. Producers oriented towards the domestic market who follow good agricultural practices join producer associations that are recognized for their strong environmental commitment, such as the Rural Change Programme, the Argentine No Till Farmers Association (AAPRESID) and the Argentine Association of Regional Consortiums for Agricultural Experimentation (AACREA).

The third strategy concerns highly regulated activities that require technicians and professionals with green jobs.

The livestock subsector provides some 58,000 green jobs, representing 16% of formal employees. While 15% of jobs associated with row crops (cereals, oilseeds, vegetables and industrial crops such as sugar cane and cotton) are green, the incidence of green employment is higher for permanent crops (mainly fruit), at 38%. Just 7% of formal employment in the livestock subsector is green.

The forestry sector employs 3,300 workers in green jobs (34% of formal employment in the sector), engaged in production activities or technical or professional roles. In the fisheries sector, the number of green jobs is estimated at about 1,500, representing 21% of formal employment. There are a further 2,400 or so public sector employees in green jobs in the fishing sector, responsible for managing its regulatory framework.

(b) Energy and fuel production

Argentina's energy mix is currently dominated by fossil fuels: 53% of energy comes from natural gas and 33% from oil. The share of coal is very low, and renewable energies represent 10% of the primary supply (Ministry of Energy and Mining, 2016a). Although the production of renewable energy is still an incipient activity in Argentina, the high share of gas makes the energy sector relatively "clean" in comparison with other economies in the region. However, Argentina's energy sector presents problems of security in resource availability (connected to this dependence on gas and oil), as well as socioeconomic problems (some sections of the population do not have access to energy from the grid because of the country's size) and environmental problems (natural gas is the main generator of greenhouse gases) (SAyDS, 2015).

The development of renewable energy sources has been a priority area for policy in recent years. The country is seeking to diversify its energy supply and improve energy efficiency through various measures, such as reductions in consumer subsidies, incentives for investment in renewable sources (such as the cutting law requiring traditional fuels to contain a percentage of biofuels, the RenovAr programme and the PROBIOMASA programme) and programmes facilitating access to energy services for rural populations.

In 2015, there were an estimated 10,000 green jobs in small hydro (22%), wind and solar power plants and in sectors linked to bioenergy production, such as biodiesel and bioethanol (46%) and other forms of biomass (24%).

(c) Manufacturing

Manufacturing is a diversified sector in Argentina and accounts for a large share of GDP (21%).[3] It includes agro-industries that supply the whole of the country's domestic demand and are a major component of exports. In addition, it comprises a variety of activities ranging from the production of textiles, metallurgical products, paper, the pharmaceutical sector, chemicals and petrochemicals, aluminium, steel and automobiles to the development of biotechnology applications, medical instruments and nuclear and space products.

A characteristic of Argentina's manufacturing sector is its great heterogeneity of production methods, with technology gaps, productivity gaps and agents of different sizes, among other things. It thus generates jobs with unequal working conditions in aspects such as pay, the degree of informality and job opportunities for women (Infante and Gerstenfeld, 2013). Manufacturing industry employed some 2.4 million people as of 2015, of whom 79% were wage earners, with 69% of these in turn being registered.

This heterogeneity is also reflected in environmental performance: segments with low productivity that cannot afford adequate conditions of employment for their workers cannot afford appropriate environmental practices eith12er.

[3] Value added in 2015, at 2004 prices.

Both dimensions, the productivity gap and the type of sector, are relevant to an understanding of environmental performance. Manufacturing industry includes subsectors whose production processes negatively affect the environment, especially through GHG emissions and water pollution, as well as groups of companies striving to move towards more sustainable modes of production (SAyDS, 2015).

Predominant among good environmental practices in industry are actions aimed at using cleaner technologies and optimizing costs. Some of the most widely followed practices are the use of alternative fuels and recycled materials (paper and cardboard, aluminium, iron and steel, glass and plastics) and product life cycle analysis (SAyDS, 2015; Stumpo and Rivas, 2013). Demand from export markets plays a significant role, prompting the incorporation of clean technologies and new environmental management criteria by local producers. These requirements take the form of quality certifications with environmental content, such as organic product certifications, ISO 14000 and eco-labelling.

On the other hand, the environmental performance of industry does not seem to have been a central issue on the political agenda in recent decades. Indeed, among the good environmental practices of the sector, the treatment of effluents, emissions and waste seems to be less prevalent.

Argentina also produces numerous goods for environmental use, defined according to the criteria of the Organization for Economic Cooperation and Development (OECD) (Sugathan, 2013). Many of these goods form part of renewable energy value chains and are the subject of policies in a production development strategy with elements of a "green industrial policy" (INTI, 2013; SAyDS, 2015).

Green jobs in manufacturing are estimated at 245,000 (19% of formal employees in the sector). This figure comprises both jobs linked to the production of goods for environmental use and jobs in companies that follow good environmental practices. A significant percentage are involved in the production of food and beverages in agro-industrial value chains that are environmentally certified during the primary stage (ILO, 2017).

(d) Urban systems

The fourth subsystem covers urban activities: waste management, water sanitation, transport and construction. Tourism is also included in this group because, although ecotourism is rural, most tourism activities in Argentina (hotels, restaurants and other services) are in urban areas.

Economic growth and access to consumption by increasingly large social groups are generating greater demand for urban systems. In Argentina, 92% of the population is urban (INDEC, 2010). Consequently, the coverage and quality of these systems have a significant impact on citizens' quality of life and the competitiveness of the economy.

The country's long distances and low population density make transport a key service both for competitiveness and for people's quality of life. From an environmental perspective, the sector is very heterogeneous. Automotive transport (freight and passenger) is one of the activities generating most pollution (GHGs, noise, congestion, accidents), to the point where it is a constraint on the sustainability of cities, while rail and water transport are more sustainable alternatives.

Two estimates of green employment were carried out for this sector, reflecting the debate on the environmental performance of public passenger transport (although a major source of emissions, it represents a significant reduction in GHG emissions when compared to private motor transport). The first mode accounts for 13% of transport sector emissions and the second for 79% (SAyDS, 2015). Thus, on a broad perspective, there are some 187,000 green jobs in the transport sector, equivalent to 29% of registered employees. The proposed subsectors are rail, maritime and river, public passenger road transport and the underground system. On a narrow perspective, it is estimated that green jobs in the sector represent only 5% of registered employees.

The coverage and quality of services in Argentina's sanitation and waste management systems need to increase: drinking water coverage extends to 83% of the population, 91% of households (urban and rural) have a regular waste collection service (only 64.7% of waste is properly disposed of) and 49% of the population has sewage coverage (INDEC, 2010). Inappropriate final disposal of waste has negative effects on the air and water. The sector emits 4.4% of GHGs (SAyDS, 2015).

Construction emits large quantities of GHGs because its ecological footprint extends throughout the value chain. The country has not yet designed a strategy to promote mass construction of sustainable housing. In addition, there seems to be insufficient infrastructure to mitigate the effects of climate change.

The quality of employment in the activities making up urban systems is generally lower than the average for the economy. Construction, waste management, some transport subsectors and tourism have high rates of informality, poor working conditions and low skill requirements. In these activities, it is common to find contrasting situations: on the one hand, a formal subsector with pay and health coverage that is better than the average for the economy and, on the other, an informal subsector that operates in situations of extreme poverty.

Waste management and sanitation activities have created some 48,000 green jobs representing 83% of formal employment in the sector. In addition, the construction sector has created some 22,000 green jobs (equivalent to about 4% of registered employees in the sector) in five activities: the construction of green buildings, water infrastructure works, renewable energy infrastructure works, the installation of solar thermal energy equipment and professional services activities.

Tourism has the same environmental problems as other activities in the urban system: waste and water management and congestion seem to be the main negative environmental externalities associated with it. The main green activities in the sector are: the good environmental practices of some hotels and tourism agencies; activities carried out in protected areas, ecotourism and adventure tourism; the services of botanical gardens; the management of national parks; the maintenance of green spaces; and library and museum services. In addition, cultural and recreational activities such as theatre, entertainment and amusement park activities should be included when sustainably managed. Tourism provides some 16,000 green jobs (representing only 6% of the sector's formal wage earners).

While not exclusively associated with any particular economic sector, there is a large set of business services that create green jobs (62,000). This set is partly made up of regulatory and enforcement bodies (28,000 jobs), activities associated with technical testing and institutions investigating environmental issues (9,000 jobs), the trade in recycled materials (5,000 jobs) and trade unions and employers' organizations (4,000 jobs) (ILO, 2017).

3. Green employment quality

Under the methodology used to estimate it, as mentioned, green employment in Argentina is the percentage of formal wage employment, i.e. decent work, carried out in sectors that contribute to environmental sustainability. This means that it meets certain quality standards.

Because of its sectoral specialization, however (green employment is overrepresented in goods-producing sectors and among providers of some very specific services, such as sanitation and transport), green employment has characteristics that differentiate it from the jobs of other registered employees. To analyse these differences, some variables available from the Employment and Business Dynamics Observatory (OEDE) in 2015 were considered: remuneration, the qualifications required for the job and the percentages of men and women (see figure 2).[4]

[4] The high level of sectoral disaggregation meant that it was not possible to carry out this analysis on the basis of the Permanent Household Survey.

With respect to the first variable, it is observed that pay is 20% higher for green jobs than for other types of registered employment. Because of their sectoral specialization, green jobs are few and far between in lower-paid sectors such as commerce, construction and services such as education.

The second variable has to do with occupations. Most green jobs are held by workers with intermediate skills. A smaller percentage require unskilled or highly skilled workers. In fact, 58% of green jobs are done by craft and related trade workers, which is almost twice the percentage of workers with intermediate skills in total formal employment (30%). At the same time, only 6% of green jobs require technical or higher qualifications, whereas this category constitutes approximately 13% of total registered wage employment.

With respect to the third variable, only about 13% of green employment is female (women represent 39% of total formal employment). Because the manufacturing, transport and agricultural sectors are so heavily represented, a large percentage of green jobs are held by men. However, public sector green employment tends to make up the difference, adding women. People aged under 25 account for 11% of green employment (young people account for 13% of total registered wage employment) and play a very important role in the agricultural, construction and tourism sectors.

Figure 2
Argentina: characteristics of green employment and total registered wage employment, 2015
(Percentages)

Source: Prepared by the authors, on the basis of Ministry of Labour, Employment and Social Security (MTEySS).

Opportunities to create better-quality green jobs are found in activities that incorporate more knowledge and technological complexity. Thus, the best-paid green jobs are associated with the production of renewable energy, manufacturing industry (particularly the most technology-intensive branches) and professional services. These activities also employ more women and a higher percentage of workers with technical or higher qualifications (see table 2).

Remuneration for green jobs in the food and beverage production sector is also above average (although highly competitive in Argentina, this sector is included in the low technology intensity category by the Organization for Economic Cooperation and Development (OECD)).

Table 2
Argentina: characteristics of green employment by subsystem

	Distribution of employment *(percentages)*	Remuneration	Percentages of workers		
			Technical or higher qualifications	Female	Young
(i) Exploitation of renewable resources		9 206	2	16	22
(ii) Energy and fuels		39 907	16	15	5
(iii) Manufacturing industry[a]	100	22 529	7	13	11
Low technology intensity	32	24 156	7	16	12
Medium-low technology intensity	14	15 088	7	8	13
Medium-high technology intensity	50	23 335	6	11	10
High technology intensity	4	25 152	24	26	10
(iv) Urban systems	100	20 124	4	10	9
Professional services	11	22 376	21	33	9
Other	99	19 947	4	10	9
Total		20 255	6	13	11

Source: Prepared by the authors, on the basis of Ministry of Labour, Employment and Social Security (MTEySS).
[a] The Organization for Economic Cooperation and Development (OECD) classification of technology intensity is employed.

The data indicate that green jobs may have better conditions of employment than other formal sector jobs and that this is particularly the case when firms are in technology-intensive and knowledge-intensive sectors. Higher productivity levels make it possible to afford better pay, more job promotion opportunities (the percentage of highly skilled workers is higher) and more women in employment.

V. Public policies and green employment: some aspects of the Argentine experience

The creation of green jobs largely hinges on the ability to formulate coordinated and effective public policies aimed at improving the environmental sustainability of some sectors and the quality of employment in others. Such policies should also aim at anticipating and mitigating possible unintended effects on employment.

This requires a high degree of integration, consistency and coordination between institutions and the initiatives undertaken (Lerda, Acquatella and Gómez, 2005), attributes that are often not present in the Argentine context (Rezk, 2005). Environmental issues have moved up the Argentine political agenda in the last 25 years, thanks to which there have been major advances in the country's regulatory framework. However, the transition to a green and inclusive economy is not yet part of national employment policy, and the institutional framework continues to present shortcomings in terms of coordination.

Some aspects of environmental policy in Argentina are presented below, with particular emphasis on initiatives that contribute to the creation of high-quality jobs and the transition to a green economy.

VI. The importance of environmental issues on the political agenda and the development of the regulatory framework

The constitutional reform of 1994 shaped the current structure of environmental responsibilities. The national authorities were given the power to legislate on minimum standards, while the right to delineate the legislative development of the resulting statutes by regulating and supplementing them was reserved for the provinces. Although consistent with the federal nature of the country and its heterogeneous territorial context, the legislative overlap in the federal regulatory framework can create ambiguous situations and slow down its application (Ábalos, 2011). Particularly in interdisciplinary and cross-cutting areas such as the environment, vertical and horizontal coordination problems are common (Rezk, 2005). An emblematic example is Law No. 26418/2010 on minimum standards for the protection of glaciers. Provincial governments, concerned about the restrictions the law places on economic activities around glaciers, introduced provincial legislation in an assertion of regulatory authority on the issue.

Although environmental issues have become more prominent in Argentina, there is still a tendency not to prioritize them when designing policy. This is reflected in the national budget allocated to green activities in 2016: for every peso allocated to the environment, 16 pesos were invested in activities with negative environmental impacts (brown activities) (Di Paola, 2017).

Environmental initiatives are often pursued in response to complex environmental situations and not as a result of strategic and preventive planning (CEMA, 2015). This is the case with the laws on watershed management, which arose in response to flooding and the "battle of Gualeguaychú" against the construction of paper mills. Furthermore, the importance of responsible consumption is only beginning to be recognized locally, and when products are environmentally certified it is often to meet the demands of foreign trade.

The low priority given to environmental issues in policy design is also seen at the stages of implementing and monitoring measures. An example is the partial application in the province of Buenos Aires of the law on thermal insulation of buildings,[5] owing to the lack of an effective oversight and monitoring system (Vagge and Czajkowski, 2012). The passivity of consumers, who show no interest whatsoever in demanding compliance with standards, is worth noting, as it reveals how little of a factor responsible consumption is in the country.

VII. Coordination between production, labour and environmental policies: energy

Perhaps because of the low priority given to environmental issues on the public agenda, environmental, production and labour policies have not been properly coordinated. Production development policies are the most established, and these do not generally contain a strong commitment to environmental issues. In recent years, however, good practices have been observed in all three policy agendas, particularly the "green production development policy" agendas.

The most important example belongs to the area of renewable energies. With Law No. 27191[6] of 2015, the Government of Argentina evinced a determination to diversify the country's energy supply

[5] Law No. 13059, enacted in 2010.

[6] National Incentive Regime for the Use of Renewable Sources of Energy for Electricity Production. The aim is for 20% of the country's electricity consumption to be met from the various types of renewable energy by 2025.

by making new investments in renewable energies with a view to moving the country away from dependence on fossil fuels and promoting job creation. The expansion of renewable energies generates direct employment in rural areas that, although rich in renewable natural resources, are characterized by a lack of job opportunities for their inhabitants. The expansion of these technologies in rural areas brings benefits to the whole community: the construction of new infrastructures or the improvement of existing ones gives rise to new SMEs and generates clusters of knowledge for local development. A number of programmes are being created within this framework, notably the RenovAr plan, which is expected to reduce annual carbon emissions by 2 million tonnes, saving US$ 300 million in fuel and generating 5,000 to 8,000 direct and indirect jobs (Ministry of Energy and Mining, 2016b).

Argentina is also developing energy policies with specific social goals. The PERMER programme, for example, seeks to install wind or solar power generation systems in rural and remote areas that do not have adequate energy, hot water, heating or cooking facilities. The project is a valuable public policy instrument that integrates economic, social and environmental objectives. Another example is the Law for the Promotion and Development of Solar Energy in Jujuy,[7] which not only establishes a sustainable energy policy but emphasizes that investment helps to reduce poverty and mitigate the effects of climate change. The law gives special priority to ventures that contribute qualitatively and quantitatively to the development of Jujuy's workforce and strengthen the development chain of local suppliers.[8]

VIII. The preparation of prospective studies and formalization of the green economy concept

The strategic planning and direction of environmental policies that are integrated with production development and the creation of decent work and are capable of fostering sustainable development requires effective diagnostic studies to be carried out. The prospective studies conducted by the Ministry of Science and Technology, which have been extensively debated at the national and local levels, are a case in point.

Two emblematic cases are: (1) the Pampa Azul initiative, which has the twofold objective of exploring marine frontiers and their potential for marine energy generation and effectively monitoring fishing activities, and (2) the development of the bioeconomy in Argentina.[9] The latter initiative has the potential to encompass numerous interconnected value chains: all agricultural, forestry, fisheries and aquaculture activities, the food and beverage industries and the pulp and paper industries, as well as certain segments of the chemical, pharmaceutical, cosmetics, textile and energy industries (Trigo, 2005). Both studies are contributing considerably to the design of industrial and development policies that are taking on a bioeconomic perspective and boosting employment in high-productivity sectors.

Lastly, although at the national level there are no public sector initiatives that specifically bear on the concepts of the green economy or green employment (Alzari, 2017), some local authorities, such as those of the Autonomous City of Buenos Aires and Santa Fe, do make explicit reference to these concepts. In Buenos Aires, the green economy is an active and specific area of work, and the city authorities recognize and use the concept of green employment formulated by ILO. Law No. 1854/05, for example, not only prescribes a set of measures aimed at efficient and sustainable waste management, but also formalizes urban ragpickers and includes them in a single mandatory register. So far, 12 cooperatives

[7] Law No. 5904, enacted in 2016.

[8] Art. 18, Law No. 5904 (Province of Jujuy), San Salvador de Jujuy, 25 January 2016.

[9] See [online] http://www.mincyt.gob.ar/accion/pampa-azul-9926; http://www.bioeconomia.mincyt.gob.ar.

and more than 5,300 ragpickers have been formalized in Buenos Aires.[10] Integrating these concepts into the national regulatory framework could be a valuable tool for inclusive and sustainable growth.

IX. Final reflections

The transition to a green economy is a process Argentina has no choice but to embark on. Adaptation efforts to reduce the country's vulnerability to the effects of climate change, the commitments made to mitigate these effects and society's growing awareness of the importance of following inclusive development paths that respect the environment are factors driving this process.

The challenge of moving towards a green economy and at the same time generating decent work for people requires strong synergy between environmental, economic and industrial policies, as well as labour policies. The goal of a sustainable economy requires a shift in the production model towards smarter and more innovative, efficient and competitive configurations.

The transition presents opportunities for the creation of new high-quality jobs that the country can capitalize on if it implements the right policies, but also challenges for some sectors that will have to be transformed, leading to job losses. Labour and social protection policies must provide support in this process.

Argentina's experience shows that green jobs are the product of society's efforts towards sustainable development. In 2015, 7% of registered wage-paying jobs in the country were green. Although found in all sectors of the economy, they predominated in goods-producing activities and in specific urban services, such as sanitation and transport. Regulations, public policies and foreign trade requirements seem to be the main factors driving the creation of this type of employment, while responsible consumption does not yet play the key role it does elsewhere. In these jobs, on average, workers have better employment conditions than other registered employees (although there is less female employment), and these conditions are better in subsectors that incorporate a broader array of knowledge.

These results show that the transition to a green economy offers opportunities for the creation of high-quality jobs and that developing managerial, institutional and productive capabilities is crucial if they are to be capitalized on.

For the transition to a green economy to be fair, then, public policies must consider the employment dimension, and this can set in motion a virtuous circle leading to a more environmentally friendly, productive and socially inclusive economy.

[10] See [online] http://www.buenosaires.gob.ar/ciudadverde/separacion/separacion-en-origen/cooperativas-de-recuperadores-urbanos.

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Annex A1

Methodology for estimating green employment in Argentina

This annex summarizes the main aspects of the methodological chapter of the study *Estimación del empleo verde en Argentina* (ILO, 2017), which provides the framework for this article.

1. Definition of green employment in Argentina

Green employment is that generated in a green economy, simultaneously encompassing the economic, social and environmental dimensions. To be included in this category, jobs must be in environmentally sustainable sectors and meet the standards for decent work, a concept defined by ILO that establishes the characteristics an employment relationship must have for work to be carried out "in conditions of freedom, equity, security and human dignity" (ILO, 2012).

2. Estimation strategy

The methodology used to estimate green employment in Argentina was taken from the manual *Assessing Green Jobs Potential in Developing Countries: A Practitioner's Guide* (Jarvis, Varma and Ram, 2011). Using a mixed approach, various techniques were employed, such as the collection of statistical and qualitative information from key informant interviews and the analysis of quantitative data from different sources.

The process was implemented in three major stages. The first stage was to analyse the links between the production, environmental and labour dimensions throughout the economy by means of an exhaustive analysis of the literature and environmental and labour regulations, and of the key informant interviews. Second, the sectors, subsectors and groups of companies following good environmental practices were estimated and labour conditions were analysed. The third stage was to validate the results obtained in workshops and meetings with sectoral representatives, following the tripartite logic of ILO.

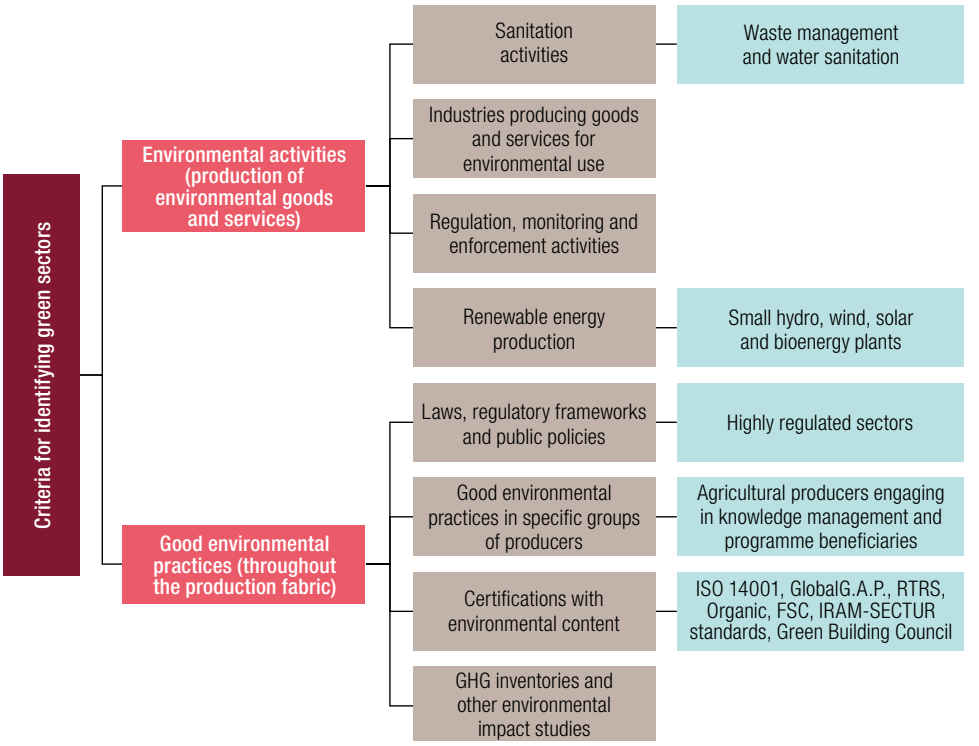
3. Criteria for identifying green sectors

In the study on Argentina, two key criteria were followed to identify green sectors: (i) activities that produce environmental goods and services and (ii) companies that follow good environmental practices in different sectors of the production structure.

Activities producing environmental goods and services were identified from international experience (OECD/Eurostat, 1999; OECD, 2017; Eurostat, 2009; UNEP and others, 2008). These activities were evaluated locally before being deemed green in the case of Argentina.

Some criteria for determining whether activities are green fall outside the logic of production sectors and show how much heterogeneity there can be within a given branch of activity or region at any particular time, with some producers making efforts to introduce more environmentally sustainable methods and others not. Diagram A1.1 summarizes these criteria.

Diagram A1.1
Criteria for identifying green sectors



Source: Prepared by the authors.

4. Decent work

To identify decent work in the study on Argentina, wage employment contributing to the social security system was taken as a proxy variable. The union membership rate in Argentina is high. The country has a minimum, living and mobile wage policy and active collective bargaining to update the basics of the agreements. However, the benefits largely accrue to registered wage earners. Female employment in the branch was also analysed as a way of considering the extent of decent work associated with the creation of job opportunities for different worker profiles.

5. Unit of analysis

All employment that meets decent work standards and is carried out in environmentally sustainable companies is considered green. The study is not able to disaggregate “green occupations”.

6. Information sources

The main source used to estimate employment was the Employment and Business Dynamics Observatory (OEDE). Employment conditions were evaluated mainly on the basis of the Permanent Household Survey conducted by the National Institute of Statistics and Censuses (INDEC), the Survey of Workers conducted by the Ministry of Labour and the system of accident indicators operated by the Superintendency of Occupational Risks (SRT).

Income elasticities and inequality of poverty in urban and rural areas of the Brazilian states: a spatial approach

Helson Gomes de Souza, Francisco José Silva Tabosa and Jair Andrade Araújo

Abstract

This study sets out to obtain values for the income elasticities and inequality of poverty in urban and rural areas of the Brazilian states. A panel data methodology capable of capturing spatial effects via a spatial lag model is used to identify whether there are spatial spillovers of poverty in the census situations studied. Changes in growth and inequality lead to spatial spillovers in the proportion of poor people in Brazil's urban areas, but this does not happen at all in rural areas. By demonstrating the existence of spatial spillovers in urban areas, the study shows that anti-poverty measures for these areas should be applied at the national level. In rural areas, the absence of spatial spillovers in the proportion of poor people means that public policies to combat rural poverty can be implemented at both state and national levels.

Keywords

Income, poverty, income distribution, poverty mitigation, rural areas, urban areas, econometric models, economic growth, Brazil

JEL classification

O15, I30, I32

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I. Introduction

Poverty is a persistent phenomenon in practically all countries, differing only in intensity. It exposes the social class suffering from it to a situation of extreme social exclusion, leading to deprivation of basic social rights.

In Brazil, as in most Latin American countries, the number of people living in poverty has historically been high. However, the situation has steadily improved, especially in the 1990s and 2000s. According to Barros (2009), the extremely poor made up almost a quarter of the Brazilian population in the mid-1970s and the situation worsened in the following 10 years. The economic stability of the 1990s, coupled with the growth that began then, resulted in a substantial reduction in the number of poor, so that by 2008 extreme poverty affected only about 8.8% of the population.

The main causes that can be adduced for the decline in the proportion of poor people in Brazil include the pace of economic growth and its impact on the country's socioeconomic dynamics. Barros, Foguel and Ulyssea (2007) show that economic growth was responsible for reducing extreme poverty by 0.7 percentage points annually as of mid-2003, rising to 1.6 percentage points by mid-2006.

Hoffmann (2001) argued that economic growth had considerably reduced poverty in Brazil, but emphasized that in most parts of the country the reduction in inequality had taken the form of an emergency exit from poverty. He also stated that unsustainable growth conjoined with an environment of instability tended to exacerbate inequality, leading to an increase in poverty.

It is a fact that the improvement in Brazilian socioeconomic indicators has been largely driven by economic growth. By way of comparison, income concentration worsened in many developed and developing countries between 1990 and 2000. Drawing on data from the World Bank and the Organization for Economic Cooperation and Development (OECD), Ramos (2015) notes this and points out that while some countries such as China and Sweden recorded high growth rates, these rates were accompanied by an increase in inequality. However, the percentage of poor people fell much more significantly in those countries. In the case of Brazil, the growth rates achieved did bring down poverty across the board, while inequality levels also declined (Ramos, 2015).

However, poverty and inequality display different characteristics when viewed from the perspective of people's census situation. For Ney and Hoffmann (2009), poverty is greater in rural Brazil than in urban areas. The authors point out that factors such as poor distribution of agricultural production resources, low education levels, low pay and ineffective social policies can aggravate poverty in these areas.

Ney and Hoffmann (2009) also show that the heavy concentration of land ownership makes it difficult to earn income from farming. Non-agricultural income can supplement the family income of farmers who have little or no land and provide the inputs they need to maintain crops and cover farming losses.

Thus, the hypothesis formulated in this paper is that urban areas sometimes provide a source of income for lower-income people in rural areas. This being so, any economic shock in urban or rural areas could lead to a change in the socioeconomic dynamics of either or both, as poor people move areas in search of an income source.

In view of these considerations, this study investigates whether there is spatial spillover of poverty in urban and rural areas of the Brazilian states and to what extent economic growth and income inequality affect poverty, taking the proximity of states into account.

The purpose of this research, then, is to obtain values for the income elasticities and inequality of poverty in urban and rural areas of the Brazilian states and ascertain whether there are spatial spillovers of poverty in urban and rural areas of the units of the Brazilian federation. The contribution of this paper to the economic literature on poverty lies in the way elasticities are obtained by a procedure capable of capturing effects from spatial proximity, enabling spatial spillovers of poverty to be quantified from

changes in economic growth and income inequality. Data from the National Household Survey (PNAD) published annually by the Brazilian Institute of Geography and Statistics (IBGE) are used for this procedure. Information on urban and rural areas in the 26 Brazilian states and the Federal District for the period 2004–2014 is considered.

The study is divided into five sections, of which this introduction is the first. The second section describes the theoretical basis for the research and the third presents its methodological underpinnings. The fourth section sets out and discusses the results and the fifth and final section presents the conclusions.

II. Literature review

This section sets out the main approaches to poverty on which the present study is based and describes the theoretical framework of the economic literature on spatial spillovers.

1. A triangular relationship: poverty, growth and inequality

The literature explores the existence of a relationship between poverty, economic growth and income inequality to account for changes that have arisen in different areas of the socioeconomic environment. This concept is used, for example, in the studies of Ravallion (2001 and 2005) and Dollar and Kraay (2001). These authors and Adams (2004) demonstrate that absolute poverty relates positively to income inequality and negatively to economic growth, with this constituting the so-called triangular relationship.

Setting out from a study of the interconnections between poverty and inequality at the global level, Ravallion and Chen (1997) concluded that poverty levels were highly sensitive to growth in countries with lower income inequality. In countries with higher levels of inequality, however, economic growth has little impact on poverty. The latter proposition has been tested in some studies on poverty in Brazil, including analyses by Hoffmann (2005) and Tabosa, Irffi and Guimarães (2014).

More recently, Fosu (2015) used this concept in a study on progress with poverty reduction in sub-Saharan Africa. This author also examined the triangular relationship between poverty, growth and inequality in a study on poverty reduction and economic development at the global level (Fosu, 2010). This relationship was likewise addressed in the study by Taques and Mazzutti (2010), who found that the evolution of economic growth and the reduction of inequalities were directly related to the socioeconomic performance of a given society.

According to Ravallion (2016), there is a great debate in the economic literature on the issues linking economic growth with income inequality and poverty, and this ties in with doubts about whether globalized economic growth can facilitate progress in reducing poverty and inequality. According to Ravallion (2016), these doubts are due to a still current classical view that economic growth in a capitalist economy is necessarily unequal.

Bourguignon (2003) and Marinho and Araújo (2012) addressed the triangular relationship between poverty, economic growth and income inequality as a factor of interaction, so that economic growth was measured in these studies by people's per capita income levels. Thus, in addition to other factors, what are meant by changes in poverty levels are both income movements and changes in the distribution of resources. These interactions are responsible for shaping the socioeconomic dynamics of a given region over time.

While it is clear from the literature that there is interaction between poverty, economic growth and income inequality, Datt, Ravallion and Murgai (2016) conduct a study on the effects of disparities and

economic growth on poverty in India, taking into account the effects of urbanization in that country. The study stresses that the interactions of these phenomena have similar causes when analysed separately in urban and rural areas. With this procedure, however, the incidence of economic growth and income inequality on poverty is different in each of the environments described.

The relationship between economic growth and income inequality operates in different ways in Brazil, depending on the region. Although the 2000s witnessed rising rates of economic growth, this failed to eliminate disparities and heterogeneity between the Brazilian states and regions. The north and north-east regions stand out for having the highest indicators of inequality during the period under review, combined with high levels of poverty and low rates of economic growth (Moreira, Braga and Toyoshima, 2010).

In the economic literature, income inequality is characterized as one of the main determinants of poverty, meaning that these phenomena are directly related to each other, as pointed out in the studies by Coelho (2009), Hoffmann (2005) and Annegues and others (2015). It should be noted that poverty in developing countries tends to be highly sensitive to changes in disparities. In other words, the distribution effect is a major determinant of poverty in those countries, and that effect, coupled with the growth effect, is responsible for much of the dynamics of income shortfalls in those areas (Bourguignon, 2003).

Ravallion (2014) conducted a study on income inequality in developing countries. Among the results, the author showed that in most of these countries it was common for increases in growth to be accompanied by increases in inequality. The positive relationship between inequality and growth can also have a direct influence on poverty.

Studies on poverty in Brazil show that public policies to combat it need to focus more on reducing income inequality. Using a dynamic panel data model, Castelar, Tabosa and Irffi (2013) concluded that public policies involving the reduction of inequalities had a greater impact on poverty reduction than measures that only dealt with economic growth.

The relationship between poverty and economic growth is presented as a complex issue in the economic literature, and it is addressed in a number of studies formulated on the basis of various approaches that seek to explain these interactions.

The pro-poor growth approach, for example, seeks to ascertain whether economic growth benefits the poorest social classes. Studies by Kakwani, Neri and Son (2010) and Netto Jr. and Figueiredo (2014) have explored this approach, whose economic rationale divides into three schools of thought. According to the first, growth is pro-poor if the average income of the population deemed poor grows faster than that of the non-poor population. According to the second, growth is pro-poor if the increase in the average income of those deemed poor is proportional to the growth of the poor population. The third determines whether growth is pro-poor by comparing changes in the number of poor people given constant income inequality (Netto Jr. and Figueiredo, 2014).

The Ravallion (2004) approach followed by Silveira Neto (2014) adopts the pro-poor growth perspective formalized both in poverty reduction as measured by an absolute indicator associated with income dynamics and in the stipulation that those deemed poor have greater variations in income than those deemed non-poor.

The pro-poor approach to growth was tested for Brazil by Pinto and Oliveira (2010). The authors found that this type of growth contributed little to poverty reduction in the country's states. However, Silveira Neto (2014) argues that, given the nature of pro-poor growth through income dynamics, results in terms of poverty reduction were better in the 2000s than in earlier periods.

In a theoretical approach, Barreto (2005) affirms that growth is a key factor in reducing the incidence of poverty and that its effects on the poorest are greatest when it is accompanied by redistributive policies. This establishes inequality as a determinant of poverty, which in turn is related to growth.

According to Chu (2003), for developing countries to be able to reach a state of growth in which poverty can be reduced at the same time, measures are needed to reduce inefficiencies related to production incentives, especially for people with lower incomes.

Araújo, Figueirêdo and Salvato (2009) analyse the relationship between poverty and growth in Brazil, carrying out a time decomposition of poverty to measure the impact of growth, as given by income, and of income concentration on poverty levels. The study shows that poverty expresses changes resulting from shifts in average income and in income inequality.

2. Spatial spillovers

Anselin, Varga and Acs (1997) describe the spillover effect as an instrument that makes it possible to identify spatial spillovers of a given variable from changes in that same variable or in other factors that have an explanatory interconnection with the phenomenon studied. This technique serves to establish spatial movements derived from changes in fixed periods or over time and can be useful for determining the space in which a given policy or measure will be applied.

Spatial econometric techniques for identifying spillovers are generally used to analyse the behaviour of a given variable or measure in places close to where the measure was implemented or where the variable fluctuated. A good example is the study by Yu and others (2013) investigating the spillover effects of the transport system infrastructure in China by applying a contiguity matrix of order 1 to the 29 Chinese provinces.

A spillover analysis was also carried out in the study by Anselin, Varga and Acs (2000), using spatial methodology applied to a cross-sectional database of university research projects. This study found that places with greater scientific coverage attracted more investments in sectors associated with the research being carried out. Accordingly, it was concluded that attracting investment affects not only the places where universities are located but also neighbouring areas, meaning that there are spatial spillovers from scientific research.

The study by Álvarez, Arias and Orea (2006) sought to ascertain the spatial spillovers deriving from the productivity of public capital in Spain. Their research showed that, taking the closest neighbours, the productivity of public capital in the country did not present spatial spillovers and had effects only in the places where the productivity applied.

Using a database with information structured into panel data, Uchôa and Menezes (2014) used a maximum likelihood estimate to ascertain the spatial spillover effects of crime in units of the Brazilian federation. A spatial lag model was used for this purpose. According to Almeida (2012), this model is capable of revealing the existence (or non-existence) of spatial spillovers when the spatially lagged dependent variable is inserted into the explanatory set of the model.

From the perspective described by LeSage and Pace (2011), it is extremely important to realize that the spillover effects encountered in a spatial econometric process are local in nature, as opposed to global autocorrelation. Likewise, according to the authors, confirming spatial spillover effects in relation to a given variable can provide information on the migration conditions of nearby residents. However, this is not explicitly demonstrated. LeSage and Pace (2011) also point out that one of the advantages of using a spatial lag model with panel data is that spatial spillover effects are also determined by means of the direct and indirect effects obtained with the estimates. In fact, it is possible to determine whether the dependent variable changes in a given region and its neighbours if there is a change in an explanatory variable in a particular area.

The spatial econometric literature has developed models capable of determining three types of effects involving the interactions of spatial units. The first effect concerns endogenous relationships associated with the dependent variable and is obtained by estimating a spatial autoregressive model

(SARM). The second type of effect concerns exogenous relationships between the explanatory variables used and is obtained by estimating a spatial autocorrelation model (SACM). The third effect concerns interactions relating to the error term and is obtained by estimating a spatial error model (SEM) (Vega and Elhorst, 2013).

III. Methodology

This section presents the methods and instruments used to address the issues raised in this paper. It also indicates the data used, their sources and the processing applied to them before going on to explain the statistical procedures followed.

1. A stationarity test for panel data

The non-stationarity or unit root problem is a characteristic of data with distributions in periods. According to Bueno (2008), stationarity occurs when a series fluctuates around a fixed mean and the variance of that series is constant over time. In addition, Bueno (2008) points out that it is essential to check for stationarity in order to proceed to statistical inferences on the parameters estimated by performing a stochastic process. Thus, before carrying out any statistical procedure, it is necessary to check the data for stationarity. This procedure can be carried out by means of an autoregressive procedure of the type:

$$Y_t = \rho Y_{t-1} + u_t \quad (1)$$

where u_t is the stochastic error term known as white noise when it has a mean of zero and constant variance and is not autocorrelated. Thus, in a situation where $\rho = 1$ there will be a unit root problem. This study uses the Levin-Lin-Chu stationarity test to detect this characteristic, so that if the null hypothesis of the test is rejected, the data used are stationary.

2. The proximity matrix

The proximity matrix is a spatial data clustering tool that serves to delimit neighbours in an area by proximity, number or contiguity. Using this concept, Almeida (2012) indicates that a matrix of spatial weights W presents the following structure:

$$W_{ij} = \begin{cases} 1 \text{ if } i \text{ and } j \text{ are neighbours} \\ 0 \text{ if } i \text{ and } j \text{ are not neighbours} \end{cases} \quad (2)$$

The matrix is constituted as a support in the set of n areas $\{A_1, \ldots, A_n\}$ giving a matrix $W^{(1)}$ $(n \times n)$ in which each of the elements W_{ij} represents the measure of proximity between A_i and A_j.

This experiment uses a normalized queen type spatial proximity matrix.[1] The particularity of the matrix is that its structure is similar to the way the queen moves on a chess board. The normalized matrix is established as a support in the original (unnormalized) matrix, dividing all the elements of each line by the sum of the line. Therefore, all the lines of the matrix have a sum equal to 1.

[1] Besides the contiguous queen matrix, neighbouring K-type matrices were tried with $k = 3$; $k = 4$; $k = 5$; $k = 8$ and $k = 10$. The matrix used was the one presenting the greatest spatial autocorrelation of the model residuals, without spatial effects.

3. The econometric model

To address the issues described in the first section, this study uses a methodology that encompasses data arranged in units of space and time, considering the spatial effects inserted in the variables. For this purpose, use is made of the method proposed by Elhorst (2014), in which a general model with panel data containing N observations of space arranged in t observations of time encompassing spatial effects is described as follows:

$$\begin{gathered} Y_t = \delta W T_t + \alpha i_N + X_t \beta + W X_t \theta + u_t \\ \text{with} \\ u_t = \lambda W u_t + u_t \end{gathered} \tag{3}$$

where Y represents the proportion of poor people, t is time, N is the number of observations, WY_t are endogenous interactions on the dependent variable, X_t is the matrix of dependent variables with the natural logarithm of the Gini coefficient and the natural logarithm of per capita income, W represents the matrix of spatial weights, δ and λ are spatial correlation parameters and u_t is the specific effect of the particular omitted variables of each unit of space over time.

Elhorst (2014) recommended using the term ξ_t, a control factor for variables covering all units of space whose omission could lead to biases in the estimates.

$$\begin{gathered} Y_t = \rho W T_t + \alpha_{iN} + X_t \beta + W X_t \theta + u + \xi_t i_N + u_t \\ \text{with} \\ u_t = \lambda W u_t + \varepsilon_t \\ \text{and} \\ u = \left(\mu_t, \ldots, \mu_N\right) \end{gathered} \tag{4}$$

Thus, the model used to capture the existence of spatial spillover effects on poverty in the units of the Brazilian federation is the spatial lag model, which is formulated on the hypothesis that the dependent variable used (the proportion of poor people) for a given region depends over time on the characteristics of the dependent variable for its neighbours. According to Elhorst (2014), this dependence arises from the inclusion of the spatially lagged dependent variable ($W_{ij}Y_{it}$) in the set of explanatory variables of the model, as follows:

$$y_{it} = \delta \sum_{j=1}^{n} W_{ij} y_{it} + x_{it} \beta + \mu_i + \varepsilon_{it} \tag{5}$$

where δ is the spatial autoregressive term and W_{ij} is a component of the matrix of spatial weights W.

4. The spatial fixed effects model

Setting out from a general panel data model with spatial effects, in the event of the effects determined being fixed ones, Elhorst (2014) and Lee and Yu (2010) showed that the model parameters were estimated in three stages. First, the u_i effects are removed from the regression equation to make way for the y and x variables. This transformation is given by:

$$y_{it}^{*} = y_{it} - \frac{1}{T}\sum_{t=1}^{T} y_{it} \quad and \quad x_{it}^{*} = x_{it} - \frac{1}{T}\sum_{t=1}^{T} x_{it} \tag{6}$$

where T is the amount of information for each cross-sectional unit used. In the second step, the transformed regression equation, $y_{it}^{*} = x_{it}^{*} + \varepsilon_{it}^{*}$, is estimated using the ordinary least squares process, where $\beta = \left(X^{*T}X^{*}\right)^{-1}X^{*T}Y^{*}$ and $\sigma^2 = \left(Y^{*}-X^{*}\beta\right)^{T}\left(Y^{*}-X^{*}\beta\right)/\left(NT-N-K\right)$, with K being the number of explanatory variables. The advantage of this process is that it means the calculation of β can include the inversion of a matrix K x K by a matrix $(K+N)$ x $(K+N)$. In this case, estimation is carried out using ordinary least squares with dummy variables (Elhorst, 2014).

Thus, estimation is carried out using the maximum likelihood procedure and the log-likelihood function is given by:

$$logL = -\frac{nT}{2}log\left(2\pi\sigma^2\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{n}\sum_{t=1}^{T}\left(y_{it}^{*} - x_{it}^{*}\beta\right)^2 \tag{7}$$

The maximum likelihood estimators β and σ^2 are $\beta = (X^{*T}X^{*})^{-1}X^{*T}Y^{*}$ and $\sigma^2 = (Y^{*}-X^{*}\beta)^{T}(Y^{*}-X^{*}\beta)/NT$, respectively. The asymptotic variance matrix of the parameters is given by Greene (2008) as follows:

$$ASY.VAR\left(\beta,\alpha^2\right) = \begin{bmatrix} \frac{1}{\sigma^2}X^{*T}X^{*} & 0 \\ 0 & \frac{NT}{2\sigma^2} \end{bmatrix}^{-1} \tag{8}$$

Thus, the fixed effects can be described in general as:

$$\mu_i = \frac{1}{T}\sum_{t=1}^{T}\left(y_{it} - x_{it}\beta\right), \qquad i = 1,\ldots,N \tag{9}$$

5. Estimating the spatial lag model with fixed effects

Formulating a fixed effects spatial lag model presents two complications. First, the endogeneity of $\sum_j W_{ij}Y_{jt}$ breaks the standard regression model assumption that $\left[\left(\sum_j W_{ij}Y_{jt}\right)\varepsilon_{it}\right] = 0$. Second, the spatial dependence of the variables in each period can affect the fixed effects estimation. Accordingly, the maximum likelihood estimation recommended by Elhorst (2014) is carried out to include the endogeneity of $\sum_j W_{ij}Y_{jt}$. The log-likelihood function of this process is:

$$logL = -\frac{NT}{2}log\left(2\pi\sigma^2\right) + Tlog\,|\,I_N - \delta W\,| - \frac{1}{\sigma^2}\sum_{i=1}^{N}\sum_{t=1}^{T}\left(Y_{it}^{*} - \delta\sum_{j=1}^{n}W_{ij}Y_{jt} - x_{it}\beta - \mu_i\right)^2 \tag{10}$$

where $Tlog\,|\,I_N - \delta W\,|$ represents the Jacobian term of the transformation of ε into y bearing in mind the endogeneity of $W_{ij}Y_{jt}$. According to Elhorst (2014), the value of μ_i is obtained by calculating the partial derivative of $\log L$ in relation to μ_i so that:

$$\mu_i = \frac{1}{T}\sum_{t=1}^{t}\left(Y_{it}^{*} - \delta\sum_{j=1}^{n}W_{ij}Y_{jt} - x_{it}\beta\right), \; i = 1,\ldots,N \tag{11}$$

This equation denotes the formulation of the spatial fixed effects of a spatial lag model. Substituting the value of μ_i into the log-likelihood function and rearranging the terms, the log-likelihood function concentrated with respect to β, δ and σ^2, we get:

$$logL = -\frac{NT}{2}log\left(2\pi\sigma^2\right) + T log\ |I_N - \delta W| \\ -\frac{1}{\sigma^2}\sum_{i=1}^{N}\sum_{t=1}^{T}\left(Y_{it}^{*} - \delta\left[\sum_{j=1}^{N} W_{ij}Y_{jt}\right] - x_{it}^{*}\beta\right)^{*2} \quad (12)$$

According to Elhorst (2014) and Lee and Yu (2010), when the variables are distributed into $t = 1, \ldots, T$ time observations, a vector $NT\,x\,1$ is obtained for Y^* and $(IT \otimes W)Y^*$ and a matrix $NT\,x\,K$ for X^*. The δ estimator of the maximum likelihood procedure is thus obtained by maximizing the concentrated log-likelihood function. Thus, β and σ are estimated by considering the value of σ, so that:

$$\beta = b_0 + \delta b_1 = \left(X^{*T}X^{*}\right)^{-1}X^{*T}\left[Y^{*} - \delta\left(I_T \otimes W\right)Y^{*}\right] \\ \text{and} \\ \sigma^2 = \frac{1}{NT}\left(e_0^{*} - \delta e_1^{*}\right)^{T}\left(e_0^{*} - \delta e_1^{*}\right) \quad (13)$$

With this, Elhorst and Fréret (2009) calculate the asymptotic matrix of the parameters, which has a symmetrical form, as follows:

$$\begin{bmatrix} \frac{1}{\sigma^2}x^{*\prime}x^{*} & & \\ \frac{2}{\sigma^2}x^{*\prime}\left(I_T \otimes \tilde{W}\right)x^{*}\beta & T^{*}tr\left(\tilde{W}\tilde{W} + \tilde{W}'\tilde{W}\right) + \frac{1}{\sigma^2}\beta' x^{*\prime}\left(I_T \otimes \tilde{W}'\tilde{W}\right)x^{*}\beta & \\ 0 & \frac{T}{\sigma^2}tr\left(\tilde{W}\right) & \frac{NT}{2\sigma^4} \end{bmatrix}^{-1} \quad (14)$$

where $\tilde{W} = W\left(I_N - \delta W\right)^{-1}$ and tr represents the trace of the matrix. An important feature of the spatial lag model is that the inclusion of the spatially lagged dependent variable in the set of explanatory variables allows the direct and indirect effects of each explanatory variable used to be calculated. According to Uchôa and Menezes (2014), direct effects indicate how much the independent variable changes, taking into consideration what is known as the feedback effect, meaning the repercussions that pass through to nearby spatial units over time and then back to the unit where the change originated. Indirect effects indicate the change in the dependent variable resulting from alterations in the variables in relation to all the spatial units used.

6. A spatial model with random effects

According to Elhorst (2014), to obtain the maximum likelihood parameters, estimation by random effects is carried out in two stages. The log-likelihood function of the random effects will be given by:

$$logL = -\frac{NT}{2}log\left(2\pi\sigma^2\right) + \frac{N}{2}log\phi^2 - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\sum_{t=1}^{T}\left(y_{it}^{*} - x_{it}^{*}\right)^{2} \quad (15)$$

where ϕ represents the spatial weights for each unit of space such that $0 \leq \phi^2 = \sigma^2/\left(T\sigma_{\mu}^2 + \sigma^2\right) \leq 1$ and the symbol (•) represents the transformation of the dependent variables into ϕ. Thus, we get:

$$y_{it}^{*} = y_{it} - \left(1-\phi\right)\frac{1}{T}\sum_{t=1}^{T} y_{it} \quad and \quad x_{it}^{*} = x_{it} - \left(1-\phi\right)\frac{1}{T}\sum_{t=1}^{T} x_{it} \tag{16}$$

If the value of ϕ is zero, then, the estimate will be identified as a fixed effect. Thus, Lee and Yu (2010) and Parent and LeSage (2012) determine that the values of ϕ, β and σ^2 can be ascertained on the basis of second-order conditions of the maximization problem used, with $\beta = (X^{\bullet T}X)^{-1}$ and $\sigma^2 = (Y^{\bullet} - X^{\bullet}\beta)^T (Y^{\bullet} - X^{\bullet}\beta)/NT$. Consequently, ϕ will be estimated by maximizing the concentrated log-likelihood function in respect of ϕ, given β and σ^2.

7. Estimating the spatial lag model with random effects

According to Elhorst (2014), if the spatial effects assumed are random, the log-likelihood function of the model is given by:

$$\begin{aligned} logL = &-\frac{NT}{2}log\left(2\pi\sigma^2\right) \\ &+ T\,log\,|I_N - \delta W| + \frac{N}{2}\,log\phi^2 - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\sum_{t=1}^{T}\left(y_{it}^{*} - \delta\left[\sum_{j=1}^{N} W_{ij}y_{it}\right]^{*}\right)^2 \end{aligned} \tag{17}$$

Thus, β, δ and σ^2 can be found by maximizing the log-likelihood function in respect of ϕ such that:

$$logL = -\frac{NT}{2}log\left[e\left(\phi\right)^T e\left(\phi\right)\right] + \frac{N}{2}log\sigma^2 \tag{18}$$

where the typical element specified by $e(\phi)$ is:

$$\begin{aligned} e\left(\phi\right)_{it} = y_{it} - \left(1-\phi\right)\frac{1}{T}\sum_{t=1}^{T} y_{it} - \delta\left[\sum_{j=1}^{N} W_{ij}y_{it} - \left(1-\phi\right)\frac{1}{T}\sum_{t=1}^{T}\sum_{j=1}^{N} W_{ij}y_{it}\right] \\ - \left[x_{it} - \left(1-\phi\right)\frac{1}{T}\sum_{t=1}^{T} x_{it}\right]\beta \end{aligned} \tag{19}$$

The equation represents interactions used when the set of parameters is alternatively estimated until a situation of convergence is reached. This procedure includes estimation methods used to find the parameters of the fixed effects spatial lag model and the non-spatial random effects model. Thus, the asymptotic variance matrix of the parameters is given by:

$$Asy.Var\left(\beta, \delta, \theta, \sigma^2\right) = \begin{bmatrix} \frac{1}{\sigma^2}X^{\bullet T}X^{\bullet} & & & \\ \frac{1}{\sigma^2}X^{\bullet T}\left(I_T \otimes \tilde{W}\right)X^{\bullet}\beta & T * tr\left(\tilde{W}\tilde{W} + \tilde{W}^T\tilde{W}\right) + \frac{1}{\sigma^2}\beta^T X^{\bullet T}\left(I_T \otimes W^T\tilde{W}\right)X^{\bullet}\beta & & \\ 0 & \frac{1}{\sigma^2}tr\left(\tilde{W}\right) & N\left(T + \frac{1}{\sigma^2}\right) & \\ 0 & \frac{T}{\sigma^2}tr\left(\tilde{W}\right) & -\frac{N}{\sigma^2} & \frac{NT}{2\sigma^4} \end{bmatrix} \tag{20}$$

8. The database

The data used in this study were obtained from the National Household Survey (PNAD) published annually by the Brazilian Institute of Geography and Statistics (IBGE). The Foster, Greer and Thorbecke (1984) index is used to obtain the proportion of people deemed poor ($P0$):

$$P0 = \frac{q}{n} \tag{21}$$

where $P0$ is the proportion of people who are poor, q is the number of poor people and n is the number of people. For the purposes of this index, people with incomes below the poverty line are considered poor. The poverty line used is that of the Institute for Labour and Society Studies (IETS), which sets a reference value for each unit in the federation, considering the year and census situation. Income was obtained by dividing monthly household income by the number of residents per household, and all values were updated to 2015 using the national consumer price index (INPC).

The income inequality used was obtained by calculating the Gini concentration index, described in Hoffmann (1998) as $G = \frac{\alpha}{\alpha + \beta}$, where β represents the area between the Lorenz curve and the abscissa axis and α represents the area between perfect income equality and the Lorenz curve. The variables used are given logarithmically so that the elasticity values can be ascertained, considering the spatial effects encompassed.

The data cover a period of 11 years from 2004 to 2014.[2] This period was chosen because data on rural areas were available for all units of the federation studied. The analyses were conducted for the rural areas and urban areas delimited by the PNAD in each of the 26 units of the federation and the Federal District.

IV. Results and discussion

The initial aim is to determine whether the data used are stationary. For Bueno (2008) and Baltagi (2005), when data are expressed in time series, non-stationarity can lead to mistaken conclusions and biased results. Table 1 shows the results of the Levin-Lin-Chu stationarity test for data from urban and rural areas.

The null hypothesis is rejected in both cases at a 95% confidence level, indicating that the data used are stationary.

Table 1
Stationarity test for the data

Urban areas		Rural areas	
Test	P-value	Test	P-value
-15.0293	0.0000	-17.3862	0.0000

Source: Prepared by the authors.

To ascertain the income elasticities and inequality of poverty during the period studied in urban and rural areas and check whether spatial effects should be incorporated, a panel data model without spatial effects was estimated. The results of this estimation are presented in table 2.

[2] Since the IBGE did not release the 2010 PNAD, the variables used for that year are averages of the 2009 and 2011 values.

Table 2
Results of the estimates for urban and rural areas without spatial effects

Urban areas					
	Fixed effect			Random effect	
	Coefficient	T-statistic		Coefficient	T-statistic
Intercept	10.2184***	41.06	Intercept	10.1042***	40.95
Ln*income*	-1.4848***	-35.22	Ln*income*	-1.4605***	-35.59
Ln*gini*	2.7264***	19.25	Ln*gini*	2.8055***	20.06
Rural areas					
	Fixed effect			Random effect	
	Coefficient	T-statistic		Coefficient	T-statistic
Intercept	9.4247***	28.91	Intercept	9.21***	30.68
Ln*income*	-1.5349***	-29.23	Ln*income*	-1.5003***	-31.58
Ln*gini*	2.2829***	13.92	Ln*gini*	2.2785***	14.25

Source: Prepared by the authors.
Note: The symbols (***) and (**) indicate significance levels of 1% and 5%, respectively.
Urban areas: (Breusch Pagan = 913.78***; Hausman = 7.24***).
Rural areas: (Breusch Pagan = 357.64***; Hausman = 2.61).

For these estimates, rejection of the null hypothesis of the Breusch Pagan test indicates that a model with panel data is preferable to a pooled ordinary least squares model. At the same time, the Hausman test indicates that fixed effects estimation is more suitable for urban areas, while the best estimates for rural areas are obtained by using random effects.

Table 2 shows that, where urban areas were concerned, all variables were statistically significant and had the expected sign. It can be seen that for each one percentage unit increase in per capita income, the proportion of poor people will fall by 1.48%. With respect to income inequality, an increase of one percentage unit in the Gini coefficient will lead to an increase of 2.72% in the proportion of poor people.

For rural areas, the income elasticity estimated (-1.5003) indicates that an increase of one percentage unit in per capita income reduces the proportion of poor people by 1.5%. When inequality elasticity is taken (2.2785), it can be stated that an increase of one percentage unit in the Gini coefficient increases the proportion of poor people by 2.28%.

These results are consistent with studies by França (2010), Pinto and Oliveira (2010), Coelho (2009) and Hoffmann (2005) showing that policies aimed at reducing inequalities bring down poverty more effectively than higher growth does.

However, questions are raised in the literature about the measurement of the spatial dependence of the models estimated in table 2. To check this, the present study applies the criterion indicated by Almeida (2012), which establishes the need to check for spatial autocorrelation in the residuals of the estimation chosen in the model without spatial effects. This procedure is carried out by applying the global Moran index to the residuals of the models indicated by the Hausman test for each unit of time. The results are shown in annex A1. Rejection of the null hypothesis for the global Moran index indicates the existence of spatial autocorrelation in the residuals of the chosen model, while acceptance of the null hypothesis indicates the absence of spatial autocorrelation.

The procedure suggested by Almeida (2012) establishes that, in the presence of spatial autocorrelation in the residuals of the estimated model, an estimate including spatial effects should be considered. If spatial autocorrelation is not observed in the residuals, a model without spatial effects will be more appropriate. Given that the results presented in annex A1 indicate spatial autocorrelation in the residuals of the models yielded by the Hausman test in table 2, it can be stated that a spatial model with panel data is preferable to the estimates made previously.

Table 3 presents the results of the estimates of the spatial lag model for fixed and random effects, including the spatially lagged dependent variable as an explanatory variable. The results obtained with the Hausman test revealed that the fixed effects could not be considered valid in the two census situations studied. Furthermore, non-rejection of the null hypothesis regarding the Breusch Pagan test indicates that, in this case, a spatial pooled model would be inconsistent.

Table 3
Results of the estimates for urban and rural areas with spatial effects

Urban areas					
	Fixed effect			Random effect	
	Coefficient	T-statistic		Coefficient	T-statistic
Intercept	-	-	Intercept	8.6257***	36.094
ρ	0.0147***	4.2538	ρ	0.0118***	3.7917
Ln*income*	-1.1918***	-14.789	Ln*income*	-1.2422***	-31.382
Ln*gini*	2.2816***	14.436	Ln*gini*	2.4168***	18.067
Rural areas					
	Fixed effect			Random effect	
	Coefficient	T-statistic		Coefficient	T-statistic
Intercept	-	-	Intercept	9.4062***	31.48
ρ	-0.0103**	-2.0763	ρ	-0.0022	-0.599
Ln*income*	-1.7251***	-16.571	Ln*income*	-1.5358***	-32.484
Ln*gini*	2.4789***	13.732	Ln*gini*	2.3176***	14.613

Source: Prepared by the authors.
Note: The symbols (***) and (**) indicate significance levels of 1% and 5%, respectively.
Urban areas: (Breusch Pagan = 18.445***; Hausman = 2.3906).
Rural areas: (Breusch Pagan = 8.3803***; Hausman = 3.4637).

According to the results presented in table 3, the values for the spatially lagged dependent variable (ρ) indicate the existence of positive spatial autocorrelation as regards the proportion of poor people in urban areas of the Brazilian states. As for rural areas, the spatial autocorrelation parameter was not statistically significant. This direct relationship between the dependent variable and the spatially lagged dependent variable indicates the existence of regional clusters of high or low values associated with urban areas in the states analysed.

The existence of spatial clusters, denoted by (ρ), affects the dynamics of urban poverty in the Brazilian states, with the positive value found for spatial autocorrelation indicating that poverty levels in the urban areas of a given state are similar to those in its neighbours'. A shift in poverty in a particular state's urban areas may present similar effects in neighbouring states.

As in the model without spatial effects, the value for the income elasticity of poverty in urban and rural areas was lower in absolute terms than inequality elasticity. These considerations reinforce the assertion that poverty reduction in the areas studied is most effective when associated with distributive measures.

An analysis of the value for income elasticity in urban areas (-1.2422) shows that, if the other variables remained constant, an increase of one percentage unit in income would reduce the proportion of poor people by 1.2422%. With respect to inequality elasticity, it is observed that a 1% increase in income inequality would increase the proportion of poor people in urban areas by 2.4168%, assuming the other variables remained unchanged.

In relation to rural areas, the elasticities reveal that a rise of one percentage unit in per capita income would lead to a 1.5358% reduction in the proportion of poor people, while a rise of one percentage unit in income inequality would increase it by 2.3176%.

By comparing the elasticities found in the spatial lag model, it is possible to affirm that poverty levels are more sensitive to changes in growth in rural areas of Brazil than in urban areas. On the other hand, urban areas in the Brazilian states are more sensitive to changes in inequality levels than rural areas. This being so, a policy of combating poverty by increasing economic growth would have greater effects in rural areas. On the other hand, anti-poverty measures based on the reduction of inequalities would be more effective if applied in urban areas.

These results were also observed for urban and rural areas of the north-east region of Brazil in the study conducted by Araújo, Tabosa and Khan (2012), which estimated the values of income elasticities and poverty inequality in that region in the period from 1995 to 2009.

Setting out from the results obtained with the earlier estimates, the aim is to verify the direct and indirect effects of the variables used. According to Elhorst (2012) and LeSage and Pace (2009), direct and indirect effects can provide information on alterations in the dependent variable in different spaces when a particular explanatory variable changes.

According to the results presented in table 4 on urban areas, the direct, indirect and total effects were statistically significant. Although the coefficients of the direct effects are very similar to those obtained in table 3, they express a small change. This arises via the feedback effect, which denotes fluctuations in the poverty of a state that are passed on to its neighbours and eventually return to the unit of the federation where the change originated.

Table 4
Direct, indirect and total effects for the models chosen

	Urban areas		
	Direct effects	Indirect effects	Total effects
Ln*income*	-1.2427***	-0.0144***	-1.2571***
Ln*gini*	2.4178***	0.028***	2.4458***
	Rural areas		
Ln*income*	-1.5357***	0.0032	-1.5325***
Ln*gini*	2.3174***	-0.0048	2.3125***

Source: Prepared by the authors.
Note: The symbols (***) and (**) indicate significance levels of 1% and 5%, respectively.

The direct effects obtained for urban areas indicate that if the urban per capita income of a given state increases by 1%, the proportion of poor people in urban areas of that state will decrease by 1.2427%. Furthermore, a one percentage unit increase in income inequality in a state's urban areas will result in a 2.4178% increase in the proportion of poor people in those same areas. In the case of rural areas, the direct effects differ little from the estimates presented in table 3 and come to have virtually the same coefficients. This is due to the non-significance of the spatial autocorrelation term (ρ), indicating that there are no spatial spillovers in these areas.

Considering that indirect effects denote the change in the dependent variable in neighbouring states resulting from a change in an independent variable in a given area (LeSage and Pace, 2011), the statistical non-significance of the spatial autocorrelation parameter (ρ) means that indirect effects for rural areas in Brazil are insignificant. This result indicates that a poverty reduction measure targeting the rural areas of a given state, whether through changes in growth or income inequality, will not lead to changes in poverty levels in rural areas of neighbouring states.

The results obtained with the indirect effects also indicate that, if income inequality remains constant, a 1% increase in urban economic growth in a given state will reduce urban poverty in neighbouring states by 0.0144%. Likewise, if growth remains constant, every one percentage unit increase in urban income inequality in a given unit of the federation will be matched by a 0.028% increase in income

inequality in the urban areas of neighbouring states. These results demonstrate the impact of spatial spillovers on urban poverty in the Brazilian states. Thus, it can be affirmed that a policy to combat poverty in urban areas, whether through changes in income or in inequality, will be more effective if applied at the national level, since applying a measure of this type locally would result in a spatial spillover of the proportion of poor people.

LeSage and Pace (2011) define total effects as the total impact on the dependent variable resulting from a change in an explanatory variable throughout the area studied. Thus, it is found that a 1% increase in economic growth will bring about a 1.2571% reduction in urban poverty in the Brazilian states if income inequality remains unchanged, with 1.2427% of this total coming from local effects and the remaining 0.0144% from the spatial overspill of the proportion of poor people.

Given the non-existence of spatial spillovers of the proportion of poor people in rural areas, the indirect effects found for those areas derive from changes at the state level. It is found that a 1% increase in rural economic growth in the Brazilian states will lead to a 1.5325% reduction in the rural proportion of poor if income inequality remains unchanged. This impact derives from direct effects. In addition, given unchanged growth, a 1% increase in income inequality in rural areas will generate a 2.3125% increase in the rural proportion of poor people, this impact likewise being caused by direct effects.

When the value of the coefficients found is analysed in the light of the indirect effects, it is observed that the income inequality effects obtained in the two types of area studied exceed economic growth in absolute terms. This reinforces the conclusion reached in the studies by França (2010), Pinto and Oliveira (2010), Coelho (2009) and Hoffmann (2005), which showed that measures aimed at reducing poverty in Brazil have a greater impact when associated with the reduction of disparities.

V. Final considerations

The present study has sought to ascertain the existence of spatial poverty spillovers in urban and rural areas of the units of the Brazilian federation. It has also sought to determine how sensitive poverty is to changes in levels of economic growth and income inequality in urban and rural areas, considering spatial effects. A panel data methodology capable of encompassing the proximity characteristics of the areas studied was employed for this purpose.

Analysis of the endogenous spatial interactions of the proportion of poor people revealed the existence of spatial poverty spillovers in urban areas and their absence in rural areas. This result indicates that any anti-poverty measure aimed at urban areas should be applied at the national level, since doing so locally may cause a spillover effect and draw in poor people from areas close to the place where the measure originated.

By comparing the endogenous spatial interactions of the proportion of poor people in urban areas and the direct and indirect effects found, the existence of a so-called feedback effect was identified for these areas. This result shows that changes in growth and income inequality in the urban areas of the Brazilian states lead to alterations in the proportion of poor people in nearby areas that eventually produce shifts in the proportion of poor people in the region where the change originated.

Analysis of the elasticities found and the estimated total effects revealed that poverty levels were more sensitive to changes in growth in rural areas of Brazil than in urban areas. It was also concluded that urban areas in Brazilian states were more sensitive than rural areas to changes in inequality.

It is concluded that, in both urban and rural areas of the Brazilian states, poverty reduction measures will be more effective if coupled with the reduction of disparities.

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Annex A1

Table A1.1
Spatial autocorrelation of the residuals of the table 2 estimates using the normalized queen matrix

Year	Urban areas		Rural areas	
	Moran	P-value	Moran	P-value
2004	0.4348	0.003	0.5483	0.001
2005	0.3895	0.006	0.4713	0.001
2006	0.3994	0.004	0.4208	0.002
2007	0.3391	0.006	0.3268	0.008
2008	0.3839	0.003	0.04	0.27
2009	-9.13	0.397	0.1766	0.07
2010	0.3466	0.013	0.3146	0.007
2011	0.0636	0.24	0.5087	0.001
2012	0.2252	0.036	0.572	0.001
2013	0.5841	0.001	0.1195	0.144
2014	-0.1483	0.209	0.516	0.001

Source: Prepared by the authors.

A typology of precarious employment for Chile: precariousness as a cross-class phenomenon[1]

Osvaldo Blanco and Dasten Julián

Abstract

This article presents a proposal for defining and measuring precarious employment. We begin by relating this phenomenon to the changing faces of work and social class. We then expound a methodology that combines the techniques of correspondence analysis and k-means clustering to produce a typology of nine groups of precarious employment. This reveals such employment to be a multidimensional phenomenon combining aspects of stability, insecurity, income, working conditions and working hours. The results point to a phenomenon that is not tied to any one class or position in the labour market or to any one dimension or indicator but is rather a multidimensional process that cuts across class divides and pervades different positions and situations throughout the Chilean employment structure.

Keywords

Employment, working conditions, employment policy, labour contracts, hours of work, measurement, social classes, Chile

JEL classification

A14, J31, J01, J81

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I. Introduction

The concept of "precariousness" seems to be encountered more and more often in different contexts and in different references to the field of the social sciences. In order to establish some criteria for analysis, this article will seek to present a multidimensional approach to precariousness that takes in different aspects associated with the features of contractual relations, social and health security, income, working conditions and working hours. Precariousness does not seem to be so much about occupying a particular place or configuring a single class or subject, but rather captures a multifaceted and fluid situation of traits and weaknesses linked to the profound changes that have taken place in labour markets, production relations and forms of accumulation. Setting out from this premise, our aim is to remedy the lack of proposals for generating employment profiles from the perspective of precariousness.

We intend to contribute to the debate on precariousness as a concept that provides a general background associated with the transformations of capitalism and the world of work and that has found a place in the literature on the sociology of work and the social sciences. Thus, precariousness is part of the recomposition of the sociology of labour, as a concept that reorders (and transcends) the debate on the crisis and supposed end of work. This revitalization of the sociology of work entails reflection on and awareness of the concept of precariousness in a discussion that remains ongoing but that we participate in here with an unprecedented proposal for measuring the phenomenon in Chile. In our country, precariousness appears to be pervasive throughout the structure of employment, starting with the multidimensional and complex impact on working conditions that we will address here.

Thus, the profound transformations affecting work make it necessary to propose new instruments and approaches, and we believe that the concept of precariousness serves to identify different forms of weakening and uncertainty arising from changes in business management models, pauperization and oversight or monitoring at work, among other structural factors. Precariousness can be understood as a social relationship and a heterogeneous class condition that breaks down and problematizes traditional approaches to understanding the structural characteristics of the composition of social classes based on work. In sum, the features of work have shattered and been reconfigured in such a way that different manifestations have proliferated, and precariousness is a prism for identifying the different faces and morphologies of class situations, reorganizing segments and profiles and necessitating the presentation of new perspectives for their study and comprehension.

II. Reference framework

1. Precarious employment

Precariousness has spread as a cross-cutting phenomenon of deteriorating working and living conditions which, coupled with the dual structure (formal/informal) of the labour market, is problematizing the old spaces of recognition and identification. Deteriorating conditions of employment have been displacing the processes of recognition and (psycho)social malaise from formality to informality, from stability to instability and from security to insecurity, as cross-cutting phenomena of colonization of the worlds of working life and the imaginaries of work (Julián, 2017). These processes of increasing precariousness not only cut across segments of low-skilled workers, but also affect professions traditionally associated with greater status and stability.

At a subjective level, precarious employment is manifested in the appearance of phenomena of individuality, risk, uncertainty (absence of certainties) and insecurity (Beck, 2000; Castel, 2010). In this set of problematizations for the study of labour, the formation of a (supposed) "new working class" has

a contradiction at its heart: on the one hand, the ways the links just mentioned, which shaped the core of identity(ies) traditionally associated with work, have deteriorated and fragmented; and, on the other, the gestation of structural convergence and cohesion under precarious employment conditions as an expression of a new "social issue of labour".

This article explores numerous facets of precarious employment in its objective aspect and proposes a diverse typology of groups as a way of arriving at an initial statistical mapping that will then need to be enhanced both qualitatively and geographically. The absence of subjectivity in our typology of precariousness is due primarily to the complexity involved in including all this knowledge in an article for scientific dissemination, rather than to any neo-positivist epistemological approach to the social situation.[2]

The central hypothesis guiding this investigation is that precariousness has moved fluidly through the structure of employment after originating in a multidimensional form of incidence in working conditions, inducing conditions of uncertainty and insufficiency that are expressed both in new modes of business management and in individual and collective strategies to cope with their consequences.[3] In this context, the idea of precariousness introduces a problematization into the traditional approaches to employment, since it flags up the concern for the transversality of the forms taken by work in the geography of the new global order (in relation to labour policies, institutions, social classes and the economic dynamics of contemporary capitalism).

Precariousness can be associated with different aspects and dimensions that have become an international trend in the reorganization of work spaces and the restructuring of production since the 1980s (Auer and Cazes, 2000; Antunes, 2001; Castel and Dörre, 2009; Marín, 2013). This incorporation of precariousness as part of the new reality of employment reveals an apparent permeability and internalization of the debates in the labour sciences and studies on changes in the socioproductive mix (Kalleberg, 2011; Paugam and Zhou, 2007; Van der Linden, 2014), a new context of increasingly flexible employment relations (Esping-Andersen and Regini, 2000; Thompson and Van den Broek, 2010) and a special connotation with respect to the processes constituting resistance, collectivities and social mobilization (Frege and Kelly, 2003; Ross, 2008; Barattini, 2009; De la Garza, 2001). At the theoretical level, a number of approaches have been used to study precariousness, of which three can be highlighted: (a) an institutionalist and regulationist approach, focusing on social protection and the identification of precariousness as the outcome of a process of State breakdown, erosion of employment conditions and retreat of social insurance policies (Castel, 2004 and 2010); (b) a neo-Marxist approach that problematizes the relationship and reproduction of precariousness with global processes and changes in the patterns of capital accumulation, especially through financialization, dispossession and the overexploitation of labour (Dörre, 2009); and (c) a post-structuralist approach that conceives of precariousness as part of a strategy and regime of governance that redefines the forms of control, domination and subordination of specific populations (Butler, 2004; Lorey, 2015).

The concept of precariousness is used instead of the concept of poverty mainly because the latter has generally been understood in terms of the possession or lack of resources (income), ignoring its relationship with work and employment. In a "multidimensional" sense, poverty implies

[2] For our study, conducted as part of FONDECYT Regular Project No. 1161347, we conducted interviews focusing on four levels of analysis: (i) meanings and narratives of work; (ii) the work process; (iii) impacts on spheres outside work; and (iv) forms of associativity, collective action and survival strategies. We have also held discussion and debating events with trade union organizations from various industries and regions of the country on the subjectivations attached to each type of cluster as set out in this article. This stands in for a more extensive study and is an attempt to synthesize a larger and further-reaching research process that cannot be shown here.

[3] Changes in the organization of work, increased labour flexibility and the uptake of technologies in workplaces has increased the importance of and interest in the skills and competitiveness required in globalized economies, and this has had repercussions for labour processes and relations (Boltanski and Chiapello, 1999). This has not fully occurred in Chile, however, because changes in firms have been characterized by an "unbalanced modernization" (Ramos, 2009): although production processes and labour relations have undergone organizational changes, these have not greatly changed the situation of workers, who remain in secondary, weak and highly subordinate positions (Aravena, 2016, pp. 108–111).

a practical interconnection in forms of habitat, health, education, occupation and social security, but "precariousness" is still a term that more specifically highlights the centrality of work. Precariousness implies a relationship with poverty: some precarious workers are also poor. However, this is not the only dimension of precariousness, since it intersects with conditions of risk and working situations that transcend poverty and call into question the institutionalization of mechanisms of vulnerability, rejection and social security, understood as an indissoluble part of the profound transformations being undergone by capitalist societies. Similarly, the concept of "quality of employment" is not used, since it is confined to a normative set of conditions conceived from a statist, wage-based and restrictive view of work. Precariousness can be understood as implying the burden of power and class relations that are constituted by deprivation in working and living conditions, so that "quality" is not to be automatically attributed as a practical imperative for subjectivation.

2. Measuring precariousness in social classes

Precariousness is a phenomenon significantly associated with the transformations of work, moving fluidly through the structure of employment. In contemporary capitalism, the social division of labour and exploitation both require increasing precariousness as a relationship instituted to pressurize and strain the potential for reproduction of the labour force. Its institutionalization in neoliberal policies and its structural persistence in Chilean society allow it to be treated as a central, instituted and constitutive social relationship of social reproduction. This has shaped heterogeneous manifestations of precarious work, as well as the formation and composition of existing social classes.

Thus, precariousness is directly related to the new features of work and social class. However, difficulties in quantifying it appear as soon as we realize how significantly problematic it is to measure social classes by occupation or employment variables. In principle, social classes and occupations belong to different theoretical orders: occupational variables express the internal stratification of the technical and functional division of labour, while social classes are defined by their position in the social relations of power, struggle and domination over the production and distribution of surpluses. The problem of how to measure social classes by occupation and employment variables is surely one of the most important considerations when it comes to proposing statistical research on social classes and, more specifically, precariousness as a cross-cutting, cross-class phenomenon.

The main reason for this lies in the complex analytical dimensions that have been raised in debates about social class, something that can make the concept difficult or downright impossible to operationalize in concrete research. The polysemy of the concept brings together a wide range of perspectives regarding its meaning, and in the area of sociology there are profound debates about the resolution of aspects linked to the mutual determination of structural and agential dimensions (Giddens, 1996; Archer, 2009), the best way to link the microsocial and macrosocial levels (Wright, 1994; Grusky, Weeden and Sørensen, 2001; Goldthorpe, 2010), the contrast between abstract and concrete ontological perspectives (Marx, 1971; Wright, 1994) and objective and subjective emphases (Bourdieu, 1994, 2001, 2002 and 2011). In general, there is a degree of consensus that the different topics of social class analyses distinguish between an analysis concerned with addressing questions related to macrophenomena of transformation or reproduction of social structures on a large scale, and an analysis concerned with explaining microphenomena in the attitudes, behaviours or life chances of specific agents.

Moreover, some approaches interpret the crisis of the Keynesian-Fordist wage society as the advent of consumer societies, with the symbolic and ideological practices around consumption expressing, at the level of consciousness and subjectivity, its supremacy as a mechanism of identity and social cohesion. However, our approach is to define classes on the basis of the transformations that have taken place in the realm of work, i.e., the spaces of production (where work is applied and put into practice) and the labour market (where work is sold as a commodity), this being crucial to

our objective of exploring the precariousness of work and classes in a peripheral-dependent society such as ours (Blanco, 2016 and 2019). Besides the importance that can be assigned to consumption as a locus for the configuration of inequalities and identity, we maintain that it is in the processes of production, i.e., of work as a social relationship, that classes experience situations of subordination, control or surveillance, as well as a network of contractual forms and forms of access to qualifications, income, security systems, length of working weeks and so on, which go to make up the multifaceted and specific features of precariousness in our society.

However, we come back to the original problem: is it possible to use occupational and employment variables to capture class relationships and models? A review of the literature shows that this problem is often avoided and the discussion of how occupations relate to concepts of social class becomes a "black box" (González and Carabaña, 1992). Some authors have indicated that class models cannot be reduced to mere classifications of labour markets (Crompton, 1994), but do not offer practical solutions for moving from one sphere to another, or for how occupations can be used as a proxy for class. This lack of explanation is a common feature in the output of many authors who have produced a wealth of empirical research.[4]

What is proposed here is a flexible research design, with the profound transformations undergone by work being the justification for the use of employment variables. To the functional division by skill levels we add the dimension of employment situations as indicators of positions in labour relations (Blanco, 2019). Thus, a social class is treated as a set of major aggregates not only of skills, but also of positions in the labour relations of production. The profound historical transformations of capitalism multiplied the forms of work, creating a wide range of groupings and segments in which occupations and employment situations are core structuring elements when we come to consider these fragments of work.

III. Methodology

1. The variables used: the five components of precariousness

The changes in capitalism involve new production paradigms that are manifested in changes to the working process and the (re)organization of work in enterprises (Ramos, 2009), more flexible employment (Echeverría and López, 2004) and the emergence of non-standard jobs (De la Garza, 2000 and 2001; Neffa, 2010). This has been shaping new conditions for production and the constitution of productive experiences, as well as the process of organizing meanings at work (Antunes, 2005). The dynamics of production models and the transformation of forms of rational work management, in addition to the transformations arising from the crisis in the hegemony of the industrial-Keynesian-Fordist model, have had a profound impact on the contractual and organizational dimensions (Gálvez, 2001; Palomino, 2001).

[4] Bourdieu, for example, uses occupational categories taken from the classification of the French National Institute for Statistics and Economic Studies (INSEE) and seems to have no qualms at all about this taxonomy. Adopting a rampant pragmatism, he argues that it is necessary to move beyond the choice "between either a pure (and simple) theory of social classes, which is based on no empirical data (position in the relations of production) and which has practically no capacity to describe the state of the social structure or its transformations; or empirical studies, like those of INSEE, which are based on no theory but which provide the only available data for analysing the division into classes." (Bourdieu, 1992, p. 31). There are other researchers who have simply done away with this step of operationalizing occupational variables in class indicators and ended up proposing empirical measurements of occupations of a markedly microscopic nature, thus replacing large class aggregations (Grusky and Weeden, 2005), excluding any type of broad social aggregate from their class analysis and moving towards class analyses based on specific occupations at the most disaggregated level possible (Grusky and Sørensen, 1998). In these two examples, it can be said that researchers take the indicators available to them without any great effort to operationalize their variables theoretically or methodologically.

Thus, in this research, precariousness is considered in five specific dimensions: (i) stability (contractual and temporal), (ii) security (social protection), (iii) sufficiency (earnings), (iv) working conditions (accident rate by occupation and characterization of workplaces) and (v) working hours[5] (see table 1).

Table 1
Multidimensional operationalization of precarious employment

Component	Operational definition	CASEN 2013 indicator
(In)stability	No contract, temporary and short-term contracts, contracts of uncertain duration.	– Is your main work or business…?
		– Contract type
		– Written contract of employment
		– With whom did you sign your contract or enter into your employment agreement?
(In)security	This component refers to the absence (or presence) of health and social security coverage.	– Affiliated to social security system
		– Paying into some social security system
		– Social security system (health)
(In)sufficiency	This component refers to the amount of wages/income.	– Earnings (grouped)
		– Earnings from main occupation (grouped)
Working conditions	Dimension that includes accident rates by occupation and characterization of workplaces.	– Place where activity carried out or business located
		– Sickness or accident
Working hours	This component is based on the number of hours worked weekly.	– Working hours in main job (grouped)

Source: Prepared by the authors.

The precariousness of work has been problematized methodologically in different ways and with different experiences and instruments for its measurement in Latin America, and these contributions need to be engaged with so that a comprehensive model of analysis can be developed (Escoto, 2010; Grau and Lexartza, 2010; Rubio, 2010; Monteforte, 2012; Mora, 2010; Fernández, 2014; Guadamarra, Hualde and López, 2015).[6] Hence, the analysis we propose works with five central components of precariousness, arrived at after a review of methodological proposals for measuring the precariousness of work in different Latin American contexts. These five levels of problematization of precariousness in wage employment take account of the proposals made by Mora (2010), whose indicators of precariousness are iconic. The data source was the 2013 National Socioeconomic Survey (CASEN 2013), which contains all the variables included in this operationalization (unlike CASEN 2015).[7]

2. Variables used: classes, occupations and employment situations

Two other significant variables are the International Standard Classification of Occupations (ISCO-1988) and the International Classification of Status in Employment (ICSE), both developed and elaborated for decades by the International Labour Organization (ILO). The reference framework defines the term "social class" as a set not only of skill aggregates, but also of positions in the labour relations of production. This translates into two central dimensions of the concept: classes as employment situations and classes as occupations (Blanco, 2019).

[5] By precariousness in terms of working hours we mean both situations of underemployment (activities falling well short of 45 hours a week) and situations where this standard working week is significantly exceeded.

[6] However, it is impossible in such a short space to enter on a discussion of the ways of measuring precariousness, considering that to detail specifically each of the measurement models cited would involve a rigorous analytical effort that lies outside the scope of this article. A whole article would be needed to supplement the proposal outlined here, detailing each of the models deployed to measure the precariousness of work and employment in Latin America.

[7] The important variable o26 disappears in the CASEN 2015 survey, which led us to choose the 2013 version in order to have as many indicators as possible for all the dimensions of precariousness presented here.

Employment, as operationalized by the ICSE*rec* (see table 2), involves work as a social relationship, i.e., a diversity of forms of direct and indirect subjection, taking in the porous boundaries between wage-paying work as an employee, own-account work and other non-standard forms of labour relations, expressing the transformations in contractual relations and in forms of organization/exploitation that have emerged in recent decades (Gálvez, 2001; Palomino, 2001). Meanwhile, occupation, which was operationalized by means of the ISCO*rec* variable (see table 3), expresses the functional division of trades and professions, distinguishing between different degrees of skill (manual, non-manual, services and commerce, skilled professionals, mid-level technicians, office workers, agricultural work, unskilled and others). Both variables have been recodified: in the case of ICSE*rec*, employers were removed, while in the case of ISCO*rec*, new groups were created, such as corporate managers, legislators, senior officials, farmers and subsistence agricultural and fishery workers, etc.

Table 2
The International Classification of Status in Employment (ICSE) and its recodification (ICSE*rec*)

ICSE	ICSE*rec*	Abbreviation
Own-account worker	Own-account worker	Own-account
Public sector employee or worker (central government and municipalities)	Public sector employee or worker	Pub sec emp
Public sector employee or worker (public enterprises)		
Private sector employee or worker	Private sector employee or worker	Pri sec emp
Live-in domestic service	Live-in domestic service	Dom ser in
Live-out domestic service	Live-out domestic service	Dom ser out
Unpaid family member	Unpaid family member	Unpaid fam

Source: Prepared by the authors.

Table 3
The International Standard Classification of Occupations (ISCO) and its recodification (ISCO*rec*)

ISCO	ISCO*rec*	Abbreviation
Legislators, senior officials and managers	Legislators and senior government officials	Leg sen gov off
	Traditional chiefs and heads of villages	Trad chiefs
	Senior officials of special-interest organizations	Off spe int org
	Corporate managers	Corp man
Professionals	Professionals	Professionals
Technicians and associate professionals	Technicians and associate professionals	Tech assoc pro
Clerical support workers	Clerical support workers	Cler support
Service workers and shop and market sales workers	Service workers and shop and market sales workers	Serv work sales
Skilled agricultural, forestry and fishery workers	Skilled and semi-skilled agricultural, forestry and fishery workers	Skilled semi-skilled ag
	Subsistence agricultural and fishery workers	Subs agr fish
Craft and related trades workers	Craft and related trades workers	Craft rel trades
Plant and machine operators, and assemblers	Plant and machine operators, and assemblers	Plant mach ass
Elementary occupations	Unskilled workers	Unskilled

Source: Prepared by the authors.

Variables such as economic sector, region and sex have been used to characterize the clusters. A variable termed the "class fraction" has also been created, combining the modalities of occupation (ICSE*rec*) and employment status (ICSE*rec*), to give a total of 78 categories (13x6) (see table 4). This is because no social class is an internally homogeneous social alignment in itself: within it there will be significant differences and variabilities reflecting "intra-category inequalities" (Fitoussi and Rosanvallon, 1997, pp. 73–81). With this it will be demonstrated that in each precariousness cluster there is a wide and fragmented range of groupings and segments, where labour contexts break up, fissuring the traditional forms of work and directly affecting the features of classes.

Table 4
The "class fraction" variable

ISCO*rec*	ICSE*rec*					
	1. Own-account	2. Pub sec emp	3. Pri sec emp	4. Dom ser in	5. Dom ser out	6. Unpaid fam
1. Unskilled	1.1	1.2	1.3	1.4	1.5	1.6
2. Plant mach ass	2.1	2.2	2.3	2.4	2.5	2.6
3. Craft rel trades	3.1	3.2	3.3	3.4	3.5	3.6
4. Subs agr fish	4.1	4.2	4.3	4.4	4.5	4.6
5. Skilled semi-skilled ag	5.1	5.2	5.3	5.4	5.5	5.6
6. Serv work sales	6.1	6.2	6.3	6.4	6.5	6.6
7. Cler support	7.1	7.2	7.3	7.4	7.5	7.6
8. Tech assoc pro	8.1	8.2	8.3	8.4	9.5	9.6
9. Professionals	9.1	9.2	9.3	9.4	10.5	10.6
10. Corp man	10.1	10.2	10.3	10.4	11.5	11.6
11. Off spe int org	11.1	11.2	11.3	11.4	12.5	12.6
12. Trad chiefs	12.1	12.2	12.3	12.4	13.5	13.6
13. Leg sen gov off	13.1	13.2	13.3	13.4	14.5	14.6

Source: Prepared by the authors.

3. Statistical techniques

The data processing combines a factorial analysis technique for categorical data involving multiple correspondence analysis (MCA) with k-means cluster analysis. The MCA technique studies the relationship between variables and categories of the nominal or ordinal variables, while reducing the joint variability to factors/dimensions that summarize them (Escofier and Pagès, 1992; Ferrán, 2001; Visauta and Martori, 2003; Pérez, 2004; Le Roux and Rouanet, 2010). Charts expressing these relationships visually are obtained, with closeness and distance proving particularly relevant: related categories are closer than unrelated ones that are further off.

The second technique used was a cluster analysis with a non-hierarchical k-means model that serves to find grouping patterns and thence how individuals are clustered or differentiated from one another (Ferran, 2001; Visauta and Martori, 2003; Perez, 2004). Cluster analysis estimates the similarities between individuals or objects through the correlation (distance or association) of the different variables. Subsequently, a procedure is established to compare the groups by virtue of the similarities, wherein the researcher can decide how many groups are to be constructed, the aim being to form the smallest possible number of groups that are as homogeneous as possible within themselves and as different as possible from one another.

The steps to be able to generate the typology of precariousness can be summarized as follows:

- Initially, the variables in table 1 plus the recodifications of ICSE (table 2) and ISCO-88 (table 3) are incorporated into a multiple correspondence analysis (MCA). With this procedure we obtain the two continua that synthesize the information of all the variables included in the model.
- These two factors summarizing the multivariate information are stored in the database as two new metric variables referring to the coordinates of the cases. These two new metric variables are used in a cluster analysis of k-means, establishing the clusters. Neither the precariousness variables nor the occupation and employment situation variables were introduced into the cluster analysis, then, but solely and exclusively the object/case scores along both dimensions. This made it possible to avoid including non-metric variables (nominal or ordinal) in the k-means method, which is designed to be used with continuous variables.

- Different options for reducing the internal variance of the groups are analysed by means of a one-way ANOVA, whereby the final number of profiles is determined.
- The next step is to characterize the groups by means of a series of employment, socioeconomic and demographic variables. Both the variables for the operationalization of precariousness and the ICSE and ISCO-88 recodifications are incorporated, as are other socioeconomic and demographic characterization variables. Each cluster was named for the most relevant precariousness and class characteristics in it.

IV. Results

1. The multidimensional model of precarious employment

The factorial model of the multiple correspondence analysis carried out with the precariousness and social class variables forms two dimensions, with a Cronbach's alpha coefficient of 0.873 for the first factor and 0.746 for the second. As regards inertia, the two-factor model explains a total of 64.3%, with the first factor accounting for 39.6% and the second for 24.7% (see tables 5 and 6).

Table 5
Model summary

Dimension	Cronbach's alpha	Variance quantified for	
		Total (eigenvalue)	Inertia
1	0.873	5.149	0.396
2	0.746	3.211	0.247
Total		8.36	0.643
Mean	0.824[a]	4.18	0.322

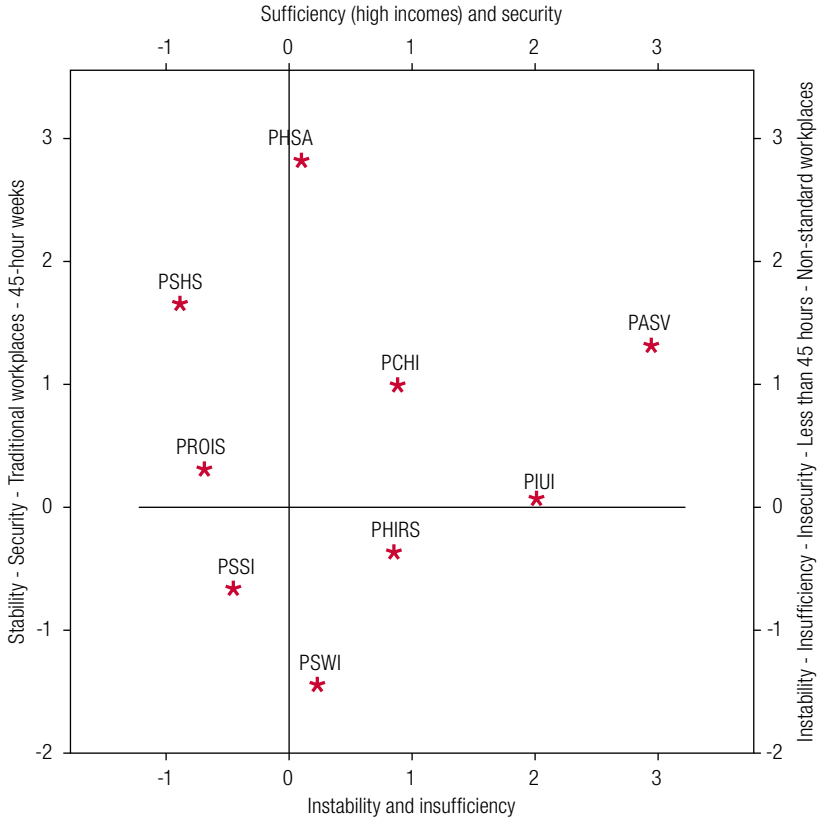
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] The mean of Cronbach's alpha is based on the eigenvalue mean.

Table 6
Discriminating measures

	Dimension		Mean
	1	2	
o.12. Is your main work or business…?	0.349	0.144	0.246
o.16. Contract type	0.156	0.119	0.138
o.17. Written contract of employment	0.263	0.053	0.158
o.20. With whom did you sign your contract or enter into your employment agreement?	0.071	0.049	0.06
o.26. Place where activity carried out or business located	0.527	0.203	0.365
o.29. Affiliated to social security system	0.409	0.018	0.213
o.30. Paying into some social security system	0.385	0.061	0.223
s.14. Social security system	0.538	0.405	0.471
s.17. Sickness or accident	0.015	0.005	0.01
o.10. Working hours in main job (grouped)	0.251	0.079	0.165
Earnings from main occupation (grouped)	0.682	0.722	0.702
Earnings (grouped)	0.692	0.709	0.7
Class fraction	0.813	0.644	0.729
Cluster[a]	1.132	0.981	1.056
Active total	5.149	3.211	4.18

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] Supplementary variable.

Figure 1
Precarious employment profiles in the multidimensional space



Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
Note: Precarious, highly skilled and autonomous (PHSA); Protected, stable and highly secure (PSHS); Precarious and constantly intensive (PCI); Precarious, autonomous and systemically vulnerable (PASV); Precarious, informal and unstable with insufficiency (PIUI); Precarious and seasonal with wage insufficiency (PSWI); Precarious with secure and stable insufficiency (PSSI); Precarious, highly insecure and relatively stable (PHIRS).

2. First dimension/pillar 1

When analysing the categories with the greatest contributions of inertia explained by this dimension, it can be said that while negative scores indicate situations of protection in employment, positive scores point to situations of precariousness (see tables 7 and 8 and figures 1 and 16). Negative scores are associated with stability (signed contracts, open-ended employment and direct negotiations with the company), security (employees affiliated to the social security system/pension fund administrators (AFP)), good working conditions (associated with traditional workplaces: factories, offices and the like) and good working hours (45-hour working week) (see table 7). There are no social class categories with significant contributions to inertia and positive factor scores. However, when clusters are incorporated as supplementary variables, it can be seen that one of the most protected clusters in the Chilean labour market, namely the Protected, stable and highly secure (PSHS) group, can show both substantial contributions in this first dimension and negative factor scores.

Table 7
Categories with negative factors scores and larger contributions (first dimension/pillar 1)

Category	Variable	Dimension of precariousness	Contribution of the dimension to the inertia of the point *(percentages)*	Factor coordinates
Yes, signed	o.17	(In)stability	56	0.509
Yes, AFP. Compulsory employee contributions	o.30	(In)security	50	0.492
Open-ended	o.16	(In)stability	37	0.493
Directly with the company or negotiates at workplace	o.20	(In)stability	27	0.307
In an independent establishment (factory, office, etc.)	o.26	Working conditions	22	0.407
Yes, affiliated to social security system	o.29	(In)security	15	0.157
45 hours	o.10	Working hours	11	0.394
PSHS[a]	Cluster	–	10	0.882

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] Supplementary variable category.

Positive scores in this first dimension (see table 8) indicate higher contributions to inertia because of situations of instability (occasional or casual employment), insufficiency (low-income deciles), insecurity (Group A of the FONASA public health system, not affiliated to the social security system or, if affiliated, not paying in), working conditions (activities carried out in non-standard places such as the customer's or own home) and working hours (less than 44 hours per week) (see table 8). Positive scores in this first dimension also have a significant relationship with own-account manual occupations and unskilled jobs that are also own-account. Considered as supplementary variables, the clusters most closely related to this area of the factorial plane are the Precarious, informal and unstable with insufficiency (PIUI) and Precarious, autonomous and systemically vulnerable (PASV) clusters, both of which have a high degree of vulnerability and informality.

Table 8
Categories with positive factor scores and higher contributions (first dimension/pillar 1)

Category	Variable	Dimension of precariousness	Contribution of the dimension to the inertia of the point *(percentages)*	Factor coordinates
Decile I	Earnings from Main Occupation	(In)sufficiency	42	-2.226
FONASA public system Group A	s.14	(In)security	37	-1.43
PASV[a]	Cluster	–	33	-2.944
Not affiliated to social security system	o.29	(In)security	32.5	-1.729
Decile I	Earnings	(In)sufficiency	32	-2.451
Occasional or casual	o.12	(In)stability	23	-1.986
<= 44 hours	o.10	Working Hours	23	-0.735
PIUI[a]	Cluster	–	23	-2.011
Not paying in	o.30	(In)security	21	-1.203
Decile II	Earnings	(In)sufficiency	17	-1.389
Craft rel trades & Own-account[b]	Class fraction	–	12	-1.885
Unskilled & Own-account[c]	Class fraction	–	12	-2.412
Employer's or customer's home	o.26	Working Conditions	12	-1.201
Own home	o.26	Working Conditions	11	-1.892

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] Supplementary variable category.
[b] Own-account craft and related trades workers.
[c] Own-account unskilled workers.

3. Second dimension/pillar 2

The categories contributing most to the inertia explained by this second dimension show negative scores associated with situations of precariousness, while positive scores are related to protected conditions (see tables 8 and 9 and figures 1 and 16). Thus, on the side of the negative scores for this second factor we have dimensions of precariousness associated with instability (fixed-term employment) and insufficiency (deciles III of earnings from work and from the main occupation) (see table 8). The class fraction of unskilled private sector employees shows a strong relationship with the negative scores of this second dimension, which is also the case for the Precarious and seasonal with wage insufficiency (PSWI) and Precarious with secure and stable insufficiency (PSSI) clusters. Thus, this is a sector of the factorial plane characterized by situations of precariousness in dependent employment, with or without signed work contracts, with low or no skills and earnings.

Table 9
Categories with negative factor scores and higher contributions (second dimension/pillar 2)

Category	Variable	Dimension of precariousness	Contribution of the dimension to the inertia of the point *(percentages)*	Factor coordinates
PSWI[a]	Cluster	–	22	1.456
PSSI[a]	Cluster	–	20	0.659
Decile III	Earnings Main Occupation	(In)sufficiency	17	0.908
Fixed-term	o.12	(In)stability	14.5	0.775
Unskilled & Pri sec emp[b]	Class fraction	–	14	1.009
Decile III	Earnings	(In)sufficiency	13	0.878

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] Supplementary variable category.
[b] Unskilled private sector employees.

Positive scores for this second factor include conditions associated with sufficiency (deciles X of earnings from work and from the main occupation) and security (health insurance institution, ISAPRE) (see table 10). The class fraction associated with this sector of the factor space is that of professionals in dependent employment in the private sector, while the most representative clusters are Precarious, highly skilled and autonomous (PHSA) and Protected, stable and highly secure (PSHS). Thus, this area of the factorial plane seems to be characterized by conditions approximating to high skills, with variable employment conditions ranging from self-employment (own-account) to protected dependent (salaried) employment.

Table 10
Categories with positive factor scores and higher contributions (second dimension/pillar 2)

Category	Variable	Dimension of precariousness	Contribution of the dimension to the inertia of the point *(percentages)*	Factor coordinates
Decile X	Earnings	(In)sufficiency	37	-1.871
Decile X	Earnings Main Occupation	(In)sufficiency	36	-1.991
PSHS[a]	Cluster	---	36	-1.645
ISAPRE	s.14	(In)security	33	-1.275
Professionals & Pri sec emp[b]	Class fraction	---	13	-1.351
PHSA[a]	Cluster	---	11	-2.81

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).
[a] Supplementary variable category.
[b] Unskilled private sector employees.

4. The nine types of precariousness in Chilean employment: main characteristics

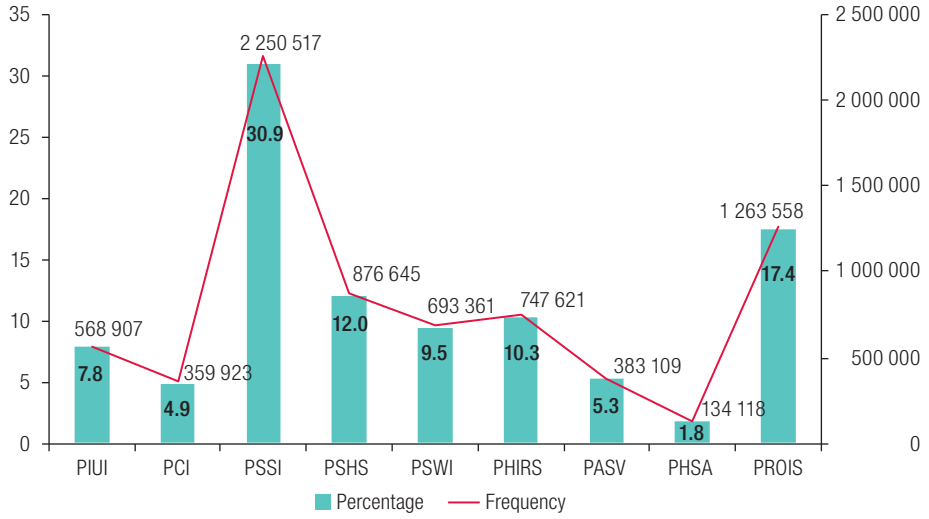
The results of the combined processing of the data with multiple correspondence analysis and k-means clustering yielded nine clusters classifying different types of situations vis-à-vis precariousness. A description and characterization of the groups identified in the typology will now be presented, detailing their main features as regards precariousness, gender composition, geographical distribution, economic sector, income deciles and fit with the occupational categories.

Table 11
Chile: the nine precariousness clusters in employment

Name		Percentage	Essential characteristics
PSHS	Protected, stable and highly secure	12% N=876 645	Group characterized mainly by highly skilled activities in a situation of dependent employment in the private and public sectors. These activities are secure in the dimensions of stability, protection, sufficiency and working conditions. The only dimension of significant precariousness is that of working hours, mainly because of the frequency of working weeks of more than 45 hours.
PROIS	Protected with intermediate sufficiency	17.4% N=1 263 558	Manual and non-manual high- and low-skilled activities in a situation of dependent employment in the private and, to a lesser extent, the public sector. An intermediate level of precariousness is observed in the dimensions of income (sufficiency) and working hours.
PHSA	Precarious, highly skilled and autonomous	1.8% N=134 118	High- and medium-skilled activities in a situation of own-account employment. High earnings, but precariousness is observed in the dimensions of stability, security, employment conditions and working hours (the last mainly because of underemployment).
PASV	Precarious, autonomous and systemically vulnerable	5.3% N=383 109	Medium- and low-skilled activities in a situation of own-account employment. Precariousness is observed in the dimensions of stability, security, sufficiency and working conditions.
PCI	Precarious and constantly intensive	4.9% N=359 923	Medium-skilled activities in a situation of own-account employment. Precariousness appears in the dimensions of security, sufficiency (intermediate), working conditions and working hours (this last because of an excessive weekly time load).
PIUI	Precarious, informal and unstable with insufficiency	7.8% N=568 907	Low-skilled and unskilled activities in a situation of own-account employment, with fractions of domestic service activities. Precariousness is observed in the dimensions of stability, security, sufficiency, working conditions and working hours.
PSSI	Precarious with secure and stable insufficiency	30.9% N=2 250 517	Private sector employees in low-skilled and unskilled activities. Low earnings, i.e., precariousness is concentrated in the sufficiency dimension.
PSWI	Precarious and seasonal with wage insufficiency	9.5% N=693 361	Mainly unskilled and low-skilled activities in a situation of dependent employment in the private sector. The significant dimensions of precariousness in this group are stability, security, sufficiency and working conditions.
PHIRS	Precarious, highly insecure and relatively stable	10.3% N=747 621	Group mainly composed of low-skilled and unskilled activities in a situation of dependent employment in the private sector combined with situations of own-account employment. The main dimensions of precariousness are stability, security, sufficiency and working conditions.

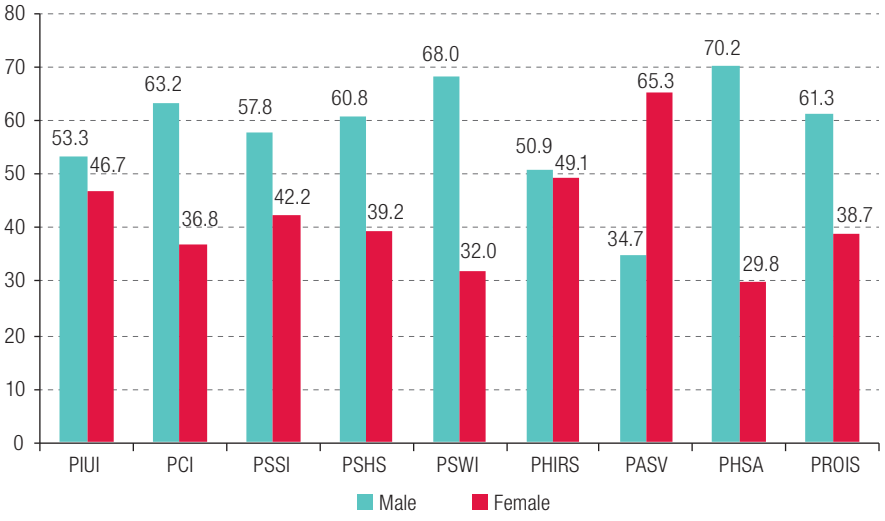
Source: Prepared by the authors.

Figure 2
Employment clusters with multidimensional precariousness
(Percentages and weighted absolute frequencies)



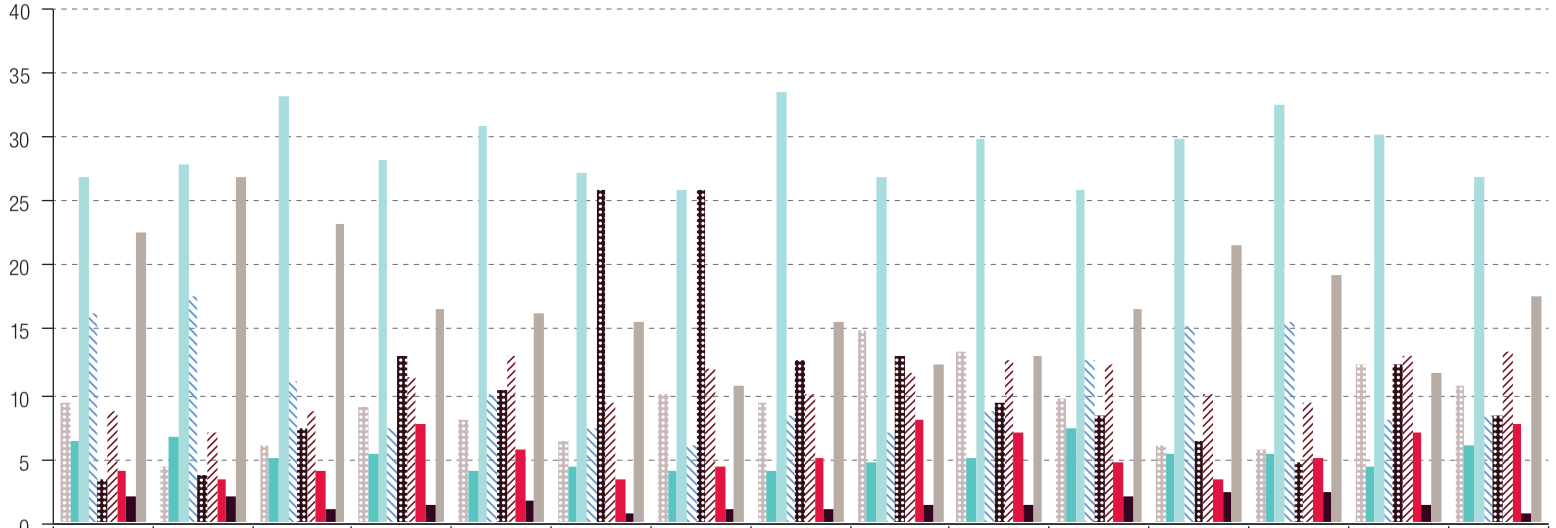
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Figure 3
Precariousness clusters by sex
(Percentages)



Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

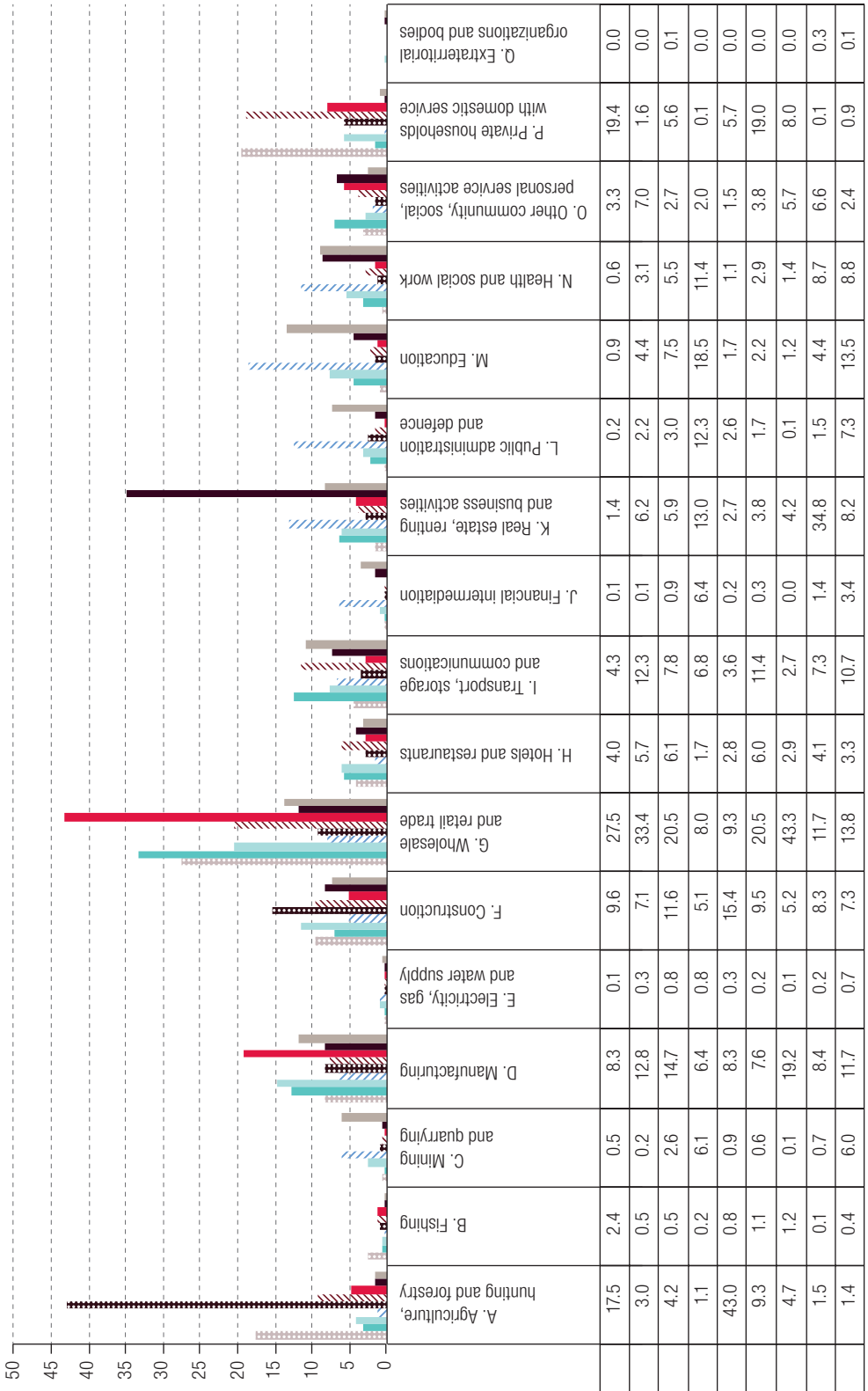
Figure 4
Precariousness clusters by region
(Percentages)



	I. Tarapacá	II. Antofagasta	III. Atacama	IV. Coquimbo	V. Valparaíso	VI. O'Higgins	VII. Maule	VIII. Biobío	IX. La Araucanía	X. Los Lagos	XI. Aysén	XII. Magallanes	Metropolitan	XIV. Los Ríos	XV. Arica and Parinacota
PIUI	9.2	4.4	6.1	9.1	8.0	6.3	10.0	9.4	15.0	13.2	9.8	6.1	5.8	12.3	10.7
PCI	6.3	6.8	5.0	5.4	4.1	4.4	4.0	4.1	4.7	4.9	7.3	5.5	5.3	4.4	6.1
PSSI	27.0	28.1	33.3	28.4	31.1	27.2	26.1	33.7	27.1	29.9	26.1	29.8	32.5	30.3	26.9
PSHS	16.4	17.6	10.9	7.4	9.9	7.2	6.1	8.2	7.0	8.8	12.5	15.4	15.8	7.9	8.2
PSWI	3.5	3.7	7.4	13.1	10.4	25.8	26.1	12.8	12.9	9.4	8.5	6.3	4.6	12.4	8.5
PHIRS	8.8	7.0	8.7	11.2	12.9	9.3	11.9	10.0	11.6	12.5	12.4	9.9	9.3	12.9	13.4
PASV	4.0	3.5	4.1	7.7	5.6	3.5	4.2	5.1	8.1	6.9	4.7	3.3	5.0	6.9	7.6
PHSA	2.0	1.9	1.1	1.2	1.6	0.7	0.9	1.1	1.4	1.5	2.1	2.2	2.5	1.3	0.8
PROIS	22.7	27.1	23.4	16.5	16.4	15.7	10.8	15.6	12.2	12.9	16.6	21.7	19.2	11.6	17.8

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

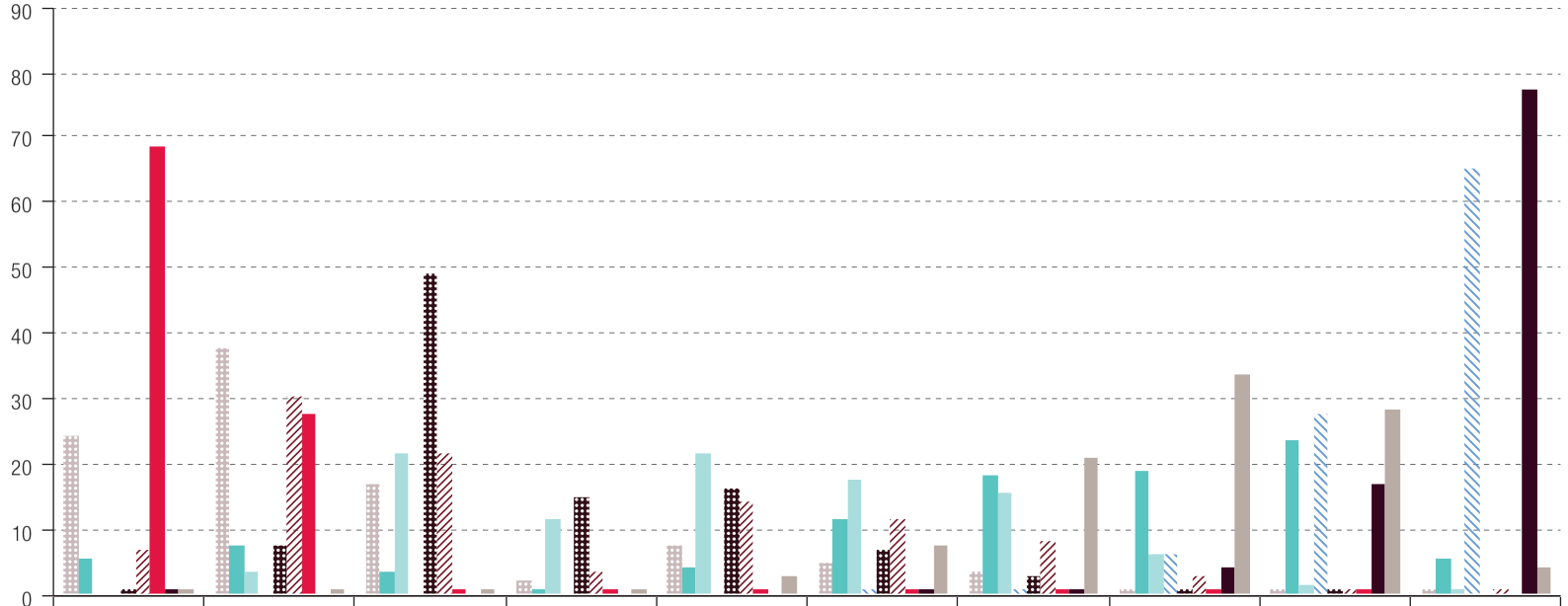
Figure 5
Precariousness clusters by economic sector
(Percentages)



	A. Agriculture, hunting and forestry	B. Fishing	C. Mining and quarrying	D. Manufacturing	E. Electricity, gas and water supply	F. Construction	G. Wholesale and retail trade	H. Hotels and restaurants	I. Transport, storage and communications	J. Financial intermediation	K. Real estate, renting and business activities	L. Public administration and defence	M. Education	N. Health and social work	O. Other community, social, personal service activities	P. Private households with domestic service	Q. Extraterritorial organizations and bodies
PIUI	17.5	2.4	0.5	8.3	0.1	9.6	27.5	4.0	4.3	0.1	1.4	0.2	0.9	0.6	3.3	19.4	0.0
PCI	3.0	0.5	0.2	12.8	0.3	7.1	33.4	5.7	12.3	0.1	6.2	2.2	4.4	3.1	7.0	1.6	0.0
PSSI	4.2	0.5	2.6	14.7	0.8	11.6	20.5	6.1	7.8	0.9	5.9	3.0	7.5	5.5	2.7	5.6	0.1
PSHS	1.1	0.2	6.1	6.4	0.8	5.1	8.0	1.7	6.8	6.4	13.0	12.3	18.5	11.4	2.0	0.1	0.0
PSWI	43.0	0.8	0.9	8.3	0.3	15.4	9.3	2.8	3.6	0.2	2.7	2.6	1.7	1.1	1.5	5.7	0.0
PHIRS	9.3	1.1	0.6	7.6	0.2	9.5	20.5	6.0	11.4	0.3	3.8	1.7	2.2	2.9	3.8	19.0	0.0
PASV	4.7	1.2	0.1	19.2	0.1	5.2	43.3	2.9	2.7	0.0	4.2	0.1	1.2	1.4	5.7	8.0	0.0
PHSA	1.5	0.1	0.7	8.4	0.2	8.3	11.7	4.1	7.3	1.4	34.8	1.5	4.4	8.7	6.6	0.1	0.3
PROIS	1.4	0.4	6.0	11.7	0.7	7.3	13.8	3.3	10.7	3.4	8.2	7.3	13.5	8.8	2.4	0.9	0.1

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Figure 6
Precariousness clusters by earnings deciles
(Percentages)



	I	II	III	IV	V	VI	VII	VIII	IX	X
PIUI	24.7	38.1	16.7	2.4	7.6	5.1	3.7	1.2	0.4	0.1
PCI	5.6	7.6	3.3	0.9	4.6	11.7	18.1	18.7	23.9	5.5
PSSI	0.0	3.5	21.5	11.5	22.0	17.8	15.8	6.1	1.5	0.1
PSHS	0.0	0.0	0.0	0.0	0.0	0.1	0.3	6.2	27.9	65.4
PSWI	0.4	7.9	49.2	14.9	16.6	7.2	3.0	0.7	0.1	0.0
PHIRS	6.8	30.2	21.4	3.5	14.1	11.4	8.2	3.0	1.1	0.3
PASV	68.7	27.6	1.1	0.1	0.3	0.5	0.7	0.3	0.8	0.0
PHSA	0.3	0.0	0.0	0.0	0.0	0.2	1.0	4.3	17.0	77.2
PROIS	0.2	1.2	1.0	0.3	2.7	7.5	21.1	33.8	28.1	4.1

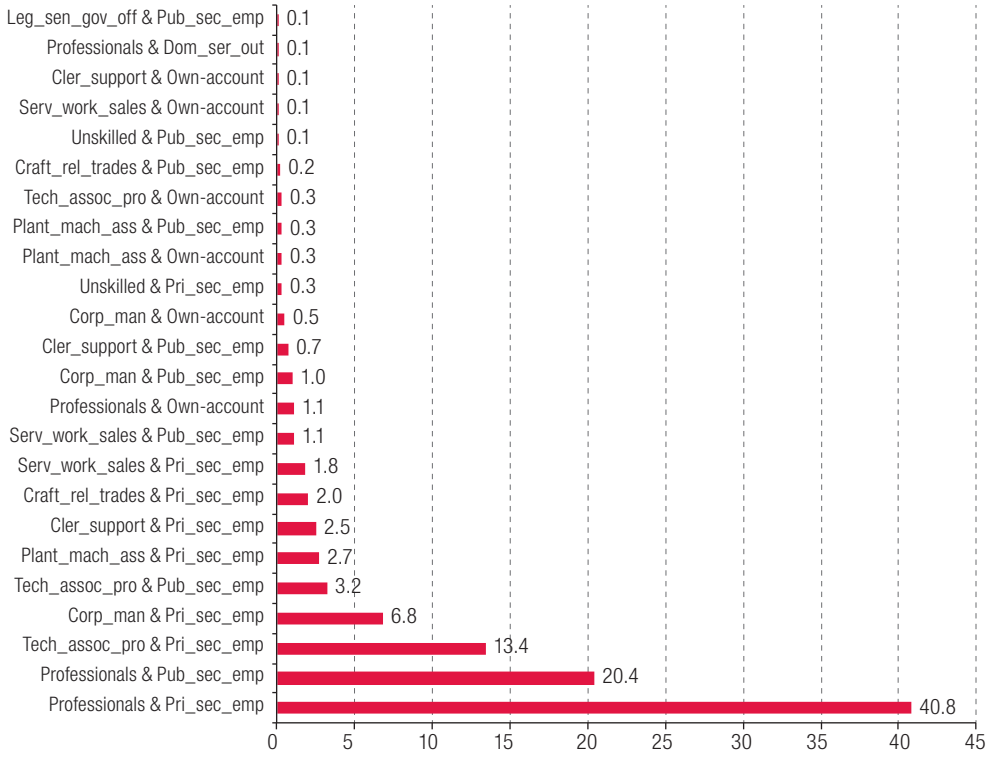
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(a) Protected, stable and highly secure (PSHS)

This group, which accounts for 12% of all cases in the Chilean labour market (see figure 2), is made up of wage workers in a situation of dependent employment who work the legally mandated hours. These are permanent activities carried out under stable employment and contract conditions, without intermediation or subcontracting. They are found in both the public and private sectors and are highly skilled. Membership of a social security system is almost universal, while ISAPREs are the predominant health system. The incomes of this group are in the top two deciles, with a population average ranging from 1,383,812 pesos to 1,389,449 pesos (estimate with 95% confidence) (see table A1.9). Although this is the most protected cluster in the whole classification, there is an element of precariousness in the working hours dimension, i.e., the number of hours worked per week exceeds the average of 45 (see table A1.12).

The class composition of the Protected, stable and highly secure cluster falls essentially into two types of professionals working in conditions of salaried dependent employment: those employed in the private sector (41%) and those employed in the public sector (20%). There are also fractions of mid-level professional technical workers who are employees in the private sector (13%) and corporate managers in the private sector (7%) (see figure 7). The main economic sectors of this male-dominated cluster (61% of its members are men) are education (18.5%), real estate, renting and business activities (13%), public administration and defence (12%) and health and social work (11%). The regions where this type of cluster is seen most are Tarapacá, Antofagasta, the Metropolitan Region, Magallanes, Aysén, Atacama and Valparaíso.

Figure 7
Class fractions in the PSHS cluster (N = 876,645)
(Percentages)

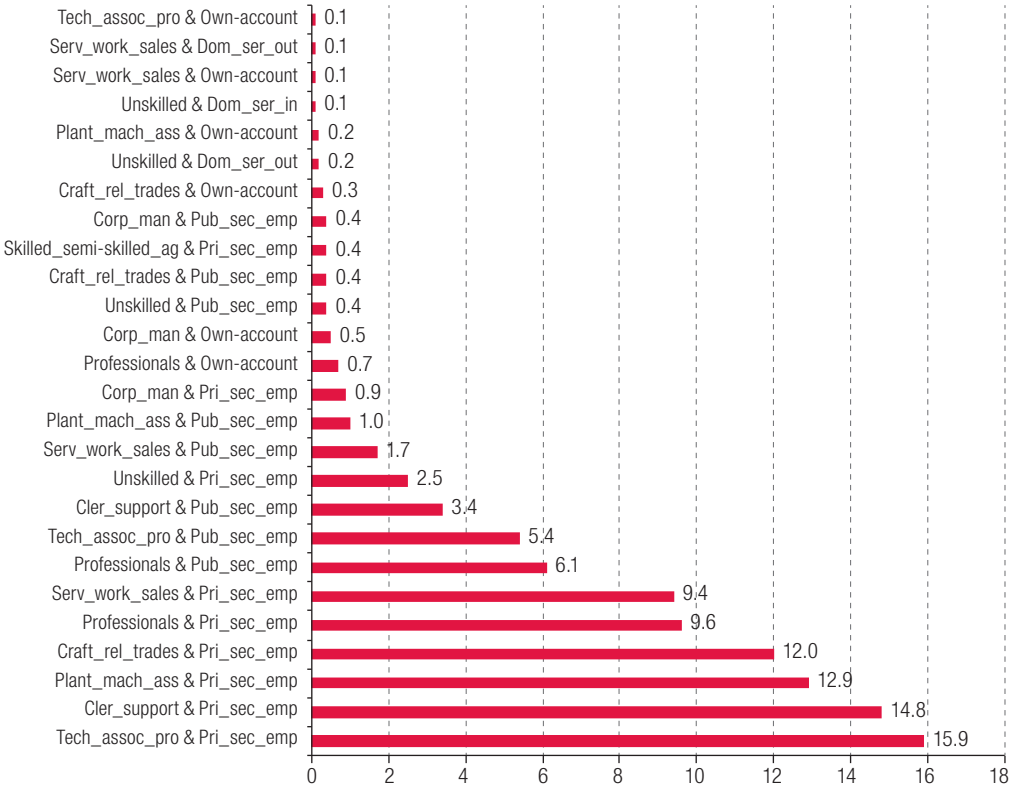


Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(b) Protected with intermediate sufficiency (PROIS)

This large group, which accounts for 17% of the labour market (see figure 2), is composed of low-, medium- and high-skilled manual and non-manual private sector employees (see figure 8). There is a high level of health protection and social security system membership. They also share a high degree of job stability, with high levels of wage employment and formal work contracts. As regards income sufficiency, few members of this group are in the last decile, and it thus has intermediate sufficiency, which may be associated with the heterogeneity of the skills and occupations represented in it. Thus, its members are distributed between deciles VII (32.7%), VIII (25.9%) and IX (23%).

Figure 8
Class fractions in the PROIS cluster (N = 1,263,558)
(Percentages)



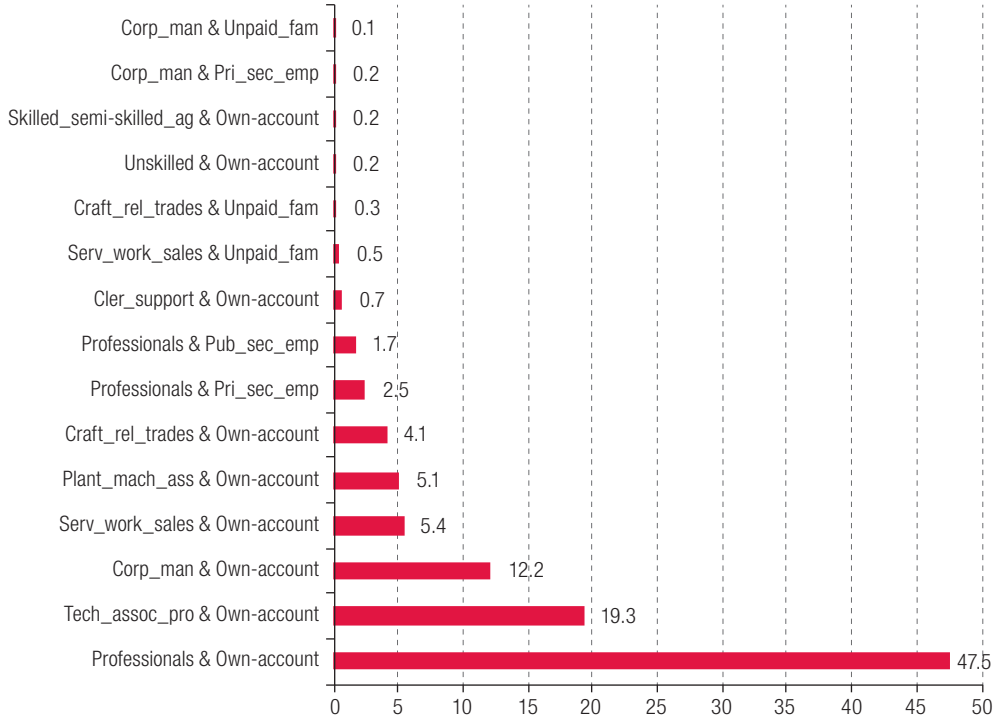
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Class fractions in a situation of dependent employment in the private sector are: technicians and associate professionals in dependent employment (16%), clerks in dependent employment (15%), machine operators and installers in dependent employment (13%), craft and related trade workers in dependent employment (12%), professionals (10%) and service workers and shop and market sales workers in dependent employment (9%). There are also fractions associated with the public sector, such as professionals in dependent employment (6%), technicians and associate professionals in dependent employment (5%) and clerks (3%).

(c) Precarious, highly skilled and autonomous (PHSA)

This group, which accounts for just 1.8% of the total Chilean labour market (see figure 2), is characterized by carrying out own-account activities in high- and medium-skilled non-manual occupations. Its working hours are undemanding and flexible. Although there is a fraction of workers stating that they have employment contracts, the central characteristic of the group is own-account work, while most employees work under open-ended contracts.

Figure 9
Class fractions in the PHSA cluster (N = 134,118)
(Percentages)



Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

There is flexibility in workplace location, which may be associated with professionals working from home and in establishments where freelance work predominates. This is a group with high earnings from their main occupation: 74% are in the top earnings decile, and this is associated with the fact that a substantial proportion prefer private health institutions and are affiliated to one of them. With regard to social security, however, there is a segment that is not affiliated, while a quarter are and do not actually pay contributions. There is a proportion of cases that show the risks of this situation; there is a 25% chance of entering a subgroup with greater exposure to risks and precariousness.

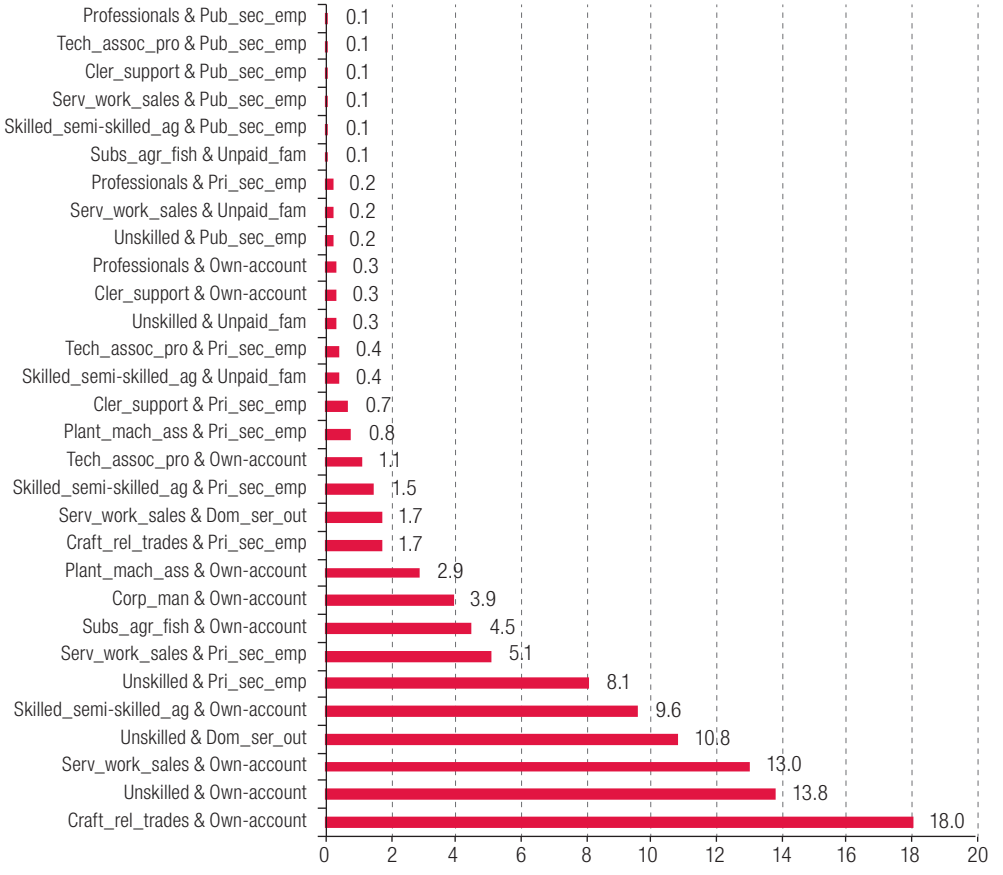
The most significant class fractions in the Precarious, highly skilled and autonomous groups are all self-employed: professionals (47.5%), technicians and associate professionals (19%) and corporate managers (12%) (see figure 9). In addition, this is a very male-dominated group (70%) whose greatest presence is in the Metropolitan and Magallanes regions and which carries out its activities mainly in the areas of real estate, renting and business activities (35%) and commerce (12%).

(d) Precarious, informal and unstable with insufficiency (PIUI)

This cluster, which accounts for 7.8% of the total (see figure 2), is essentially made up of workers who are highly informal, since they do not contribute to the social security system, do not have an employment contract and belong to Group A of FONASA. They work few and flexible hours because their businesses and production activities are highly unstable. Own-account workers are found together with unskilled and unformalized employees on low incomes. Thus, these workers are characterized by a web of vulnerabilities in terms of protection, security and solvency.

Figure 10 shows that the class composition of the Precarious, informal and unstable with insufficiency group is mainly formed by the following categories: own-account craft and related trades workers (18%), own-account unskilled workers (14%), own-account service workers and shop and market sales workers (13%), unskilled live-out domestic service workers (11%), skilled and semi-skilled own-account agricultural workers (10%) and unskilled employees in the private sector (8%). Furthermore, this cluster does not show any significant difference as regards sex, but includes both men and women. La Araucanía, Los Lagos and Los Ríos are the regions where this type of precariousness is most prevalent, while commerce, households with domestic service workers and agriculture are the most important economic sectors.

Figure 10
Class fractions in the PIUI cluster (N = 568,907)
(Percentages)



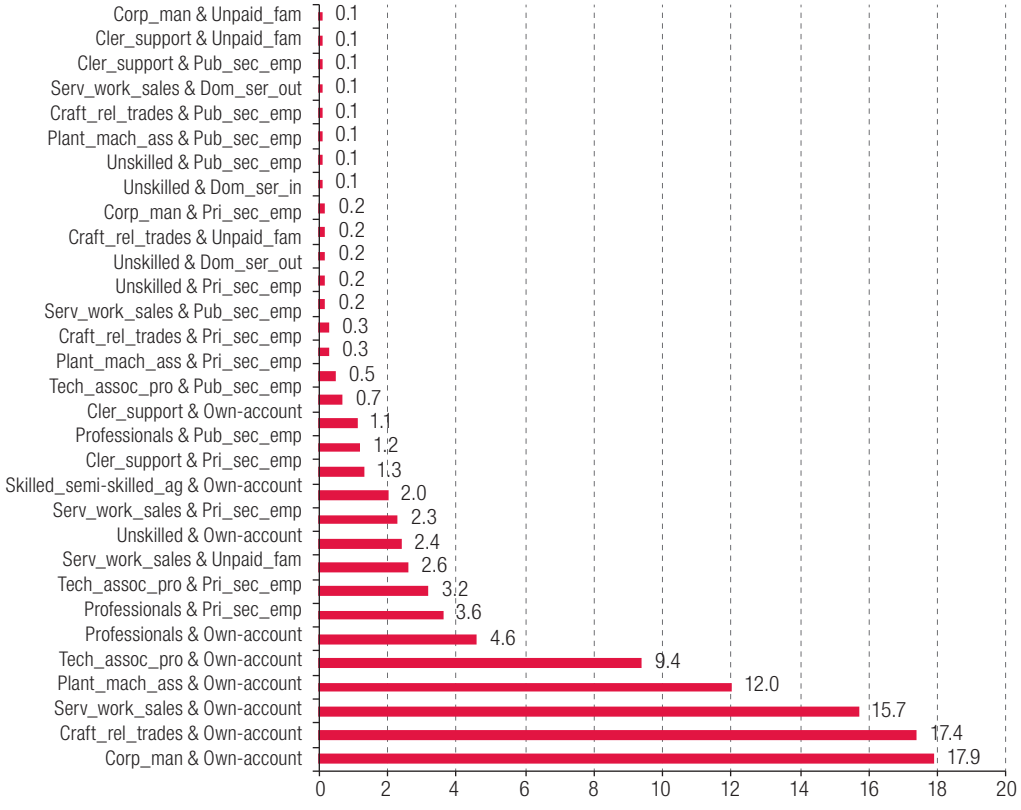
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(e) Precarious and constantly intensive (PCI)

This group makes up 4.9% of the total (see figure 2), with working days that exceed statutory norms and workplaces located in areas close to housing or in the public street, making it difficult to distinguish between family and working life. Businesses are permanent, even though contracts for those who have them are mostly fixed-term. Income levels are uneven, which is reflected in health coverage. There is a discrepancy between social security system membership and the actual payment of contributions, associated with the prevalence of own-account work and unstable employment. Permanence stems from this structural condition of intensive working hours coupled with disparities in the value set on the workforce.

The most important class fractions within this cluster are self-employed. Among the main ones are own-account service workers and shop and market sales workers (16%), own-account plant and machine operators, and assemblers (12%), and own-account technicians and associate professionals (9%) (see figure 11). Although with significantly lower figures, it is also possible to find some cases of dependent employment in the public and private sectors, with low and high skill levels and both manual and non-manual occupations. With regard to economic sectors, the main ones include commerce (33%), industry (13%) and transport, storage and communications (12%). In addition, men are in a substantial majority (63%), while Aysén and Antofagasta are the most important regions.

Figure 11
Class fractions in the PCI cluster (N = 359,923)
(Percentages)



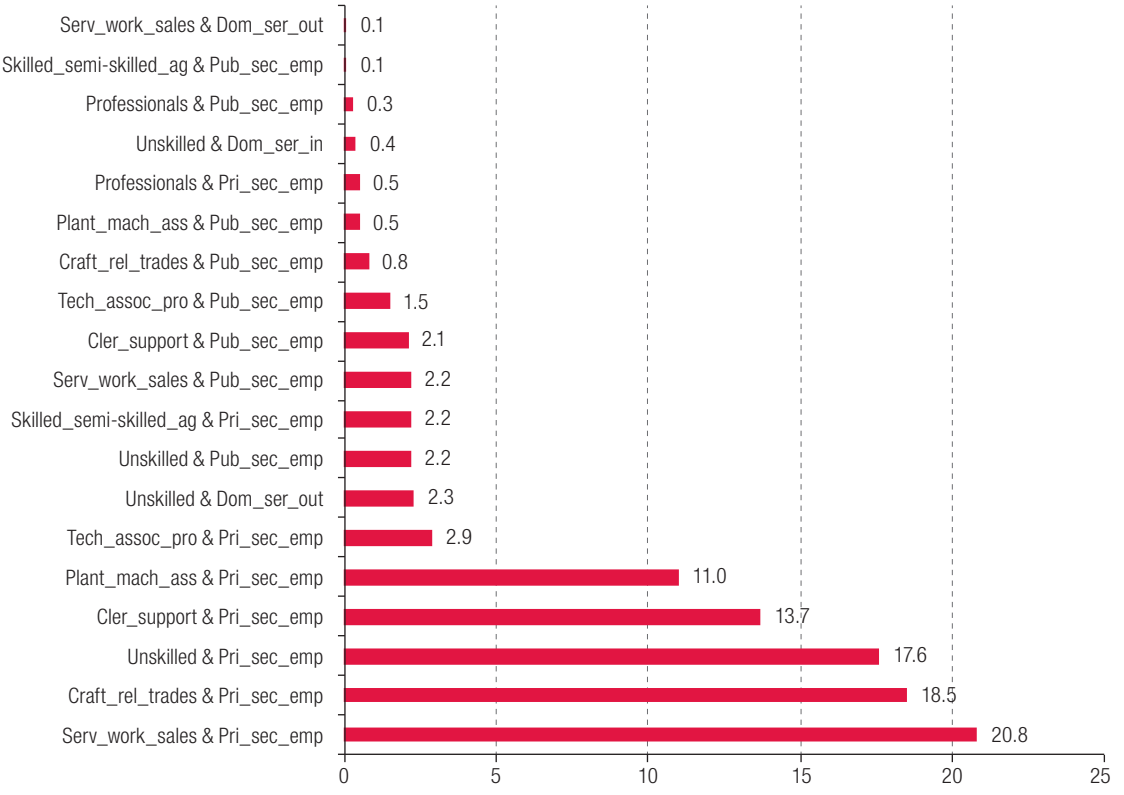
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(f) Precarious with secure and stable insufficiency (PSSI)

This is the group with the most cases in the whole typology (31%) (see figure 2); it is composed of a set of workers with a very high level of dependent wage employment. This status as employees and the prevalence of formal contracts ensure that they participate in social security networks and institutional health care support. Their work is mainly carried out in independent establishments outside the home, subcontracting is found to a marginal extent and employment is highly stable. Notwithstanding the social and working time guarantees offered by these types of formal wage-paying employment, 62% of these jobs pay less than the minimum wage, while 82% pay no more than 300,000 pesos. Thus, the insufficiency dimension is a key feature of this group, as is its concentration in the private sector of the economy.

The fractions composing this group are mainly in a situation of dependent employment in the private sector: service workers and shop and market sales workers (21%), craft and related trades workers (18.5%), unskilled workers (18%), clerks (14%) and machine operators, and assemblers (11%) (see figure 12). The Precarious with secure and stable insufficiency group is 58% male, while the regions with the greatest presence of cases belonging to this cluster are Biobío, Atacama, the Metropolitan Region and Los Ríos. Lastly, the most important branches observed are commerce (20.5%) and industry (15%), although it is important to note that this cluster is distributed across many economic sectors.

Figure 12
Class fractions in the PSSI cluster (N = 2,250,517)
(Percentages)



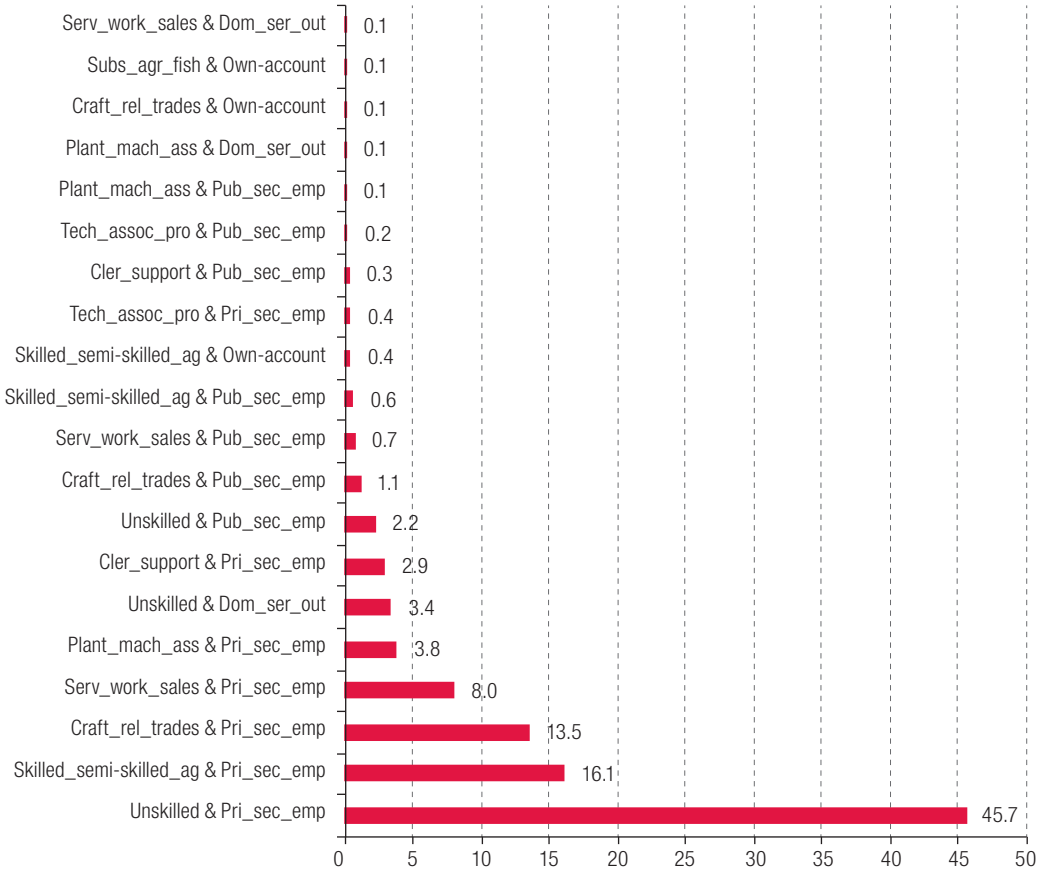
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(g) Precarious and seasonal with wage insufficiency (PSWI)

This group represents 9.5% of the cases studied (see figure 2) and comprises low-skilled and unskilled workers. They work in the private sector, in businesses that are mostly seasonal or temporary. Thus, the predominance of fixed-term contracts indicates a high level of employment instability, and this in a sector (28.5%) that does not have signed contracts. This situation, atypical in dependent waged employment, implies a vulnerable situation as regards social security, something that is not fully illustrated by the stability of contributions and the irregularity of working conditions in terms of hours. Lastly, the vulnerability of this sector is borne out by its position in the State health system (Funds A and B), which is of a piece with the income insufficiency affecting most of the group.

The Precarious and seasonal with wage insufficiency cluster is largely made up of workers in dependent private sector employment: unskilled workers (46%), followed by skilled and semi-skilled agricultural workers (16%) and craft and related trades workers (13.5%) (see figure 13). This cluster is 68% male and most heavily concentrated in the Maule and O'Higgins regions, with agriculture, hunting and forestry as its most important economic sector (43%), followed a long way behind by construction (15%).

Figure 13
Class fractions in the PSWI cluster (N = 693,361)
(Percentages)



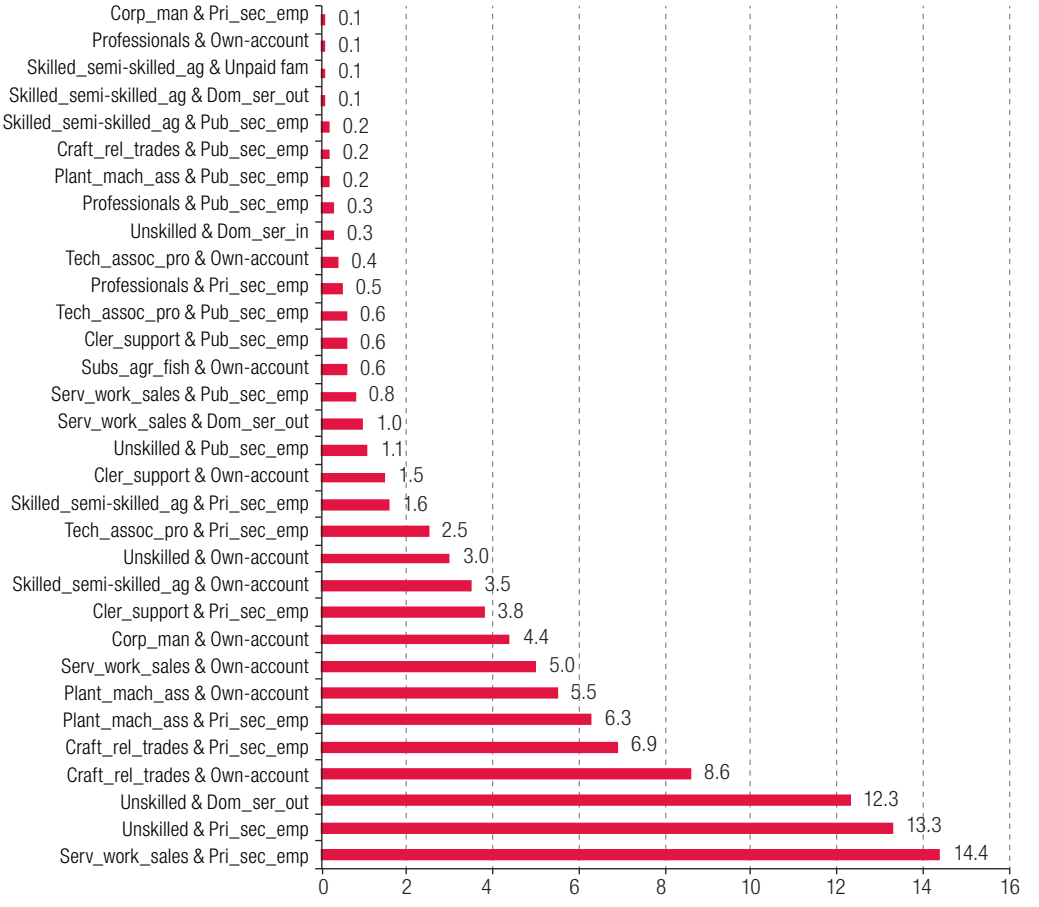
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(h) Precarious, highly insecure and relatively stable (PHIRS)

This group accounts for 10.3% of cases (see figure 2) and is composed of unskilled workers and low-skilled or unskilled non-manual workers who are in a grey area between stable and unstable work. This cluster predominantly lacks contracts, while the level of threat to the stability of employment is high. At the same time, the spatial location of activity is heterogeneous, which is explained by the large shares of live-out domestic service workers and private sector street workers. A critical element that identifies this group is the marked lack of social security coverage or actual contributions by many of its members (34.8%). In addition, these workers present a high degree of income insufficiency, with most being in the low deciles II and III, earning less than the minimum wage (79.1%).

These workers are concentrated in the private sector, where they work as employees. The class fractions that characterize the cluster are unskilled workers, unskilled market and sales workers, and live-out domestic service workers (see figure 14). They are found in the branches of commerce (20%) and domestic service (19%). Men and women have an equal share. They are characterized by membership of the FONASA system (Funds A and B) and, although the vast majority are dependent wage earners, over 50% are not paying into the social security system.

Figure 14
Class fractions in the PHIRS cluster (N = 747,621)
(Percentages)



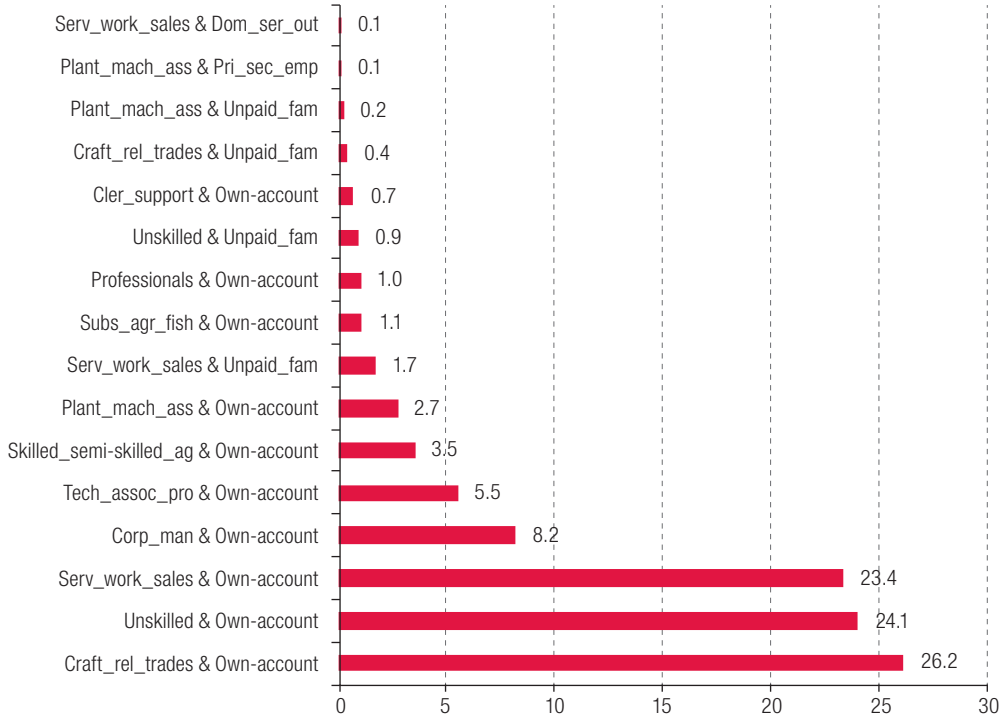
Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

(i) Precarious, autonomous and systemically vulnerable (PASV)

This group accounts for 5.3% of the total (see figure 2) and is made up of low-skilled or unskilled own-account workers with profiles ranging from manual to non-manual activities. Jobs are unstable, being short-lived and without signed contracts. This may be linked to a high prevalence of subcontracting, together with practices on the part of the companies or main businesses that weaken contractual ties.

The location of the work is another symptom of the vulnerability of such jobs, since they are carried out in private premises such as the worker's or employer's home, and often in the public street. Women are overrepresented in this cluster (65%), and it is concentrated in the regions of Araucanía, Coquimbo and Arica and Parinacota. More than 40% of its members work in the commerce sector.

Figure 15
Class fractions in the PASV cluster (N = 383,109)
(Percentages)



Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Another characteristic of this group is the great lack of social security coverage and of actual contributions to the social security system. It is one of the groups with the largest number of sick workers, although this situation is not directly associated with work and is supported by Fund A of FONASA. Lastly, the group is characterized by main incomes that barely exceed the poverty line, while incomes grouped by work (main and secondary) are less than 171,000 pesos in almost all cases (96.3%). For all these reasons, this is a group that presents systemic vulnerability vis-à-vis the dimensions of precariousness in work.

Table 12
Clusters and the component(s) of precariousness they possess

Cluster	Components
PIUI	Instability, Insecurity, Insufficiency, Working conditions, Working hours.
PSWI	Instability, Insecurity, Insufficiency, Working conditions.
PASV	Instability, Insecurity, Insufficiency, Working conditions.
PHIRS	Instability, Insecurity, Insufficiency, Working conditions.
PCI	Insecurity, Insufficiency (intermediate), Working conditions, Working hours.
PHSA	Instability, Insecurity (intermediate), Working conditions, Working hours.
PROIS	Insufficiency and Working hours (both intermediate).
PSSI	Insufficiency.
PSHS	Working hours.

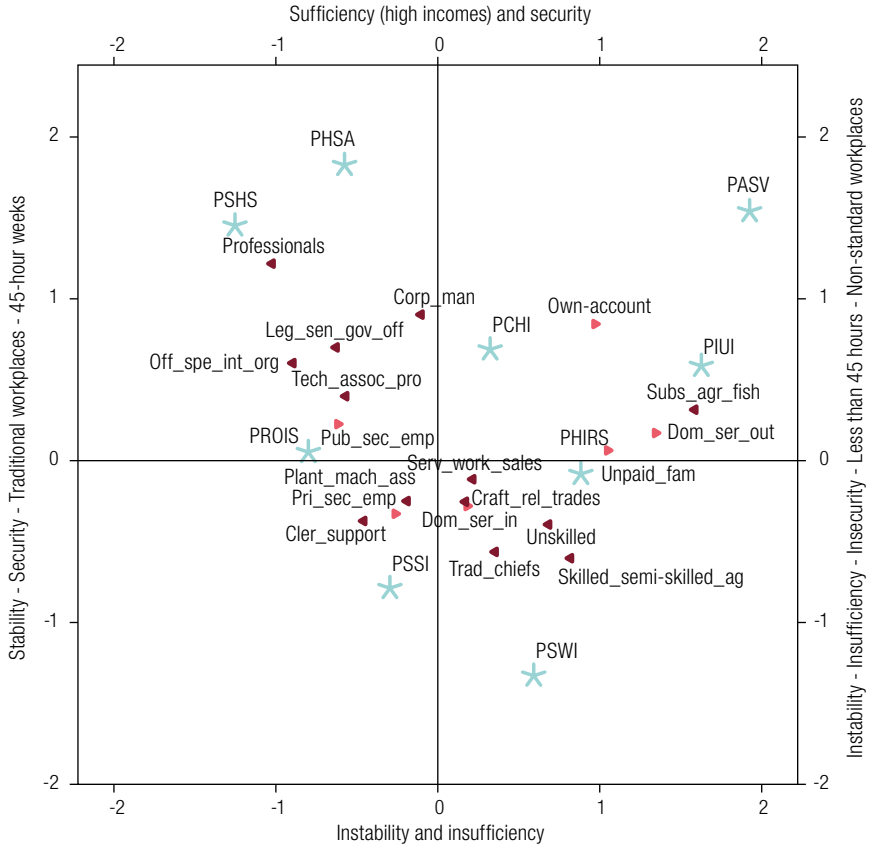
Source: Prepared by the authors.

Table 13
Presence of precariousness in the clusters

	(In)stability	(In)security	(In)sufficiency	Working conditions	Working hours
PSHS	+	+	+	+	–/+
PROIS	+	+	–/+	+	–/+
PHSA	–	–/+	+	–	–
PASV	–	–	–	–	–
PCI	+	–	–/+	–	–
PIUI	–	–	–	–	–
PSSI	+	+	–	+	+
PSWI	–	+	–	–	+
PHIRS	–	–	–	–	+

Source: Prepared by the authors.
Note: (+) Indicates a positive situation (protection) in the dimension; (–) indicates a negative situation (precariousness) in the dimension; (–/+) indicates substantial but not preponderant precariousness in the dimension.

Figure 16
Precariousness profiles, ISCO*rec* and ICSE*rec* in the multidimensional space



Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

V. Conclusions

Precariousness linked to the "(in)stability" component embodies situations involving the absence not only of employment contracts, but also of contributions to the social security and health systems, low earnings and highly seasonal jobs, all of which makes the activities performed unstable and is found in class fractions in situations of self-employment and dependent employment alike. The clearest example of this can be found in the Precarious, informal and unstable with insufficiency (PIUI) and Precarious and seasonal with wage insufficiency (PSWI) clusters.[8] Features of this type of precariousness are also found in the Precarious, highly insecure and relatively stable (PHIRS) cluster[9] and, to a lesser extent, the Precarious, autonomous and systemically vulnerable (PASV)[10] and Precarious with secure and stable insufficiency (PSSI)[11] clusters.

[8] Both groups show a significant presence of precariousness in the four variables of the "(in)stability" dimension: a large proportion of non-permanent and fixed-term employment, absence of written contracts and subcontracting. See tables A1.2, A1.3, A1.4 and A1.5 for estimates of the sample point statistic and the population parameters with their 95% confidence intervals.

[9] With a substantial presence in non-permanent and fixed-term employment, and absence of contracts (see tables A1.2, A1.3 and A1.4).

[10] With precariousness in non-permanent jobs and subcontracting (see tables A1.2 and A1.5).

[11] With precariousness only in fixed-term employment (see table A1.3).

A second precariousness issue concerns the "(in)security" component. Non-contribution to the social security system and to health systems is a marker of those activities, which are mainly carried out on a self-employed basis and tend to be very unstable in terms of working time, low incomes, social security shortfalls and inability to access health plans. The clusters most representative of this component are the Precarious, informal and unstable with insufficiency (PIUI), Precarious, autonomous and systemically vulnerable (PASV),[12] Precarious and constantly intensive (PCI)[13] and, to a lesser extent, Precarious, highly insecure and relatively stable (PHIRS) and Precarious, highly skilled and autonomous (PHSA) groups.[14]

The "(in)sufficiency" component affects low-income activities and is associated with a whole model of labour force valuation in the country (Julián, 2014) and the proliferation of forms of work that are subject to poverty. Its presence across almost all the clusters indicates an income structure subject to precariousness and lack of financial resources in daily life, raising questions about the supplementary economic and associative strategies that make possible the reproduction of labour and life. The clusters with the lowest average incomes are the Precarious, autonomous and systemically vulnerable (PASV) and Precarious, informal and unstable with insufficiency (PIUI) clusters, to which we might add the Precarious, highly insecure and relatively stable (PHIRS), Precarious and seasonal with wage insufficiency (PSWI) and Precarious with secure and stable insufficiency (PSSI) clusters (see table A1.9).

The fourth component is "working conditions". The variable that proved most relevant for describing precariousness in this dimension was the performance of work in non-standard locations (places other than factories or offices), which may be the worker's or customer's own home, workshops attached to dwellings, the public street, open-air production or work sites, etc. The groups most likely to be present in such places are the Precarious, autonomous and systemically vulnerable (PASV), Precarious, informal and unstable with insufficiency (PIUI), Precarious and constantly intensive (PCI), Precarious and seasonal with wage insufficiency (PSWI), Precarious, highly insecure and relatively stable (PHIRS) and Precarious, highly skilled and autonomous (PHSA) clusters (see table A1.10). Occupational sickness or accidents are significantly rare in the nine groups studied.

In the case of "working hours", it is possible to identify phenomena such as underemployment and autonomy in setting hours, as well as overwork and long working days that exceed the legal maximum. Thus, the differentiation of working time evinces heterogeneous situations. First, long hours are worked in situations of self-employment, which implies an individual strategy or inducement. However, some of the self-employed work very short hours. In the case of employees, protection may be accompanied by long working hours. In general, the longest hours are worked by the Precarious and constantly intensive (PCI) and Protected, stable and highly secure (PSHS) groups, while the shortest hours are worked by the Precarious, informal and unstable with insufficiency (PIUI) and Precarious, autonomous and systemically vulnerable (PASV) groups (see table A1.12).

Lastly, tables 11, 12 and 13, which show the main dimensions of precariousness and protection in each group, can be reviewed by way of summary. From all this it is possible to conclude that our typology not only includes a configuration of precariousness for lower class positions, with manual occupations and situations of own-account, dependent and other non-wage employment, but also shows that precariousness permeates segments of the middle and upper working classes. A first example of this is the Precarious, highly skilled and autonomous (PHSA) cluster, a small group (1.8%) of high-income, highly skilled workers who have significant weaknesses in that most are own-account workers, as well as working in non-standard workplaces (in their homes, workshops or premises attached to their homes, etc.). The other group of workers in the middle and upper segments are the Protected, stable and highly

[12] The Precarious, informal and unstable with insufficiency (PIUI) and Precarious, autonomous and systemically vulnerable (PASV) clusters have a high level of non-affiliation to social security systems and lack of actual contributions (see tables A1.6 and A1.7).

[13] Group with a marked lack of actual contributions (see table A1.7) and without health system coverage (see table A1.8).

[14] These last two groups have a high level of non-payment of contributions (see tables A1.7 and A1.8).

secure (PSHS) cluster, who, though protected in different ways, have the third-longest average working day. Thus, the processes leading to precariousness (in its various dimensions) have become pervasive not only in the low-skilled segments, but also in activities that have traditionally enjoyed a higher status, forcing these groups of non-manual workers to undergo processes of adaptation and subsistence in a context of great instability and job churn. All of this reveals levels of precariousness distributed across different social classes, occupations (skilled and unskilled) and employment situations (self-employed, dependent employees in the private sector, etc.).

In short, precariousness as a multidimensional condition is expressed as a cross-cutting and cross-class phenomenon that reaches to the different corners of the Chilean labour market. The consequences and social impacts of precariousness are expressed in the inequality, insufficiency, lack of rights and persistent social vulnerability in which a large part of the working population lives. These kinds of precariousness in working life could be considered the main feature of a society far removed from sociopolitical projects focused on welfare, a precarious society which needs to be made aware of the consequences of this precariousness, and for which mechanisms must be designed to improve the life opportunities of its population.

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Annex A1

Table A1.1
Precariousness groupings by the variables of instability, insecurity, working conditions and working hours
(Percentages)

		PIUI	PCI	PSSI	PSHS	PSWI	PHIRS	PASV	PHSA	PROIS
Is your main work or business…?	Permanent	54.1	82.9	89.9	97.5	31.4	71.3	44.3	86.0	94.2
	Seasonal	17.5	3.4	2.7	0.5	42.9	11.7	8.1	2.9	1.5
	Casual	25.0	10.1	0.9	0.2	4.0	10.4	46.7	9.1	0.6
	Probationary	0.3	1.6	0.5	0.0	2.8	1.2	0.2	0.1	0.2
	Fixed-term	3.0	2.0	5.9	1.8	18.9	5.4	0.7	1.9	3.6
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Contract type	Open-ended	30.9	49.2	83.7	93.0	22.6	56.4	18.0	78.2	89.7
	Fixed-term	69.1	50.8	16.3	7.0	77.4	43.6	82.0	21.8	10.3
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Written contract of employment	Yes, signed	4.9	54.2	96.2	97.5	64.5	37.7	0.0	74.5	96.5
	Yes, but not signed	2.0	1.3	0.7	0.6	3.6	3.0	10.9	3.6	1.1
	No	91.1	42.1	2.2	1.6	28.6	56.1	89.1	18.9	1.7
	Don't remember or don't know if contract signed	2.0	2.4	0.9	0.4	3.4	3.2	0.0	3.0	0.6
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With whom did you sign your contract or enter into your employment agreement?	Directly with the company, or negotiates at workplace	96.5	98.4	89.2	98.5	81.4	93.9	73.7	100.0	94.6
	With a goods or services contractor or subcontractor	2.6	1.6	10.0	1.4	16.7	5.5	26.3	0.0	5.1
	With a temporary services firm, staff supplier or employment agency	0.9	0.0	0.7	0.1	1.9	0.6	0.0	0.0	0.3
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Social security system	Yes	47.5	65.8	98.9	99.0	91.3	74.4	43.0	76.9	98.8
	No	52.5	34.2	1.1	1.0	8.7	25.6	57.0	23.1	1.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Paying into some social security system	Yes, AFP. Compulsory employee contributions	4.5	23.9	96.1	89.3	76.9	35.4	3.1	30.9	93.1
	Yes, AFP. Voluntary contributions by self-employed worker	3.0	22.0	0.4	2.7	0.5	4.2	4.7	39.0	1.0
	Yes, Institute of Social Security (IPS), formerly Institute of Social Security Standardization (INP). Retirement Fund for Public Sector, Private Sector Employees, Social Security Service (SSS), etc.	1.2	0.4	0.4	0.3	0.6	1.5	1.4	0.5	0.4
	Yes, National Defence Retirement Fund	0.1	0.7	0.1	2.6	0.0	0.1	0.2	0.8	0.8
	Yes, Carabineros Pension Service	0.0	0.4	0.0	2.7	0.0	0.0	0.4	1.0	0.5
	Yes, other. Please specify	0.0	0.5	0.1	0.3	0.0	0.1	0.1	0.5	0.2
	Not paying in	91.1	52.1	3.0	2.0	22.0	58.6	90.0	27.2	4.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table A1.1 (concluded)

		PIUI	PCI	PSSI	PSHS	PSWI	PHIRS	PASV	PHSA	PROIS
Health	FONASA A	66.5	24.6	6.7	0.5	27.4	40.2	59.1	4.0	1.9
	FONASA B	17.6	24.3	38.5	2.6	47.0	32.0	20.1	8.5	10.5
	FONASA C	3.1	5.8	28.9	1.8	12.8	7.6	3.6	4.1	15.1
	FONASA D	1.7	5.4	12.6	9.1	3.3	4.1	3.4	7.1	29.5
	FONASA group unknown	2.0	5.6	8.9	1.6	5.0	4.1	3.0	2.8	7.0
	Armed forces and police	0.5	2.2	0.3	5.8	0.0	0.5	1.4	3.6	2.6
	ISAPRE	1.1	17.5	2.3	77.6	0.1	2.9	3.7	61.6	31.0
	None	6.6	13.6	0.5	0.6	3.0	7.6	5.2	7.4	1.3
	Other system	0.7	0.9	1.3	0.3	1.3	1.0	0.5	0.7	0.9
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Place where activity carried out or business located	In home	7.6	17.2	0.3	0.4	0.1	1.7	33.0	22.4	0.7
	Workshop or premises attached to home	6.3	17.5	1.0	0.8	0.6	4.0	8.3	8.4	0.9
	In an independent establishment (factory, office, etc.)	13.4	34.0	73.2	86.1	29.8	39.7	7.5	49.7	77.4
	On a farm	16.8	2.1	2.4	0.5	41.7	8.1	2.7	0.8	0.5
	At sea	1.5	0.4	1.0	0.4	1.0	1.0	0.6	0.2	0.8
	In employer's or customer's home	31.6	8.8	4.7	1.0	7.7	23.9	19.1	5.8	1.7
	In the public street, land, air or water transport	18.3	15.5	5.9	2.3	5.5	15.0	22.2	6.5	7.0
	Production and construction sites, mines, etc.	1.8	1.9	10.3	7.0	12.9	4.3	0.6	2.3	9.8
	Elsewhere	2.7	2.6	1.2	1.4	0.8	2.2	5.9	3.8	1.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sickness or accident	Yes, sickness caused by work	2.6	2.7	3.3	3.8	2.3	2.3	3.1	3.4	3.5
	Yes, sickness not caused by work	14.4	14.5	11.8	14.0	10.4	13.8	19.9	12.3	12.1
	Yes, accident at work or school	0.6	0.2	0.7	0.6	0.8	0.7	0.3	0.4	0.5
	Yes, accident not at work or school	1.5	1.2	0.8	1.0	0.7	0.8	2.1	0.9	0.9
	No sickness or accident	80.9	81.3	83.3	80.6	85.8	82.4	74.7	83.0	83.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Working hours	<= 44	66.8	46.9	18.1	33.9	19.7	47.7	84.5	47.7	25.2
	45–45	10.5	12.8	60.7	41.8	61.3	23.4	3.0	16.8	50.9
	46+	22.7	40.3	21.2	24.4	19.1	28.9	12.5	35.5	23.8
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.2
Parameter estimates: non-permanent jobs

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval (percentages)	
				Lower	Upper
PIUI	568 907	45.67	49.81	45.54	45.80
PCI	359 923	17.01	37.57	16.89	17.13
PSSI	2 250 517	10.05	30.07	10.01	10.09
PSHS	876 645	2.51	15.64	2.48	2.54
PSWI	693 361	68.42	46.48	68.31	68.53
PHIRS	747 621	28.54	45.16	28.44	28.64
PASV	383 109	54.72	49.78	54.56	54.87
PHSA	134 118	13.90	34.59	13.71	14.08
PROIS	1 263 558	5.78	23.33	5.73	5.82

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.3
Parameter estimates: fixed-term employment

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	21.45	41.05	21.34	21.56
PCI	359 923	6.53	24.71	6.45	6.61
PSSI	2 250 517	16.25	36.90	16.21	16.30
PSHS	876 645	6.55	24.73	6.49	6.60
PSWI	693 361	76.56	42.36	76.47	76.66
PHIRS	747 621	28.29	45.04	28.19	28.39
PASV	383 109	0.24	4.90	0.22	0.26
PHSA	134 118	0.81	8.99	0.77	0.86
PROIS	1 263 558	9.91	29.89	9.86	9.97

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.4
Parameter estimates: no written contract

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	29.51	45.61	29.39	29.63
PCI	359 923	5.90	23.56	5.82	5.98
PSSI	2 250 517	3.81	19.15	3.79	3.84
PSHS	876 645	2.28	14.93	2.25	2.31
PSWI	693 361	35.13	47.74	35.02	35.24
PHIRS	747 621	40.06	49.00	39.95	40.17
PASV	383 109	0.29	5.41	0.28	0.31
PHSA	134 118	0.95	9.72	0.90	1.00
PROIS	1 263 558	3.37	18.04	3.34	3.40

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.5
Parameter estimates: subcontracting

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	42.34	49.41	42.22	42.47
PCI	359 923	13.40	34.07	13.29	13.51
PSSI	2 250 517	3.63	18.71	3.61	3.66
PSHS	876 645	0.70	8.31	0.68	0.71
PSWI	693 361	46.76	49.90	46.65	46.88
PHIRS	747 621	22.00	41.42	21.90	22.09
PASV	383 109	53.83	49.85	53.67	53.98
PHSA	134 118	11.93	32.42	11.76	12.11
PROIS	1 263 558	2.04	14.13	2.01	2.06

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.6
Parameter estimates: not affiliated to social security system

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	50.78	49.99	50.65	50.91
PCI	359 923	32.81	46.95	32.66	32.96
PSSI	2 250 517	1.05	10.17	1.03	1.06
PSHS	876 645	0.99	9.91	0.97	1.01
PSWI	693 361	8.45	27.82	8.39	8.52
PHIRS	747 621	24.92	43.26	24.83	25.02
PASV	383 109	56.02	49.64	55.87	56.18
PHSA	134 118	22.58	41.81	22.35	22.80
PROIS	1 263 558	1.22	11.00	1.21	1.24

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.7
Parameter estimates: affiliated to social security system but not paying in

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	41.71	49.31	41.59	41.84
PCI	359 923	32.41	46.80	32.25	32.56
PSSI	2 250 517	2.91	16.82	2.89	2.93
PSHS	876 645	1.99	13.98	1.96	2.02
PSWI	693 361	19.19	39.38	19.09	19.28
PHIRS	747 621	41.72	49.31	41.61	41.83
PASV	383 109	37.77	48.48	37.61	37.92
PHSA	134 118	19.89	39.92	19.68	20.10
PROIS	1 263 558	3.90	19.35	3.86	3.93

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.8
Parameter estimates: not affiliated to health system

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	6.51	24.66	6.44	6.57
PCI	359 923	13.24	33.89	13.13	13.35
PSSI	2 250 517	0.50	7.05	0.49	0.51
PSHS	876 645	0.55	7.42	0.54	0.57
PSWI	693 361	2.91	16.80	2.87	2.95
PHIRS	747 621	7.44	26.24	7.38	7.50
PASV	383 109	5.15	22.10	5.08	5.22
PHSA	134 118	7.27	25.97	7.14	7.41
PROIS	1 263 558	1.29	11.28	1.27	1.31

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.9
Parameter estimates: mean earnings

Cluster	N	Point estimate of the mean *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	551 355	156 790	119 834	156 474	157 106
PCI	338 834	470 009	402 979	468 652	471 366
PSSI	2 225 037	280 413	105 838	280 274	280 552
PSHS	874 723	1 386 631	1 344 898	1 383 812	1 389 449
PSWI	664 417	221 514	52 453	221 388	221 640
PHIRS	718 468	217 396	127 915	217 100	217 692
PASV	361 915	78 191	78 014	77 937	78 446
PHSA	131 587	1 688 940	1 487 077	1 680 906	1 696 975
PROIS	1 247 400	513 347	312 763	512 798	513 896

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.10
Parameter estimates: non-standard workplaces

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	86.16	34.53	86.07	86.25
PCI	359 923	65.27	47.61	65.12	65.43
PSSI	2 250 517	26.81	44.30	26.75	26.87
PSHS	876 645	13.92	34.62	13.85	14.00
PSWI	693 361	70.22	45.73	70.11	70.32
PHIRS	747 621	60.04	48.98	59.93	60.15
PASV	383 109	91.89	27.30	91.80	91.98
PHSA	134 118	49.97	50.00	49.70	50.23
PROIS	1 263 558	22.61	41.83	22.54	22.68

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.11
Parameter estimates: occupational sickness or accidents

Cluster	N	Point estimate of the proportion *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	3.11	17.37	3.07	3.16
PCI	359 923	2.89	16.75	2.83	2.94
PSSI	2 250 517	3.99	19.57	3.96	4.01
PSHS	876 645	4.29	20.26	4.25	4.33
PSWI	693 361	3.08	17.28	3.04	3.12
PHIRS	747 621	2.92	16.85	2.89	2.96
PASV	383 109	3.29	17.84	3.23	3.35
PHSA	134 118	3.64	18.74	3.54	3.74
PROIS	1 263 558	3.91	19.37	3.87	3.94

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

Table A1.12
Parameter estimates: average weekly hours

Cluster	N	Point estimate of the mean *(percentages)*	Standard deviation *(percentages)*	95% confidence interval *(percentages)*	
				Lower	Upper
PIUI	568 907	40.7	85.1	40.5	40.9
PCI	359 923	50	86.4	49.7	50.3
PSSI	2 250 517	46.5	39	46.4	46.5
PSHS	876 645	47.9	58.4	47.7	48
PSWI	693 361	46.1	39.4	46	46.2
PHIRS	747 621	45.1	72.8	45	45.3
PASV	383 109	38.1	118.5	37.7	38.5
PHSA	134 118	46.1	58.9	45.8	46.4
PROIS	1 263 558	48.4	59	48.3	48.5

Source: Prepared by the authors, on the basis of the 2013 National Socioeconomic Survey (CASEN).

What is life like for our elderly? An empirical study of the quality of life of older people in Colombia[1]

Bilver Adrián Astorquiza Bustos and Óscar Armando Chingal

Abstract

Life expectancy has increased considerably over the last 50 years; and population pyramids have inverted as the number of older people has grown. This study analyses the quality of life enjoyed by older people in nine of Colombia's regions or departments, as rated in four categories: "Very good", "Good", "Fair" or "Poor". It estimates an ordered multinomial logistic model using 20,720 observations taken from the 2018 National Quality of Life Survey, which altogether represent 3,914,448 individuals. The results suggest that the average probability of having a quality of life rated good is 80.2%, with variations between geographical areas and differences that are associated positively with being a woman, belonging to medium and high socioeconomic groups, not missing daily meals, having a home of one's own home, not being affiliated to the subsidized social security regime and not feeling insecure or poor, among other factors.

Keywords

Ageing person, quality of life, social welfare, measurement, evaluation, population aspects, surveys, statistical methodology, econometric models, Colombia

JEL classification

J14, I31, C35, I10

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[1] We are very grateful for the valuable comments made by Professor Rosa Emilia Bermúdez, which have greatly improved this article from a sociological perspective.

I. Introduction

Life expectancy has increased considerably over the last 50 years, as a result of technological progress, government policies to improve the population's living conditions and the early detection of diseases that compromise human health and for which effective treatments were not previously available. World Bank population indicators show that average life expectancy in Europe and Central Asia, North America, East Asia and the Pacific, the Middle East and North Africa, sub-Saharan Africa and Latin America and the Caribbean was 18.9 years shorter in the early 1960s than in 2017, which is evidence of increasing population longevity (see table 1).

Table 1
Life expectancy and population by geographical region

Region	Life expectancy		Population *(millions)*		Population growth *(percentages)*
	1960	2017	1960	2017	
Colombia	56.75	74.56	16.06	48.90	204.53
East Asia and the Pacific[a]	45.72	74.64	894.88	2 068.16	131.11
Europe and Central Asia[a]	63.39	73.18	275.15	415.71	51.09
Latin America and the Caribbean[a]	55.64	75.57	204.21	603.25	195.40
North America	69.89	78.94	198.62	361.75	82.13
Sub-Saharan Africa[a]	40.38	60.80	227.19	1 050.06	362.19
Middle East and North Africa[a]	46.61	73.23	97.55	376.55	285.99
Average	54.05	72.99			

Source: Prepared by the authors, on the basis of data from the World Bank.
[a] Excluding high-income countries.

Colombia is no exception to this trend. The population projection report of the National Administrative Department of Statistics (DANE, 2017) states that the country had some 5,970,956 inhabitants aged 60 years or over (12.4% of the population) in 2017; and, of these, an estimated 54.87% were women. World Bank figures for Colombia also support the hypothesis of an inversion of the population pyramid, since life expectancy increased from 56.75 years in 1960 to 74.56 in 2017. This demographic transition is also evidenced by an analysis of population growth between 2005 and 2017: while the number of young people aged 12 to 25 years increased by 6.1%, the number of older persons (aged 60 or over) grew by 56.5%. (DANE, 2017).

This population dynamic attracted research agendas in various fields towards studying ways to improve the living conditions of older people. The research is being led mainly by the clinical sciences, given the intrinsic relationship between an individual's quality of life and his/her health status, as demonstrated, for example, by the studies of Ehlke (1998), Bazo (1999), Rivera-Ledesma and Montero (2005) or Marín and others (2009). Although it has been possible to identify a number of factors associated with enhanced well-being among the older-age population (actions, behaviour or characteristics that are conducive to a better quality of life), the literature is still sparse, especially in the economic sciences.

As people today can expect to live longer than their forbears, there is an urgent need to examine the state of well-being of older persons, using quantitative methodologies of statistics and economics that are easy to transfer academically and could be replicated in other countries. This study therefore poses the following exploratory question: what were quality-of-life conditions like for older persons in Colombia in 2018? To answer this, an analysis is made of a set of factors that influence the likelihood that older people will have a quality of life rated very good, good, fair or poor. The ratings are obtained directly from the question on perceptions prepared by the National Administrative Statistics Department (DANE) of Colombia, which ranks the categories using the method of summary evaluations on a Likert

scale. In the scientific domain, it has been found that when the number of categories is large, individuals tend to bias their response towards one category in particular. Accordingly the question designed by the Colombian institution has only four.

To answer the question referred to above, the following statement is tested as a research hypothesis: "In 2018 older people in Colombia are more likely to enjoy a quality of life rated good than one rated very good, fair or bad; nonetheless, this may be influenced by the region in which the person lives, which denotes the existence of specific conditions that reflect not only sociodemographic characteristics, but also geographical ones".

Quality of life is a multidimensional concept, since it is based on subjective and objective conditions that are present throughout the life cycle —such as income level, years of schooling, feelings of security, health status, personal satisfaction, family relations, social services and social participation (Giraldo and Arango, 2012, p. 161). Thus, to analyse the quality of life, a set of variables are introduced which, for simplicity, are condensed into four categories: (i) demographic characteristics, (ii) socioeconomic characteristics, (iii) employment relationships; and (iv) perceptions of the surroundings. This makes it possible to quantify the chances of having a very good, good, fair or bad quality of life, along with the associated characteristics.

This article is structured in five sections, including this introduction. Section II reviews the quality-of-life literature, specifically as regards the study group (older people). Section III then briefly discusses the demographic definition of older people, by chronological age, since this makes it possible to objectively define the population classified as older and also follows the criterion established by various international agencies. The next section describes the methodological approach: the control variables, their functional form, the justification for using the econometric method and the main sample statistics. Lastly, section V presents the results of the econometric inference, followed by conclusions, recommendations and the limitations of the study.

II. Literature review

Health is one of the factors associated with quality of life, since poor health generates bodily and mental problems that degrade an individual's well-being. Authors such as Ehlke (1998), Bazo (1999) and Rivera-Ledesma and Montero (2005) argue that a large proportion older people present health problems that tend to worsen with age, affecting their functional capacity and, hence, their quality of life. Along the same lines, Bazo (1999) specifies that the most prevalent diseases are chronic-degenerative ones, the severity of which depends on the lifestyle that individuals have led and on whether they attend periodic medical check-ups. Thus, despite being condensed in simplistic terms, it is clear that health affects an individual's quality of life, but how it does so is determined by his/her economic capacity.

The Fernández-Ballesteros study (1997) analyses the quality of life of 1,014 persons aged over 65 in Spain, in terms of variables such as health status, gender, functional skills, economic status, social relations, activity (social role) or access to social services, among others. In particular, it analyses whether there are quality-of-life differences that depend on the type of home in which the elderly person lives —in his/her own home, as a resident in a public institutions or else in a private institution. Based on this segmentation, the author finds that high socioeconomic level, male sex, middle and high income level and living in one's own home explain the presence of a better quality of life during old age, since such individuals report having better functional skills and greater social integration. However, there are no empirical data that support the hypothesis that the type of home, whether public or private, in which an elderly person lives, determines his/her quality of life exclusively.

In another study, Chackiel (2000) analyses the implications of the increase in the number of older people in Latin America. A theoretical framework is used to show that not all people reach old age at the same time, since that stage of life is identified in terms of physical and cognitive abilities. Moreover, the author provides a conceptual overview of the inversion of the population pyramid (fewer births and more people surviving to an advanced age) due to the effect of the demographic transition associated with a country's development. The second part of the study focuses on the fiscal challenges of coordinating social investment in order to reduce the dependency rates that can affect older persons, since a scenario of fewer births and larger numbers of older people imposes a heavier burden on the State in the pension system, and reduces incentives for young people who are active in the labour market to contribute to private funds.

Bravo (2000) also analyses population ageing in Latin America, noting that the region has gone through a rapid demographic transition process and projecting low birth rates and much longer life expectancy in the years to come, which will affect pension systems and, therefore, the population's standard of living. Unlike the previous study (Chackiel, 2000), this author makes a more in-depth analysis of the fiscal sustainability of pension systems based on "the transition costs". He argues that, whereas countries such as Argentina and Cuba are in advanced stages of the demographic transition, Colombia is at an early stage. Nonetheless, he concludes that, in general, all economies face enormous huge in their pension systems, which justifies efforts to find mechanisms that will help alleviate the concomitant fiscal pressures.

In a diagnosis of the well-being of older persons in Latin America, the Economic Commission for Latin America and the Caribbean (ECLAC, 2004) states that older persons have difficulty accessing the pension system if they have engaged in informal economic activities during the productive stage of their life; and this situation leads to heavy social dependency on other persons, whether family members or others. In some cases, such third-party support is not available, leading to conditions of vulnerability that can result in poverty. The publication argues that this explains why the quality of life of older people is less than good: they have low coverage in the health system, precarious conditions of care and treatment of their illnesses, limited access to recreation and leisure, and occupational health problems. In contrast, affiliation to the social security system (as a sign of formal labour market activity) is associated with access to services that would otherwise be inaccessible, such as the health system.

The study by Arango and Ruiz (2006) analyses the trend of a number of socioeconomic indicators of Colombia's elderly population, by comparing the 2005 and 1993 population censuses. The authors suggest that there is still a clear social deficit in terms of elderly care, arguing that better indicators of access to the pension system and expanded coverage of the health system should lead to better living conditions. They also highlight this population group's susceptibility to poverty, which in principle is explained by low income at the pension stage; and they again emphasize the high rates of family dependency that tend to be created.

Ramírez-Vélez and others (2008) conducted a clinical study in the city of Santiago de Cali (Colombia) to analyse the socioeconomic and anthropometric variables associated with the emergence of chronic noncommunicable diseases among women aged 65 to 87 without physical or psychological difficulties and not hospitalized in any medical centre or residence. Their findings show that factors such as being overweight, suffering from hypertension and loss of functional capacity, which lead to a high prevalence of disabilities among this population, detract from their quality of life.

The effect of feeding habits and symptoms of depression on a person's quality of life has been addressed by Ávila-Funes, Garant and Aguilar-Navarro (2006), with an analysis based on 1,748 older people in Mexico. These authors applied a compendium of variables aligned on the categories of oral health, mental function and functionality, and used as a dependent variable the Yesavage geriatric depression scale, which ranges from 0 to 12 (scores above 6 indicate the presence of depressive symptoms). The results show that diet affects symptoms of depression; but dental problems, difficulty

in handling money and high blood pressure are factors linked to the symptomatology of cognitive dysfunction and, therefore, also affect the quality of life of the elderly person. Thus, health conditions are again associated with quality of life, in this case highlighting the importance of feeding patterns.

Marín and others (2009) reiterate the multidimensional nature of quality of life, highlighting aspects associated with pathological, health, demographic, anthropometric, clinical and nutritional conditions, among others, which are clearly decisive for elderly well-being. The research analyses health promotion as a strategy to improve quality of life, using a sample of 700 older people in Argentina. The conclusion is that living alone in the home, having physical impairments and presenting depressive symptoms, cholesterol problems, overweight and nutritional risk are associated with fair or poor health; while a good quality of life is determined by the absence of pathological conditions that restrict mobility, such as obesity, heart disease or undernourishment, among others.

Estrada and others (2011) state that, although the concept of quality of life is multidimensional, each area of knowledge is approached from a different theoretical framework or methodological process: for economists the concept focuses on well-being, income and living standards and conditions. From a sample of 276 people over 65 years of age in the city of Medellín, the authors analyse the relationship between demographic characteristics, social support, nutritional status, symptoms of depression, anxiety risk and functional capacity, using the quality of life assessment scale for older people proposed by the World Health Organization (WHO). The profile of an older person with a lower score on the scale and, therefore, worse quality of life, can be characterized as follows: she is a woman, feels mistreated by family members and has diabetes, symptoms of depression and an increasingly limited functional capacity.

Melguizo, Acosta and Castellano (2012) were the first to use econometrics as a methodological strategy for measuring the quality of life of older people. The authors develop a logistic regression model and obtain results similar to those of this research, in terms of health-related quality of life. Firstly, they identify gender differences in quality of life: being a man is associated with better physical and emotional well-being, while women display better self-care. They also note that elderly pensioners, at any socioeconomic level other than low, who live in a free union and whose level of education is better than basic primary, display better physical and psychological well-being, self-care and occupational functioning.

As regards the interest of this research in finding a relationship between the labour market and quality of life, the study by Escarbajal and Martínez (2012) provides a relevant approach. These authors note that older people who are still productively employed score better in terms of quality of life than the unemployed; they argue that retirement is one of the most important changes an older person experiences: in most cases it leads to a loss of social status, reduces support networks and causes a drop in income, which leads to a redefinition of personal relationships with their surroundings.

Studies that analyse pensions and their impact on quality of life include that of Schatz and others (2012). These authors perform a quantitative and qualitative analysis of how pensions influence the well-being and health of men and women in South Africa. Using logistic regression as a contrasting method, they found that pensions had a particularly strong impact on the declared well-being of older women. However, qualitative data suggested that men initially used their pension to buy large household items, while women used it for daily household maintenance.

Lloyd-Sherlock and others (2012) make a comparative study of older people in South Africa and Brazil, considering the relationship between pension and well-being with data obtained from two surveys conducted in 2002 and 2008. In South Africa, older people were defined as those over 54 years of age, while in Brazil 60 was used as the cut-off age. The results of the 2002 survey support the claim that pensions could have a significant effect on the economic status of poorer households in countries such as Brazil and South Africa; while data from the 2008 survey suggest that the South African health system is much more effective in serving older people than its Brazilian counterpart, so pensions and the health system have a positive impact on the well-being of this population group.

Another interesting finding on the effect of pensions on the quality of life of older people is provided by Kaushal (2014). The author analyses the pension system in India and its effect on people over 65, and notes that receiving pension is associated with an increase in expenditure on medical care. He also estimates that in 50 years' time 80% of the world's elderly will live in developing countries, since the increase in life expectancy is more recent in these countries.

Research on older people has continued in the clinical setting in the last few years. Rubio and others (2015) explain why the quality of life of older people ought to be studied; and they use the guidelines issued by health authorities in Cuba to establish standards for their quality of life. The authors argue that quality of life is determined by sociodemographic characteristics; so protocols are needed for a systematic evaluation to identify the key factors that lead to a better quality of life in domains such as mental health, public and private services, social protection, the economy and education, among others. The authors argue that improving the quality of life is more important than increasing life expectancy.

Varela and Gallego (2015) make a qualitative assessment of the perception of quality of life among a group of older people located in Envigado (Colombia). The authors selected a sample of people with different income levels and interviewed them to identify the subjective and objective conditions that could affect their quality of life. Based on analytical categories, various elements were identified which showed that retirement income was a decisive factor in enabling older persons to live independently from their families; and that leisure activities, State support and access to a good health system were essential to ensure a good quality of life. On the other hand, it was noted that women were at a disadvantage compared to men, since they were less likely to have worked in the formal sector having been engaged in household activities, so they did not have access to a pension.

Alba and others (2017) note that roughly 1.2% of older persons in Colombia live in old-people's homes, and classify their quality of life on the basis of physical, psychological, relational and environmental dimensions. To identify these factors, the authors used the WHO instrument to measure quality of life, and compared its indicators on the basis of a qualitative and descriptive study with people aged 60 or older. It was found that the municipalities of Cajicá and Tenjo offered a better quality of life, despite low scores in the psychological and relational dimensions. The most revealing finding was that there was no correlation between age and quality of life, nor significant differences between the sexes within the sample, which concurs with some of the results found in this research.

A cross-sectional study by Pons and others (2018), to analyse the quality of life of older people living in a geriatric hospital in the town of Manzanillo (Cuba), found that individuals with a low level of schooling tended to perceive their quality of life as bad as they grew older. The perception of health was also an important determinant of quality of life for the individuals in the sample. A comparison of the results of previous studies with more recent ones shows differences in terms of the relationship between the age of older people and how they perceive their quality of life, while the relationship between this and the level of schooling was constant.

This literature review has reported research aimed at studying the factors that influence the quality of life of older people; but this type of research is still sparse. Its conclusions reveal the importance of incorporating components ranging from the physical conditions of the individual and his/her health status, to socioeconomic and demographic variables as a way of defining the concept of quality of life more precisely. However, most of the studies investigate clinical conditions and characteristics that can only be identified in health-oriented surveys. This is the main shortcoming of this research: there is no information on the symptoms or diseases displayed by this population group in Colombia, since the data in question were not available in the information sources used; and the National Demographic and Health Survey (ENDS) does not contain a module addressing these requirements, nor does it include a module for the representativeness of the national population.

This research therefore identifies the quality of life of older people in the nine major regions of Colombia through probabilistic estimation. It recognizes the multidimensional nature of the concept of quality of life and includes characteristics associated with the four key categories of analysis presented above. This is one of the contributions of this research from the standpoint of the economic sciences, since there are few studies that enable significant inferences to be made for an entire population group. Similarly, the profile of the older person with a good or bad quality of life is identified, and an assessment is made of whether quality of life changes according to the region in which the person in question lives.

III. Demographic definition of older persons

As individuals enter a stage of the life cycle in which age directly affects their social and motor functioning and involves the loss of social and family roles, their participation in different environments, such as work, declines. In this sense, the chronological connotation of age becomes the most appropriate conceptual framework for defining the population group targeted in this research. This conceptual approach to age makes it possible to overcome the lack of theoretical consensus that has developed around the term "old age" (older persons); although the concept of old age forms part of life cycle theory, which also uses discriminatory criteria in its definition based on approaches such as physiological age and social age. Abstracting a biological definition based on the number of years that a person has lived presupposes a series of norms that define an individual's responsibilities and privileges (Araníbar, 2001) and, therefore, make it possible to identify the population group objectively.

An example of this is Colombia's Law 1.276 of 2009, which defines an older person as an individual aged 60 years or older, or someone between 55 and 60 years of age with specific physiological and psychological conditions. This law argues that grouping social agents by age makes it possible to determine the social appearance of old age, which in turn reflects social conventions such as that a person ages as his/her age increases (Araníbar, 2001, p. 12).

While there are alternative approaches to understanding the concept of older person, such as the social approach and the theory of modernization, to name just two, adopting them would make the definition depend on a range of socially accepted behaviours and patterns, including physical, demographic, cultural and socioeconomic characteristics. This would require an extensive conceptual framework that goes well beyond the objectives and scope of this research. Any definition other than the age of the individual would mean creating a metric that incorporates these social factors, which are often subjective.

Accordingly —and as a second shortcoming of the research— the data source used only makes it possible to objectively define the condition of older person by the age that the individual declares at the time of completing the form in the National Quality of Life Survey, and not by the way in which society perceives the individual, or by his or her health status. Establishing the age at which the biological, psychological and social characteristics of ageing usually appear is undoubtedly a complex process, since it is clearly not the same for every individual. Moreover, the definition of collective criteria for doing so would be biased by the objectives being pursued by the researchers. Nonetheless, it would likely be more useful, since it would incorporate components that could not be captured by age (a person of 60 in good health is not the same as someone of 60 who is mobility-impaired due to illness).

Various authors have also used criteria other than age to define older people. These include Pugliese (2010), who discusses demographic criteria. Although the theoretical discussion focuses on cognitive and physical capacities to define older people, it also notes that the international policy criterion established by the United Nations, ECLAC and WHO is based on age: 60 years of age is considered the appropriate time in the life cycle to start to refer to an individual as an "older person".

Nonetheless, the author notes that, as age increases, the implications for health, care and dependency also increase; so special attention should be paid to people over 75 and 85 years of age, who may well represent the third and fourth ages, respectively. The author makes this reflection in view of the fact that life expectancy has already surpassed 85 years in several parts of the world, and the characteristics of the individual display greater deterioration.

IV. Methodological considerations

The 2018 National Quality of Life Survey was considered the appropriate data source for this research, since its forms contain multiple components that reveal the socioeconomic, demographic and geographical conditions that, in conjunction with the age variable, identify 20,720 people aged 60 years or older, representing about 3,914,448 individuals from nine regions of the country. Moreover, as it is a household survey conducted by DANE, its sample design is probabilistic, stratified, multi-stage, conglomerate and representative of the national territory (DANE, 2016, p. 6).

The dependent variable adopts the functional form proposed by DANE in the entry "Currently, living conditions in your home are...", formulated to investigate how people perceive their quality of life. This involves a subjective response, because a person's perception is determined by the conditions in which he/she lives. The choice of this formula is justified by the ad hoc multidimensionality of the quality-of-life concept, whereby its measurement must incorporate a series of components that depend on each individual, and any quantitative proposal to construct it would incorporate a researcher's bias. In statistical terms, this variable adopts a four-category Likert scale, which reduces the likelihood of respondents biasing their response towards a particular category. Its interpretation must also be a specific observation on which an econometric analysis is performed and which, conditioned by control variables, identifies both the probability that an individual enjoys a good quality of life and the profile associated with this condition. Thus, the dependent variable is ranked from highest to lowest with four possible replies: "Very good", "Good", "Fair" or "Bad", for which DANE does not provide any definition or interpretation.

The explanatory or control variables are arranged in four central groups. The first is demographic, which encompasses three variables: the sex of the individual as a phenotypic distinction, taking the value one if male and zero if female; age, in order to analyse whether quality of life deteriorates with age; and membership of an ethnic-racial minority (a variable that includes individuals who identify themselves as Afro-Colombians, Raizales, Palanqueros, Mulatos, Roma or Indigenous), taking the value one if the individual belongs to one of these groups and zero otherwise.

The second component is socioeconomic and consists of 11 variables: socioeconomic level, the highest level of education attained, marital status, whether or not the individual owns his or her home, the number of people living in the household, whether daily meals are limited by lack of income, whether or not the home has access to public water supply, whether it is connected to the gas network, and whether it uses firewood, charcoal or waste material for cooking. Total household income is also studied in order to determine whether there is a close link between monetary resources and quality of life, a relationship revealed in some of the research documented thus far; and, lastly, whether the individual receives income from the *Colombia Mayor* programme, since that programme's monetary transfers aim to improve the living conditions of older people living in poverty by increasing their income.

The third component, employment relationships, analyses older people's labour market participation, paying special attention to whether or not they receive a pension and the social security system to which they are affiliated: contributory, special or subsidized. This makes it possible to establish whether the loss of social roles implicit in labour market participation over the years is associated with a deterioration in the quality of life.

The final component is perceptions: it groups the variables that make it possible to analyse (without specifying degree) how the individual's quality of life is affected by conditions that are specific to his/her environment and change how he/she perceives reality. The following variables are studied: feelings of security, poverty status, health status and quality of the social security system to which he/she is affiliated. Lastly, the region variable is introduced into this analysis to capture one-off fixed effects that would increase the chances that older people enjoy a better quality of life just because they live in a specific place. This evaluation seeks to clarify whether there are differences between the following regions or departments: Capital District of Bogotá, the Central, Atlantic, Eastern and Pacific regions, and the departments of Antioquia and Valle del Cauca, the island department of San Andrés and the department of Amazonas in the Orinoco region. This is based on the hypothesis that the national capital has a larger number of resources and services, better centres of attention and other specific features that could imply better care for this population group.[2] The estimated econometric specification is as follows:

$$CVAM_i = \sum_{j=1}^{3} \beta_j X_{j_{Demographic_i}} + \sum_{j=1}^{11} \beta_j X_{j\ Socioeconomic_i} + \sum_{j=1}^{2} \beta_j X_{j\ Labour\_participation_i} + \sum_{j=1}^{4} \beta_j X_{j_{Perception\_environment_i}} + Dummy\_Region_i + \varepsilon_i \quad with\ i = 1,2,3,4 \tag{1}$$

The equation represents an ordered multinomial logistic model, where the subscript i refers to one of the four categories of the dependent variable CVAM (*calidad de vida del adulto mayor* – quality of life of the older adult). The four key categories of the study are accompanied by the coefficients β_j and the parameters X_j representing the independent variables, thus facilitating understanding of the number of variables introduced into the model in accordance with the established components.

Before conducting the estimation process, the suitability of implementing the first modelling alternative (ordered logit model) was validated through the Akaike and Bayesian information criteria (AIC and BIC, respectively); it was found that the technique proposed was correct, since in both cases the information criterion was of lower magnitude in the logit. This decision criterion is presented in annex table A1.3; while table A1.4, based on the variance inflation factor, shows that there is no correlation between the independent variables that could cause multicollinearity and large variances in the estimates. This invalidates the hypothesis of statistical significance, since the average value of the statistic was less than 10 and, according to Mansfield and Helms (1982), the smaller the model the less likely it will suffer from problems related to this condition.

V. Econometric inference and results

The estimation of this econometric model shows that the probability of having a quality of life rated good is 80.2%, whereas the chance of a quality of life rated fair is 14.85%. This finding confirms the research hypothesis as formulated, since in 2018 older people in Colombia had a good quality of life; and the difference between this and the next category in probabilistic terms was over 65.35 percentage points. This suggests that a large proportion of older people in Colombia perceive their living conditions as good and express their well-being. However, a significant number of older people rate their quality of life as fair, which makes it possible to compare the characteristics that determine the probability of having a good or fair quality of life. For this purpose, the coefficients and signs found in the four key components reported in the estimate in table 2 are considered in detail: the marginal effects *(dy/dx)* of the ordered multinomial logistic regression (logit) model.

[2] Tables A1.1 and A1.2 in the Annex present the functional form of the variables and their main statistics, respectively.

Table 2
Colombia: ordered multinomial logistic regression model *(dy/dx)* of the key components in the study of the quality of life of older people

	Characteristics by component	Bad	Fair	Good	Very good
Demographic	Sex [1=Male]	0.0007*** (0.0002)	0.0189*** (0.0051)	-0.0129*** (0.0034)	-0.0066*** (0.0018)
	Ethnic minorities [1=If a member]	-0.0001 (0.0002)	-0.0023 (0.0069)	0.0016 (0.0047)	0.0008 (0.0024)
	Between 75 and 90 years of age	-0.0002 (0.0002)	-0.0049 (0.0048)	0.0033 (0.0033)	0.0017 (0.0017)
	Over 90 years of age	0.0037*** (0.0012)	0.0923*** (0.0254)	-0.0757*** (0.0230)	-0.0203*** (0.0036)
Socioeconomic	Middle socioeconomic level	-0.0015*** (0.0002)	-0.0440*** (0.0053)	0.0285*** (0.0033)	0.0170*** (0.0023)
	High socioeconomic level	-0.0028*** (0.0002)	-0.0862*** (0.0054)	0.0334*** (0.0020)	0.0557*** (0.0064)
	Misses one of the three main meals owing to lack of money	0.0064*** (0.0008)	0.1485*** (0.0152)	-0.1273*** (0.0144)	-0.0277*** (0.0017)
	Access to public water supply	-0.0010*** (0.0002)	-0.0295*** (0.0060)	0.0191*** (0.0036)	0.0115*** (0.0026)
	Access to natural gas	-0.0007*** (0.0002)	-0.0190*** (0.0061)	0.0134*** (0.0044)	0.0062*** (0.0019)
	Uses firewood, charcoal, or waste material as a fuel for cooking	0.0011*** (0.0003)	0.0311*** (0.0088)	-0.0230*** (0.0069)	-0.0093*** (0.0023)
	Lives alone	0.0011*** (0.0002)	0.0310*** (0.0051)	-0.0201*** (0.0031)	-0.0120*** (0.0022)
	Household income	-0.0012*** (0.0001)	-0.0334*** (0.0025)	0.0231*** (0.0018)	0.0115*** (0.0009)
	Basic primary or preschool	-0.0001 (0.0002)	-0.0023 (0.0063)	0.0016 (0.0043)	0.0008 (0.0022)
	Basic secondary or upper secondary	0.0002 (0.0003)	0.0054 (0.0080)	-0.0037 (0.0056)	-0.0018 (0.0027)
	Technician/technologist with or without diploma	-0.0014*** (0.0003)	-0.0418*** (0.0092)	0.0242*** (0.0041)	0.0190*** (0.0055)
	University/postgraduate with or without diploma	-0.0015*** (0.0003)	-0.0446*** (0.0081)	0.0268*** (0.0041)	0.0193*** (0.0044)
	Free union	0.0007*** (0.0003)	0.0203*** (0.0070)	-0.0146*** (0.0052)	-0.0064*** (0.0020)
	Widow	0.0011*** (0.0003)	0.0297*** (0.0073)	-0.0214*** (0.0055)	-0.0094*** (0.0021)
	Separated or single	0.0021*** (0.0003)	0.0555*** (0.0075)	-0.0412*** (0.0059)	-0.0164*** (0.0019)
	Own home [1= Yes]	-0.0014*** (0.0002)	-0.0385*** (0.0050)	0.0279*** (0.0038)	0.0120*** (0.0014)
	Colombia Mayor programme [1= receives this subsidy]	0.0004* (0.0002)	0.0099* (0.0059)	-0.0070* (0.0042)	-0.0033* (0.0019)
Employment status	Receives a pension [1= Yes]	0.0003 (0.0002)	0.0080 (0.0054)	-0.0055 (0.0037)	-0.0028 (0.0020)
	Special regime	-0.0008** (0.0003)	-0.0221** (0.0088)	0.0141*** (0.0051)	0.0088** (0.0040)
	Subsidized social security regime	0.0024*** (0.0003)	0.0659*** (0.0067)	-0.0465*** (0.0049)	-0.0218*** (0.0022)
Perceptions	Feels secure in place of residence	-0.0058*** (0.0005)	-0.1420*** (0.0075)	0.1159*** (0.0068)	0.0319*** (0.0013)
	Self-defines as poor	0.0058*** (0.0004)	0.1498*** (0.0060)	-0.1133*** (0.0051)	-0.0424*** (0.0017)
	Quality of the health service considered bad	-0.0016*** (0.0003)	-0.0479*** (0.0092)	0.0289*** (0.0046)	0.0207*** (0.0050)
	Quality of the health service considered good	-0.0029*** (0.0005)	-0.0783*** (0.0122)	0.0585*** (0.0097)	0.0228*** (0.0031)
	Quality of the health service considered very good	-0.0039*** (0.0003)	-0.1192*** (0.0055)	0.0174*** (0.0067)	0.1056*** (0.0115)
	Health status bad	-0.0024*** (0.0004)	-0.0674*** (0.0102)	0.0434*** (0.0061)	0.0264*** (0.0046)
	Health status fair	-0.0061*** (0.0006)	-0.1607*** (0.0127)	0.1144*** (0.0094)	0.0524*** (0.0042)
	Health status good	-0.0045*** (0.0003)	-0.1431*** (0.0039)	0.0911*** (0.0191)	0.2386*** (0.0220)

Table 2 (concluded)

	Characteristics by component	Bad	Fair	Good	Very good
Region or department	Central	-0.0007*** (0.0002)	-0.0195*** (0.0070)	0.0128*** (0.0043)	0.0074** (0.0030)
	Atlantic	0.0005* (0.0003)	0.0129* (0.0077)	-0.0092* (0.0056)	-0.0042* (0.0024)
	Eastern	0.0000 (0.0003)	0.0005 (0.0071)	-0.0004 (0.0049)	-0.0002 (0.0024)
	Pacific	0.0010** (0.0004)	0.0281** (0.0115)	-0.0208** (0.0089)	-0.0084*** (0.0030)
	Antioquia	0.0003 (0.0003)	0.0092 (0.0077)	-0.0065 (0.0055)	-0.0030 (0.0025)
	Valle del Cauca	-0.0005** (0.0003)	-0.0151** (0.0075)	0.0100** (0.0048)	0.0056* (0.0030)
	Island-San Andrés	-0.0000 (0.0021)	-0.0003 (0.0580)	0.0002 (0.0400)	0.0001 (0.0201)
	Orinoco-Amazonas	-0.0006 (0.0005)	-0.0177 (0.0145)	0.0115 (0.0087)	0.0069 (0.0063)
	Probability of occurrence	0.45%	14.85%	80.18%	4.52%
	Pseudo R^2	0.225			
	No. of observations	20 720			

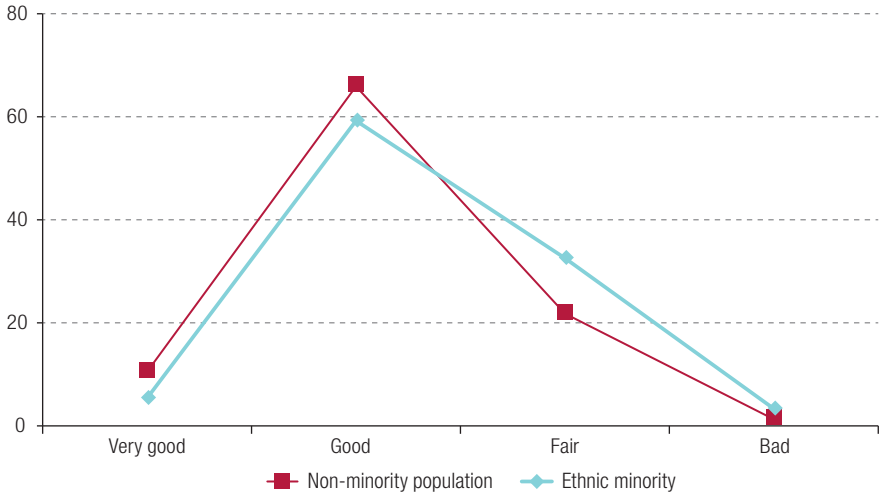
Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.
Note: The asterisks indicate that the variables are significant at the 10% (*), 5%(**) and 1% (***) levels.

The demographic component produces three important results: the first suggests the existence of gender-based differences in the quality of life. The coefficient is significant in all four categories of this component; and, although the magnitude is relatively low, the analysis concludes that older men are less likely to have a good quality of life. This contradicts the findings of Fernández-Ballesteros (1997) and Estrada and others (2011), which both claim that men have a better quality of life; while Vega (2009, p. 98) reinforces this argument by stating that, as men withdraw from the labour market at a later age, they postpone household responsibilities that are usually assumed by women, and this enhances their self-care and positively affects their quality of life. Nonetheless, this author also notes that a homogeneous structure cannot be assumed when studying old age; on the contrary, it must be heterogeneous, because of the biological factors that cause bodily change and the emergence of diseases.

On the other hand, when exploring individual characteristics such as ethnic-racial status, the results differ from those associated with the variable "sex". Although the coefficients are not statistically significant, they suggest that quality of life does not differ between ethnic minorities during old age, although the estimated coefficients for the good and very good categories are positive. This reiterates the need for studies targeting this population group, because its percentage in the "Fair" and "Bad" categories falls less steeply than in the case of the non-minority population when evaluating the quality of life in statistical terms (see figure 1).

The third result of this component uses the assumption that the older person's age adversely affects quality of life at some point. This variable considers persons aged between 60 and 74 years, those between 75 and 90, and those over 90 years old. The results of the estimation show that a person over 90 years of age is 7.7 percentage points less likely to have a good quality of life than someone aged between 60 and 74; while the result for those between 75 and 90, while not significant, is positive, suggesting that the quality of life in this stage of life is better than later. This would seem to indicate that the older you are, the poorer your quality of life. Cuervas (2004) and Vega (2009) argue that people aged between 75 and 90 tend to receive greater support from family members or government entities, who mainly look after their emotional and physical health; and that there is a degree of social conformism that has accepted many of the changes that old age brings with it (such as the feeling of loneliness produced by a distancing from one's children), which would explain the result displayed by this group. The second result concurs with the literature referring to the fourth age, which argues that feelings such as loneliness, loss of mobility and decreased social participation become inevitable with age, to the detriment of mental health.

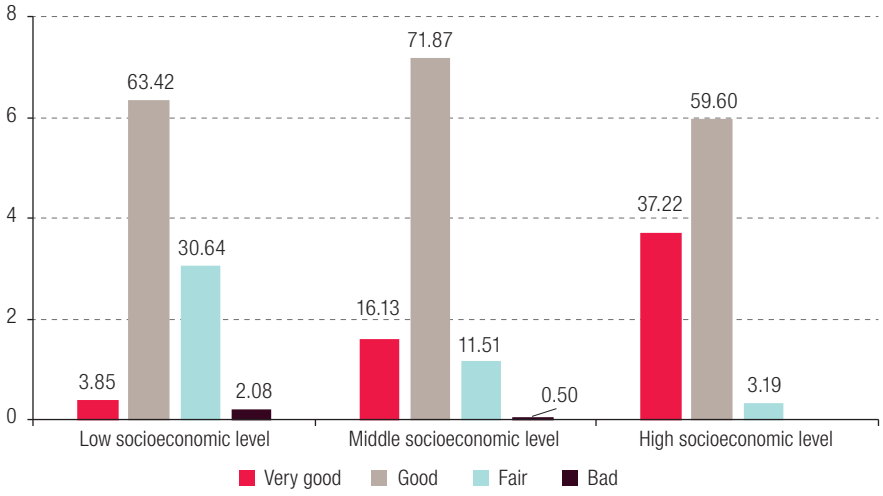
Figure 1
Colombia: quality of life of older people by ethno-racial status, 2018
(Percentages)



Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

The socioeconomic component considers the relationship between quality of life and the social status of individuals resulting from lifelong habits and which affects their well-being. Belonging to the middle and upper socioeconomic level reduces the likelihood of having only a fair quality of life by 4.40 and 8.86 percentage points, respectively, compared to being in the lower socioeconomic bracket. When the econometric analysis is complemented with the statistical analysis (see figure 2), it can be seen that none of the older people in the upper bracket perceives that living conditions in their household are bad; on the contrary, 96.81% state that their conditions are either very good or good, and only 3.19% describe their quality of life as fair. Conversely, 32.73% of older people in the lower bracket rate their living conditions as either fair or poor. Thus, a good quality of life seems to depend on socioeconomic status, which is a product of the capacity of individuals to accumulate wealth from an early age.

Figure 2
Colombia: quality of life of older people by socioeconomic status, 2018
(Percentages)



Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

Household income, the possession of certain goods and certain feeding habits are all factors that can have a positive effect on the quality of life. As household income rises, the probability of having only a fair quality of life falls by 3.34 percentage points. In fact the effect of income is significant at 1% in all four categories of the study. The possession of certain goods in the household also reflects an individual's purchasing power; and analysis shows, for example, that the probability of having a very good quality of life is reduced by 0.93 percentage points for older people who use rudimentary materials such as firewood, charcoal or waste as their main fuel source for cooking. Conversely, those who are connected to the gas and public water supply are, respectively, 1.34 and 1.91 percentage points more likely to have a good quality of life.

Missing at least one of the three daily meals recommended for a healthy diet (breakfast, lunch and dinner) also affects quality of life. The estimated coefficient in this case suggests that missing meals, presumably owing to lack of income, increases the probability of having only a fair quality of life by 14.85 percentage points. Given the magnitude of the coefficient and its high statistical significance (1%), this result reveals an urgent need to analyse this problem in depth, and to develop programmes aimed at guaranteeing nutrition among older persons, since this is clearly a decisive factor in determining their well-being.

In view of this finding, a brief analysis of the *Colombia Mayor* programme was made from the standpoint of effect rather than cause, since, in the absence of an impact assessment study, it would be inappropriate to affirm or deny that the programme exerts a causal effect on the living conditions of older people. However, the analysis proposed in this research makes it possible to identify effects; and an analysis of the estimated coefficient and its statistical significance suggests that the living conditions of older people who receive these conditional transfers from the State do not affect their well-being, since the coefficient is negative in the "Very good" and "Good" categories. This may be because the programme targets individuals who have incomes of up to half the minimum wage, live alone, or are living in the street, or belong to levels 1 or 2 of the Potential Social Programme Beneficiary Identification System (SISBEN), among other conditions that clearly indicate low levels of quality of life and are unlikely to improve with the programme's subsidies.

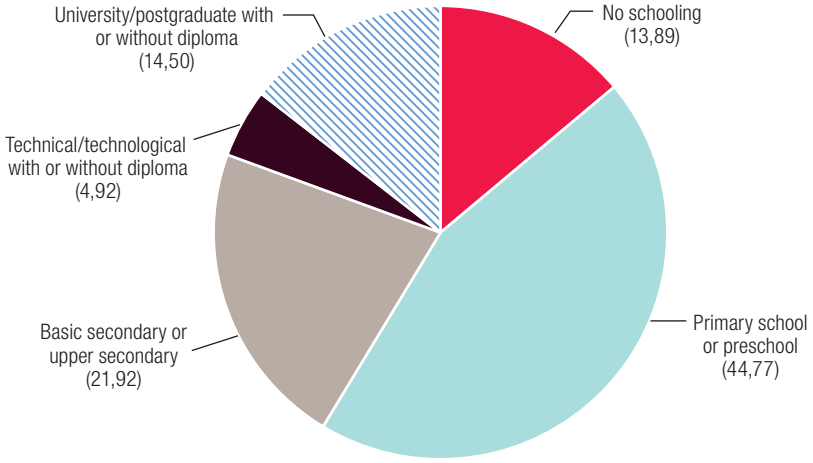
Two variables were included in the model to analyse emotional stability and ascertain the effects of living with others in a household: the first variable, namely whether the home is owned and fully paid for, proves to be positively associated and raises the probability of having a good quality of life by 2.79 percentage points. The second variable, whether the person lives alone or is accompanied, showed that living alone reduced the likelihood of having a good or very good quality of life. These results suggest that companionship in old age is associated with greater well-being; and they are in line with the approach developed by Marín and others (2009) and Aldana and Pedraza (2012), for whom the feeling of loneliness is an important factor in depression among older people, which affects their quality of life. At the same time, policies aimed at improving conditions for acquiring a home will be justified by the future impact they will have on the population.

The last factor to be considered is the effect of marital status and level of schooling. Being married is associated with a better chance of having a quality of life rated good or very good, since any other marital status returns a negative coefficient. For example, it was found that being single or widowed is associated with a reduction in the likelihood of having a good quality of life by 4.12 and 2.14 percentage points, respectively. In the case of schooling, the econometric results indicate that quality of life improves with the level of human capital: the estimated coefficients show that the probability of enjoying a good quality of life increases between 2.42 percentage points for technical or technological education and by 2.68 points for university education.

This highlights the importance of education or training, not only for employment in early stages of the life cycle, but also for the quality of life later on. In descriptive terms, figure 3 shows that 58.7% of the older population have a basic primary or preschool level of education, while only 14.5% have a

university training, which is positively associated with the likelihood of having a quality of life rated good or very good. It is therefore important to improve human capital continuously throughout the life cycle, to maintain adequate living conditions in old age.

Figure 3
Colombia: education level of older persons, 2018
(Percentages)



Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

One of the variables analysed in the third component is whether or not the person receives a pension and the impact of this on their quality of life. As noted in the literature review, this condition implies a loss of social roles which impairs quality of life. However, the estimated coefficient is not significant, so the present research considers that the data are not entirely conclusive for establishing the effect of receiving a pension on the well-being of older persons. As regards the social security system, being affiliated to the subsidized system reduces the likelihood of having a good quality of life, compared to older people who belong to the contributory system; while those in the special regime are more likely to enjoy a good quality of life than those in the subsidized system. Without being conclusive, the national literature reports serious problems in the subsidized health system ever since its creation: although the coverage of affiliates has increased, service providers have been unable to gain the financial capacity needed to offer a subsidized social security system of high quality (Gañán, 2010), which results in care problems that can clearly affect how users perceive their quality of life.

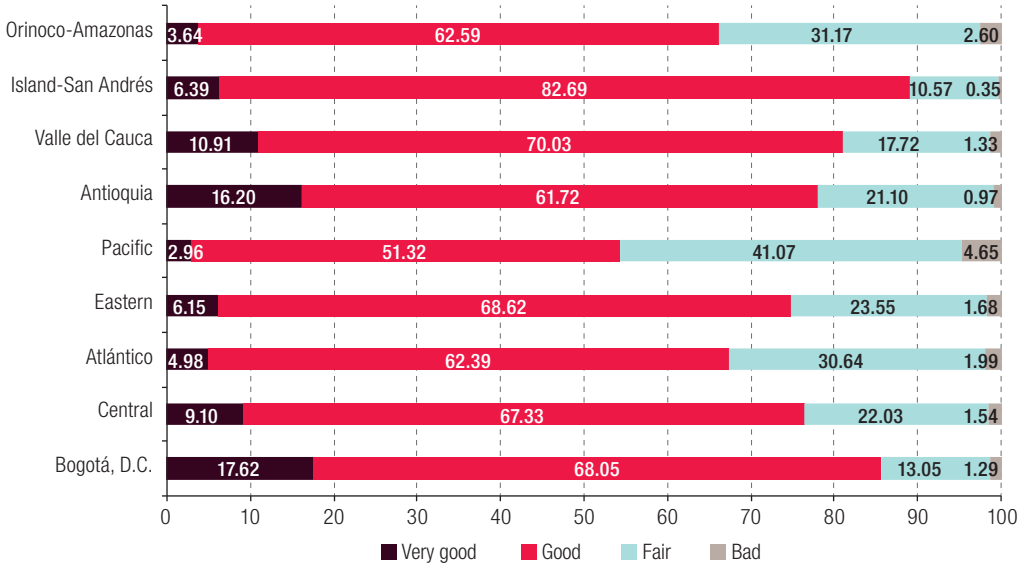
The perceptions component yields four major results, all of them with high statistical significance. A sense of security is associated with a better quality of life: the results show that this increases the probability of having a good quality of life by 11.59 percentage points relative to persons who feel insecure, which underlines the importance of addressing this external factor. In contrast, a perception of being in poverty is negatively related, since the probability of having a quality of life rated good or very good is reduced by 11.33 and 4.24 percentage points, respectively, among older people who consider themselves poor. Thus, the direct effect of the heterogeneous distribution of income on the standard of living in society is again an issue for discussion. Although this is not one of the key objectives of this research, by examining the determinants of poverty more closely, complementary empirical data are obtained for quality-of-life studies with a population-segmentation focus.

The quality of the health service and individual health status are the last two indicators in the perceptions component. The results suggest that good health and a positive opinion of the quality of the health service increase the likelihood of having a very good quality of life by 23.86 and 2.28 percentage points, respectively. This result is consistent with the finding reported in the literature review; and health is one of the main factors when determining quality of life. Nonetheless, the coefficients of the other categories are also statistically significant: the reference category is to perceive a very bad health status and quality of service; so, any other perception raises the probabilities.

In order to explore whether there are regional characteristics that directly affect the quality of life and the development of opportunities for individuals to improve their socioeconomic level (such as schooling, among others), a dummy variable for geographical regions was added to the model. This makes it possible to assess whether the region in which the elderly person lives has any effect on his/her quality of life, and to investigate the existence of particular conditions by geographical characteristics. When using the Capital District of Bogotá as a reference category, the results showed that living outside this city-region is associated with a negative sign in some cases, which supports the hypothesis of divergences in the quality of life between regions.

Older people living in the Central region and the Valle del Cauca department are more likely to have a good quality of life than those in Bogotá; whereas a negative coefficient indicates that the quality of life is lower in the Atlántico department and the Pacific region. Although this reveals discrepancies between regions, it is impossible to make an argument to justify this, since objective data would be needed and conditions such as investments in the health system and care programmes for the elderly would have to be introduced in the specification. Nonetheless, the result confirms that disparities do exist. Figure 4 shows the relationship between quality of life and regions: the Pacific region has the highest proportion (45.72%) of older people with a fair and poor quality of life, which shows that the model is capturing profound social dynamics which warrant in-depth exploration in future research on the subject.

Figure 4
Colombia: quality of life by region or department
(Percentages)



Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

V. Conclusions, recommendations and limitations

Colombia's demographics, like those of other economies in the world, are characterized by an increase in the population's life expectancy. This is changing the shape of the population pyramid, which justifies the need for studies that analyse the quality of life of different population groups —in this case, older people— both quantitatively and using other approaches.

The proposed econometric estimation satisfies the conditions needed to sustain the technical rigour of the study's findings: the relationship between the regressors and the dependent variable is broadly in line with the theoretical approaches posited in other research. The discrete-choice ordered logit-type multinomial was an appropriate model for testing the research hypothesis as formulated and to attain the proposed objectives.

The key result in the demographic component suggests that old age is experienced in different ways depending on the age and sex of the individual in question. The socioeconomic component shows that missing at least one of the three daily meals recommended for an adequate diet, possibly owing to a lack of income, increases the probability of having only a fair quality of life by 14.85 percentage points. Policies are therefore needed to guarantee the nutrition of older people in addition to assistance programmes that increase their income, since this factor has a profound impact on their well-being. Social policies also need to be targeted by age structure and ethnic group, since people belonging to minority ethnic groups are shown to have poorer quality of life; and, although it is impossible to say that they deserve priority, they should be given greater attention.

The theoretical approaches to human capital developed by Solow (1956), Schultz (1961) and Becker (1964) are particularly important for this study, since the results show that older people with university or higher education are less likely to have only a fair quality of life and more likely to enjoy a quality of life rated good. This process clearly starts at an early age, so policies to promote educational inclusion and quality should be strengthened, to ensure that a large proportion of the population attains high levels of education.

The results of the perceptions component show how a sense of security is important for the quality of life of older people, as well as its impact on the probability of having a good quality of life. As regards the perception of poverty, the measurement is subjective, since, despite not being defined quantitatively, it is formulated relative to the norms of the society in which the individual is immersed. Policies should endeavour to improve the allocation of resources and, consequently, also the living conditions of society.

In terms of the original research question, having considered certain factors that are theoretically associated with quality of life, the conclusion is that older people in Colombia in 2018 are more likely to have a quality of life rated good than very good, and more likely to have a quality of life rated fair than bad (a probability of 80.18%, compared to 14.85% in the case of only a fair quality of life).

On the other hand, the data show that the conditions specific to each region produce differential results in terms of their populations' quality of life. The research showed that older people living in the Central region or the Valle del Cauca department were more likely to have a good quality of life than those living in Bogotá. Based on these data, older people who are most likely to have a good or very good quality of life can be profiled as follows: being a woman, belonging to the medium and high socioeconomic level; not missing any daily meals; living in their own home; having technical or higher education and being affiliated to the contributory social security regime; not feeling insecure or considering themselves poor; feeling in good health and living in the Valle del Cauca department or the Central region.

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Annex A1

Table A1.1
Colombia: explanatory variables for the study of the quality of life of older people, 2018

Variables	Coding
Quality of life	0= Bad 1= Regular 2= Good 3= Very good
Sex	0= Woman 1= Man
Marital status	0= Married 1= Free Union 2= Widowed 3= Separated 4= Single
Age	0= Between 60 and 74 years old 1= Between 75 and 90 years old 2= Over 90 years old
Ethnic minorities	0= Not part of an ethnic minority 1= Part of an ethnic minority (Indigenous, Roma, Afro-Colombians, Raizal and Palenquero)
Socioeconomic level	1= Low 2= Medium 3= High
Level of schooling	0= None or basic 1= Baccalaureate 2= Technician or technologist 3= University 4= Specialization 5= Master or magister 6=Doctorate
Lives alone	0= No 1= Yes
Log. Income	Natural logarithm of household income
Own home	0= Not own home 1= Own home
Self-identification as poor	0= Not Self-identifies as poor 1= Self-identifies as poor
Major Colombia programme	0= Not affiliated to the programme 1= Affiliated to the programme
Social security regime	0= Contributory regime 1= Special regime 2= Subsidized regime
Firewood, charcoal or waste material used as a fuel for cooking	0= No 1= Yes
Connected to natural gas grid	0= No gas available 1= Gas available
Food prepared using water from public grid	0= No 1= Yes
Secure in the place of residence	0= Doesn't feel secure 1= Feels secure
One of the three meals missed for lack of money	0= Yes eats all meals 1= No does not eat all meals
Region or department	0= Bogotá 1= Central 2= Atlántico 3= Eastern 4= Pacific 5= Antioquia 6= Valle del Cauca 7= Island-San Andrés 8= Orinoco-Amazonas
Quality of health service	0= Very bad 1= Bad 2= Good 3= Very good
Health status	0= Very bad 1= Bad 2=Good 3= Very good
Receipt of a pension	0= Does not receive a pension 1= Does receive a pension

Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

Table A1.2
Colombia: main statistics of the study of the quality of life of older people, 2018

Variable	Observations	Mean	Deviation	Minimum	Maximum
Perception of quality of life	20 720	2.148	0.597	1.000	4.000
Sex [Male]	20 720	0.571	0.495	0.000	1.000
Ethnic minorities	20 720	0.098	0.297	0.000	1.000
Age	20 720	0.282	0.477	0.000	2.000
Socioeconomic level	20 720	0.461	0.632	0.000	2.000
Does not eat all of the three meals for lack of money	20 720	0.043	0.204	0.000	1.000
Prepares food with water from public grid	20 720	0.796	0.403	0.000	1.000
Connected to natural gas grid	20 720	0.695	0.460	0.000	1.000
Uses firewood, charcoal or waste material to cook food	20 720	0.104	0.306	0.000	1.000
Lives alone	20 720	0.236	0.424	0.000	1.000
Log Income	20 720	14.197	1.188	8.034	18.590
Level of schooling	20 720	1.637	1.212	0.000	4.000
Marital status	20 720	1.436	1.203	0.000	3.000
Has own home	20 720	0.725	0.446	0.000	1.000
Colombia Major programme	20 720	0.216	0.412	0.000	1.000
Receives a pension	20 720	0.694	0.461	0.000	1.000
Social security scheme	20 720	0.924	0.973	0.000	2.000
Feels secure in place of residence	20 720	0.812	0.391	0.000	1.000
Self-identifies as poor	20 720	0.365	0.481	0.000	1.000
Quality of health service	20 720	1.844	0.629	0.000	3.000
Health status	20 720	1.625	0.636	0.000	3.000
Region	20 720	2.797	2.081	0.000	8.000

Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

Table A1.3
Colombia: information criteria for the choice of model in the study of the quality of life of older people, 2018

Statistic	Ordered Logit	Ordered Probit
LL	-14 400	-14 400
AIC	28 923.324	28 924.296
BIC	29 264.695	29 265.667
Pseudo R^2	0.225	0.225

Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.
Note: LL – Log likelihood; AIC – Akaike information criterion; and BIC –Bayesian information criterion.

Table A1.4
Colombia: variance inflation factor (VIF) of the variables in the study of the quality of life of the elderly, 2018

Variable	VIF	1/VIF
Log. income	2.24	0.4471
Socioeconomic level	2.19	0.4560
Marital status	1.91	0.5225
Prepares food using water from public grid	1.91	0.5226
Connected to natural gas grid	1.86	0.5376
Level of schooling	1.86	0.5383
Socioeconomic level	1.78	0.5623
Uses firewood, charcoal or waste material as a cooking fuel	1.62	0.6162
Sex [Male]	1.52	0.6563
Colombia Major programme	1.51	0.6637
Lives alone	1.46	0.6868
Has a pension	1.44	0.6966
Self-identifies as poor	1.37	0.7277
Health status	1.19	0.8434
Age	1.14	0.8801
Own home	1.1	0.9098
Region	1.09	0.9173
Social security regime	1.07	0.9363
Quality of health service	1.07	0.9385
Misses one of the three daily meals for lack of money	1.06	0.9438
Ethnic minorities	1.05	0.9485
Average VIF	1.41	

Source: Prepared by the authors, on the basis of data from the Quality of Life National Survey (ENCV) 2018.

Canton growth in Ecuador and the role of spatial heterogeneity

Nicola Pontarollo, Rodrigo Mendieta and Diego Ontaneda

Abstract

This paper identifies the determinants of per capita gross value added (GVA) growth in Ecuador during the 2007–2015 period, using a spatial extension of the Mankiw, Romer and Weil (MRW) model. Because as a country Ecuador is characterized by deep territorial socioeconomic imbalances, estimates using classical techniques that measure average or "global" effects would not be as justifiable and would have limited political implications. Accordingly, this study uses a spatial filtering technique, which is a recent evolution of geographically weighted regression (GWR), to account for the spatial heterogeneity of the coefficients of a growth regression that explicitly considers both physical and human capital. The results show that Ecuadorian cantons have a wide range of convergence rates and that the effect of physical and human capital varies across space.

Keywords

Economic growth, economic analysis, regional development, regional economics, econometric models, development indicators, Ecuador.

JEL classification

C21, O47, R11.

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[1] Neither the European Commission nor any person acting on its behalf is responsible for the use which might be made of the information contained in this publication. The views expressed herein are of the authors and do not necessarily reflect the position of the European Commission.

I. Introduction

This paper aims to estimate the determinants of economic growth in Ecuador's cantons, based on a β-convergence model (Baumol, 1986; Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992). It examines 214 cantons during the 2007–2015 period.[2] An alternative spatial technique called "spatial filtering" (Griffith, 2008) is used to address both spatial dependence and heterogeneity in the impact of independent variables.

Compared to other areas of the world, the literature on subnational economic growth in Latin America is rather scarce.[3] In the case of Ecuador, few authors have measured convergence and the determinants of economic growth, as analysis has been restricted by the absence of reliable economic information at the province and canton levels until 2006. In one of the first studies of the case of Ecuador, Mendieta Muñoz (2015) found conditional convergence between 2007 and 2012 using canton-level data. In the same vein, Ramón-Mendieta, Ochoa-Moreno and Ochoa-Jiménez (2013), concluded, based on province-level data from 1993 to 2011, that there was regional convergence in Ecuador. However, this process is not sufficient to reduce regional disparities. Furthermore, spatial econometric techniques produce results that show that although there is a convergence process, it only involves the cluster of the most developed cantons (Mendieta Muñoz and Pontarollo, 2016). Like the above-mentioned studies, using parametric and non-parametric models Szeles and Mendieta Muñoz (2016) found evidence of absolute and conditional convergence at the canton and province levels for the 2007–2014 period.

This study differs from those described above because it estimates the β-convergence model using an econometric technique —spatial filtering— that takes into account the spatial dependence between canton economies, but which also allows the variables included in the model to have a differentiated effect between cantons, owing to different production structures and contexts. As a result, it is not necessary to assume, as in some previous analyses, that all cantons respond in the same way to variables that affect growth, which is a plausible approach if there are structural differences between cantons.

With respect to spatial dependence, many studies, including those by Fingleton (1999) and Le Gallo and Ertur (2003), have demonstrated that there is spatial correlation in the residuals of traditionally estimated growth models. This leads to an incorrect inference in estimates of significant parameters (spatial error model) or biased and inefficient estimates of parameters (spatial lag model). The spatial filtering technique solves the problem of spatially autocorrelated residuals by taking into account the effects of the spatial interaction between variables. This approach also allows for consideration of the effects of spatial spillovers (Griffith, 2003). In addition, because it is an extension of the geographically weighted regression (GWR) (Fotheringham, Brunsdon and Charlton, 2002) proposed by Griffith (2008), this technique allows for estimation of different local coefficients and not a single coefficient for each variable, as in the ordinary least squares (OLS) method.

[2] The municipalities of Putumayo, Shushufindi, Cuyabeno, Orellana, La Joya de los Sachas, Sevilla de Oro and Quinsaloma have been excluded from the analysis because of their atypical gross value added (GVA) values, primarily owing to mineral extraction.

[3] The countries with the most empirical evidence include Brazil, Colombia and Mexico. Esquivel (1999) and Gomez-Zaldívar, Ventosa-Santaulària and Wallace (2012) found evidence of convergence between Mexican regions from 1940 to 1995, and from 1940 to 2009, respectively, while Rodríguez-Pose and Villarreal (2015) focused on the role of socioeconomic conditions according to growth. Cárdenas and Ponton (1995) and Gómez and Santana (2016) focused on Colombian regional convergence and also found evidence of convergence. Royuela and García (2015) confirmed that there is convergence in Colombia in key social variables —although not in the classic economic variable (per capita GDP)— and that spatial autocorrelation reinforces convergence processes. In the case of Brazil, Azzoni (2001) noted that there was regional convergence between 1939 and 1995, but that inequality changed over time. Lastly, De Andrade Lima and Silveira Neto (2016) discovered marked spatial dependence between Brazilian microregions and determined that investments in both physical and human capital are important for the growth of Brazil's regional economies. This result was confirmed by Resende and others (2016).

Section II describes the spatial dynamics of per capita gross value added (GVA). Section III outlines the empirical model used in the study of growth and details the spatial model employed. Section IV examines the results and section V offers some conclusions.

II. Spatial dynamics of regional growth in Ecuador

The preliminary analysis of spatial dynamics in the case of Ecuador is based on Moran's I (MI) (Moran, 1950), which is one of the most commonly used means of detecting and measuring spatial dependence (autocorrelation). Moran's I essentially relates the value of a given variable to its spatial lag, in other words the value assumed by said variable in neighbouring locations. Moran's I can therefore be defined as:

$$MI = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}\left(x_i - \bar{x}\right)\left(x_i - \bar{x}\right)}{\sum_i \left(x_i - \bar{x}\right)} \quad (1)$$

Where N is the number of units on the map (that is to say areas or points); x is the variable of interest; $\bar{x}$ is the mean of x, and w_{ij} is an element of spatial weight matrix W_{ij}, where j represents the set of neighbouring regions to i. Moran's I generally varies between the maximum and minimum eigenvalue. In a matrix standardized by row, it varies between -1 and 1. A positive coefficient indicates positive spatial autocorrelation, in other words clusters of similar values can be distinguished on the map. A negative coefficient represents negative spatial association, which is to say that dissimilar values are grouped together on the map. A Moran's I of close to 0 indicates a random spatial pattern.

According to the First Law of Geography of Tobler (1970), which states that "everything is related to everything else, but near things are more related than distant things", each element i of the W_{ij} spatial weight matrix is considered to be neighbouring to all other j cantons, but the weight of neighbours is proportional to the inverse of the square distance between the centroids.

This eliminates the need to select ad hoc spatial weight matrices that are based on maximizing the Akaike Information Criterion (AIC) and do not take into account the potential reasons why one definition is more appropriate than another in practice, something that is done by Arbia, Battisti and di Vaio (2010) and Postiglione, Andreano and Benedetti (2017), for example. In addition, it allows for greater interaction between two cantons that have a smaller distance between their centroids than between those that have a larger distance.

The left scale of figure 1 shows the "σ-convergence", that is to say the dispersion of the (ln) of per capita GVA.[4] The right scale shows Moran's I of the same variable for the 2007–2015 period.[5] The p-value of Moran's I obtained through 1,000 randomizations is significant for all the years considered. Moran's I rises very slightly during the period, while σ-convergence shows a much more marked upward trend over time. These patterns indicate that the disparity in per capita GVA between cantons increased during the period of analysis, while polarization remained stable.

[4] σ-convergence measures the dispersion of territories' income and shows how, over time, differences between economies tend to diminish. This means that disparities between territories will tend to diminish over time and therefore approach a single steady state. Following the approach proposed by Barro and Sala-i-Martin (1992), σ-convergence can be measured as the standard deviation of the logarithm of per capita income.

[5] Per capita GVA was obtained from the data repositories of the Central Bank of Ecuador and from population statistics provided by the National Institute of Statistics and Censuses (INEC).

Figure 1
Ecuador: σ-convergence and Moran's I of the log of canton per capita gross value added (GVA), 2007–2015

Source: Prepared by the authors.

The analysis is complemented by maps of local spatial autocorrelation indexes, used to detect clusters, which is not possible with global spatial association measures. This means that, although global contrasts may indicate a specific spatial autocorrelation, it may not be maintained for the entire sample. Meanwhile, local analysis particularly examines subregions, determining whether such an area represents a hot spot or a cold spot (Celebioglu and Dall'erba, 2010; Cravo and Resende, 2013).

The local Moran statistic (Anselin, 1995) is expressed as:

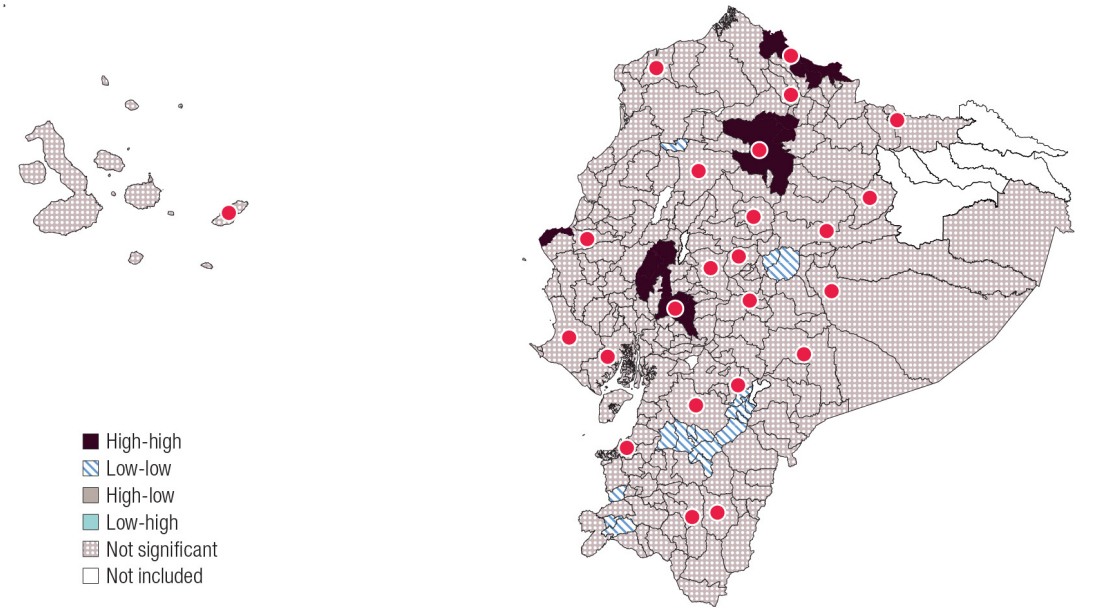
$$I_i = \frac{\left(x_i - \bar{x}\right)}{\sum_i \frac{\left(x_i - \bar{x}\right)^2}{N}} \sum_{j \in J_i} w_{ij}\left(x_j - \bar{x}\right) \qquad (2)$$

The Moran statistic fulfils two requirements: (i) it quantifies the degree of significant clustering of similar values around an observation and (ii) it fulfils the need for the sum of the indicator for all observations to be proportional to the global indicator of spatial association. The p-values of the local Moran statistic are based on the Bonferroni correction.

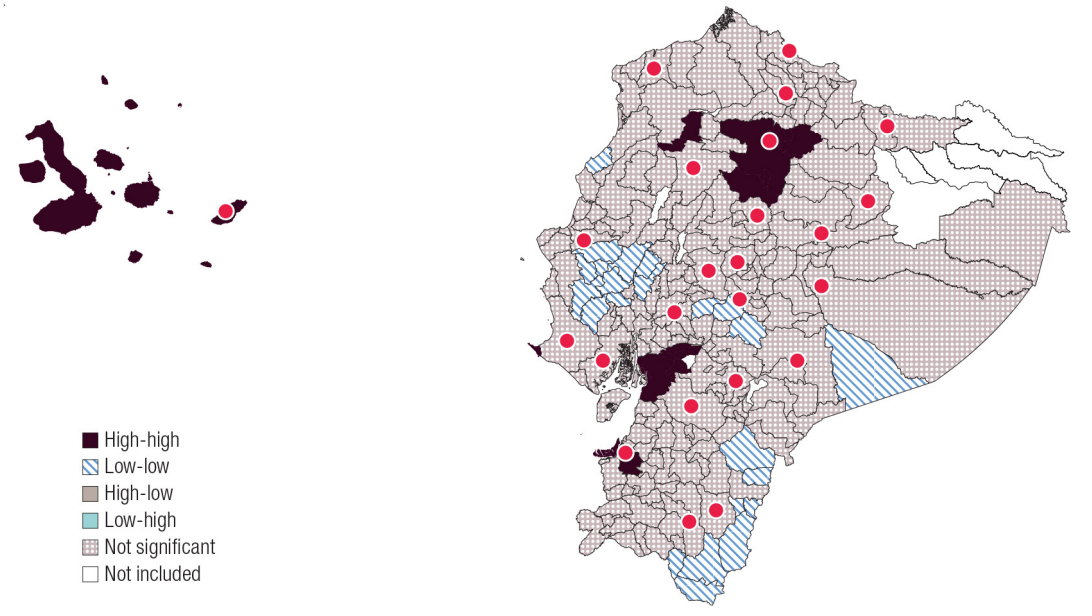
Map 1 shows that while there is a small number of cantons that form clusters that are significant in terms of growth, there are more cantons, and more defined cantons, for per capita GVA in 2007. The significant high-high clusters are located in the areas of Quito and Guayaquil, while the low-low clusters are in the south of the country, in Cañar, and in the central part of the coastal zone.

Map 1
Ecuador: local Moran statistic of the variables included in the model

A. Growth in per capita gross value added (GVA), 2007–2015



B. Per capita gross value added (GVA), 2007



Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

III. The theoretical model, data and spatial methodology

1. The theoretical model and the data

Our empirical model is based on the concept of conditional β-convergence, which is contrasted using the following cross-sectional econometric model (Mankiw, Romer and Weil, 1992):

$$\frac{1}{T}ln\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha_i+\lambda_i ln\left(y_{i,0}\right)+\pi_i ln\left(n_i+g+\delta\right) \\ +\vartheta_i ln\left(inv\right)+\gamma_i ln\left(h\right)+u_{it} \quad (3)$$

Where $\lambda_i=-T^{-1}\left(1-e^{-\beta T}\right)$ and $\alpha_i=g_i-\lambda_i\left(ln A_{i,0}-ln y^E_{i,\infty}\right)$

This means that the mean growth rate of the per capita product of territory i in time period T, to the left of equation (3), is related to its level of per capita product in the initial period ($y_i,0$). In the constant α_i are the terms g_i (which measures technological progress), $A_i,0$ (the level of efficiency of each worker) and $y^E_{i,\infty}$ (steady state). To approximate human capital h, the logarithm of the mean number of years of schooling of people aged 24 and over residing in a given canton was adopted.[6] The data were obtained from the 2010 Population and Housing Census. Physical capital, inv, was constructed on the basis of fixed asset information reported by companies in the National Economic Census conducted in Ecuador in 2010. Fixed assets, also known as property, plant and equipment, are tangible assets used by a company in the production or supply of goods or services that are expected to be used for more than one period. δ is the rate of depreciation, n_i is the population growth rate, and, as suggested by Mankiw, Romer and Weil (1992), g+δ has been assumed to be 0.05. Annex A2 shows a mapping of the variables.

The negative and statistically significant coefficient λ_i is used to determine the value of β that approximates the rate of convergence and u_{it} is the estimation error. The rate of convergence is calculated as $\beta_i=-ln(1-\lambda_i T)/T$, and the half-life as $\tau=ln(2)/\beta_i$.[7] According to Abreu, de Groot and Florax (2005), standard errors of β_i are obtained as $\sigma\beta_i=\frac{\sigma_{\lambda i}}{T\left(1-\lambda_i\right)}$, where $\sigma_{\lambda i}$ corresponds to the standard errors of $\lambda_{i,}$ estimated as indicated by Dawson and Richter (2006) and T is the number of years. Once the errors have been obtained, the t values can be easily determined.

The first studies on convergence (Barro and Sala-i-Martin, 1992) generally analysed this process without adding control variables and assuming that $\alpha_i = \alpha$ and $\lambda_i = \lambda$, that is to say presuming that economies have a homogeneous structure. A negative and statistically significant value of λ indicates that poorer regions grow faster than richer ones, denoting acceptance of the hypothesis of absolute convergence to the same steady state. Thus, as the levels of per capita product of a country's territory increase, its growth rate should slow, meaning that poor territories grow faster than rich ones and that, in the long term, all of them converge, in per capita terms, to the same rate of income growth and the same level of capital (steady state). Therefore, there is a tendency towards disappearance of the initial economic disparity. However, as Solow (1999, p. 640) states, "there is nothing in growth theory to require that the steady-state configuration be given once and for all" —the steady state will change from time to time, when there are major technological revolutions, demographic changes or changes in the willingness to save and invest.

[6] This is the variable used as a proxy for human capital in De Andrade Lima and Silveira Neto (2016), De La Fuente (1994), Benhabib and Spiegel (1994), Barro and Lee (1993) and Kyriacou (1991).

[7] Half-life refers to the number of years needed to eliminate half the deviation from an initial value of per capita GVA and the value of the long-run steady state.

Therefore, if there is not the same long-term steady state $ln\, y^{E}_{i,\infty}$, or if structural variables significantly affect growth, then "conditional β-convergence" appears (Sala-i-Martin, 1994; Cuadrado-Roura, Mancha-Navarro and Garrido-Yserte, 2000), which allows for territories not converging towards a common economic equilibrium, but towards individual steady states, determined by specific savings ratios, levels of investment and technology, which are in turn the result of specific economic structures.

As shown in equation (3), to estimate conditional β-convergence a series of additional variables are considered that affect the pattern of growth towards the steady state: physical capital, human capital, and population growth. This approach, which presupposes heterogeneity in the steady states, still assumes homogeneity among convergence rates.

This last point has been criticized by Temple (1998 and 2000), who observes that in a cross-sectional model for different countries, parameter heterogeneity, extreme values and measurement errors are all very frequent. In this regard, Ketteni, Mamuneas and Stengos (2007), and Fotopoulos (2012), for example, find that there is no linearity in processes of economic growth. In terms of regional specificities, however, problems related to spatial dependence must be considered (see, for example, Anselin, 1988; Rey and Montouri, 1999; Arbia, 2006), as well as those related to spatial heterogeneity (Ertur, Le Gallo and LeSage, 2007; Pede, Florax and Lambert, 2014).

In this article, through the use of a model that explores the spatial filtering technique explained in section III.2, the possible presence of heterogeneity is considered, both in the convergence rate, that is to say $\lambda_i = \lambda$, and in the variables that affect growth (Durlauf, Johnson and Temple, 2005). Compared to the article by Cravo and Resende (2013), where the Getis statistic (1995) is used to remove the spatial component from each variable, in this paper the possibility of not only autocorrelation but also non-stationarity is admitted, as explained below.

2. The spatial model

Spatial phenomena are of great importance, especially if consideration is given to socioeconomic factors (Bockstael, 1996; Weinhold, 2002) and to the implications for policymakers (Lacombe, 2004). The presence of spatial patterns that positively or negatively affect economic variables requires rigorous and systematic evaluation of their impact and form. Spatial filters represent a new and interesting research perspective for spatial econometric analysis. This tool can divide geo-referenced variables into two components —spatial and non-spatial— highlighting the spatial autocorrelation component.

The filtration technique proposed by Griffith (2003) uses the technique of decomposition of the matrix into its eigenvectors and eigenvalues, and allows for extraction of the $n \times n$ matrix of uncorrelated numerical orthogonal components (Tiefelsdorf and Boots, 1995).

This non-parametric approach aims to manage the presence of spatial autocorrelation by introducing variables —the eigenvectors— that can be used as predictors instead of variables that are not explicitly considered in the model (Fischer and Griffith, 2008). Compared to Getis's technique (1995), which filters each variable separately by dividing the spatial component from the non-spatial component, this approach offers the advantage that non-negative variables can be used (Griffith, 2010), allowing growth rates, for example, to be included in the analysis.

The model is derived from the matrix form of Moran's I defined in equation (1):

$$MI = \frac{n}{1^t W 1} \frac{Y^t MWMY}{Y^t MY} \tag{4}$$

where W is the matrix of spatial weights, n is the number of cantons, Y is the vector of values and $M = \left(I - \frac{11^t}{n}\right)$ is the matrix in which I is the identity matrix of size $n \times n$, 1 is a vector of one dimension $n \times 1$ and the exponent t is the transposed matrix. The particularity of the M matrix is that it focuses on the Y vector.

Tiefelsdorf and Boots (1995) showed that each of the n eigenvalues of the expression MWM (4) is an MI value, once multiplied by the term to the left of the expression (4), that is to say $\frac{n}{1'W1}$.

The eigenfunction linked to the geographical contiguity matrix W can be interpreted as the latent spatial association of a geo-referenced variable (Getis and Griffith, 2002). E_1 (the first eigenvector) is the set of numerical values that has the highest value of MI for the given geographical contiguity matrix. E_2 (the second eigenvector) is the group of numerical values that has the greatest value of MI for each set of numerical values not correlated with E_1. This sequential construction of eigenvectors continues to E_n a set of numerical values that has the largest MI achievable by any set of numerical values which is uncorrelated with the preceding $n-1$ eigenvectors. These n eigenvectors describe the full range of all possible orthogonal and uncorrelated map patterns and may be interpreted as summary map variables that represent the nature (positive or negative) and level (low, moderate, high) of spatial autocorrelation.

The spatial model used in this paper refers to a recent study by Griffith (2008), which proposes a new approach to the GWR model (Fotheringham, Brundson and Charlton, 2002), based on spatial filters through construction of new variables created from the product of the spatial filter and the spatial variables. The spatial filtering approach overcomes the problems of multicollinearity and a lack of degrees of freedom typical of the estimates obtained through the GWR model (Wheeler and Tiefelsdorf, 2005).

The GWR model estimates a "local" regression for each location in space, weighting the observations by distance from the region under study, based on the following expression:

$$Y = \beta_{0,(u,v)}1 + \sum_{p=1}^{P} X_p \beta_{p,(u,v)} + \varepsilon \tag{5}$$

Where Y is an $n \times 1$ vector, and represents the dependent variable, β is the regression coefficient, X_p is an $n \times 1$ vector of values of the variable p, ε is an $n \times 1$ vector containing the random error terms, and (u, v) indicates that the parameters must be estimated for each location whose spatial coordinates are given by the pair of vectors (u, v), implicitly assuming that Y, X and ε are geo-referenced.

In his model, referred to here as "GWR-spatial filtering" (GWR-SF), Griffith (2008) proposes the inclusion of an interaction term between each attribute variable and each candidate eigenvector. A normal linear model with spatial filter incorporates a set P of regressors, $X_p = (k = 1.2, \ldots, P)$, with a k set of selected eigenvectors, $E_k = (k = 1.2, \ldots, K)$, which represent different spatial models and the following form:

$$\begin{aligned} Y &= \beta_{0,GWR} + \sum_{p=1}^{P} X_p \beta_{p,GWR} \approx \\ &\approx \left(\beta_0 1 + \sum_{k_0=1}^{K_0} E_{k_0} \beta_{k_0}\right) + \sum_{p=1}^{P} \left(\beta_p 1 + \sum_{k_p=1}^{Kp} E_{k_p} \beta_{k_p}\right) \bullet X_p \end{aligned} \tag{6}$$

Where • denotes the element-wise matrix multiplication (that is to say Hadamard matrix multiplication) and k_p identifies the eigenvector numbers that describe attribute variable p (k_p being the total number of these vectors). Equation (6) reveals the presence of the interaction terms in question, namely $E_{kp} \bullet X_p$. The sum of the first and second terms of equation (6) returns the intercept coefficient expression, while the sum of the third and fourth terms multiplied by X_p, results in the local coefficients of the covariates. Then, by rearranging the results obtained, when all K candidate eigenvectors are considered, yields:

$$Y = \beta_0 1 + \sum_{p=1}^{P} X_p \bullet 1\beta_p + \sum_{k=1}^{K} E_k \beta_{E_k} + \sum_{p=1}^{P} \sum_{k=1}^{K} X_p \bullet E_k \beta_{pE_k} + \varepsilon \quad (7)$$

Where the regression coefficients represent global values, and the eigenvectors represent local modifications of these global values; the first two terms (that is to say the intercept coefficients and the global attribute variable coefficients) are multiplied by the vector 1, which is also a spatial filter eigenvector. The last two terms are the local variations of the intercept and of the variables themselves. More precisely, the global values are the coefficients needed to construct linear combinations of the eigenvectors, in order to obtain GWR-type coefficients. The estimation of equation (7) needs to be followed by collecting all terms containing a common attribute variable and then factoring it out in order to determine its GWR coefficient, which will be the corresponding sum appearing in equation (6). The GWR coefficients are $n \times 1$ vectors. Operationally, the process is as follows:

1. The eigenvectors extracted from contiguity matrix W are computed.
2. All interaction terms $X_p \bullet E_k$ are calculated for the P covariates for the K candidate eigenvectors (with $MI > 0.25$).
3. The interaction terms, including the eigenvectors, are selected using step-wise regression, maximizing the value of the Akaike information criterion.
4. The geographically varying intercept term is computed, determined by the first two terms of equation (6).
5. The geographically varying covariate coefficient is computed, determined by the last two terms of equation (6).

IV. Empirical results

This section presents the results of the model described in section III.

Table 1 shows the results of the estimates with ordinary least squares and with spatial filtering of the global coefficients (or means). In order to compare the results of different models, two types of spatial filtering were used: in the first, called SF, individual intercepts are considered, as suggested by Getis and Griffith (2002), selecting the eigenvectors with step-wise regression, to filter spatial autocorrelation in the residuals; the second type is the GWR-spatial filtering approach, which adds to the individual intercepts the eigenvectors associated with each independent variable.

The coefficient of determination R^2 increases considerably (from 0.35 to 0.72) in the GWR-spatial filtering, while in the case of spatial filtering with individual intercepts it is 0.53. The Akaike information criterion confirms this result, as does the root mean square error (RMSE), which is used to measure the differences between the values predicted by a model and the values actually observed, which improves markedly in the GWR-SF model. Simultaneously, it is observed that in the second and third models there is no spatial autocorrelation between the residuals, since the Moran test is not statistically significant. Heteroscedasticity persists in the first two models, while the Breusch-Pagan test is not significant in the case of GWR-spatial filtering. The coefficient associated with the logarithm of per capita GVA in 2007 increases marginally in the GWR-spatial filtering model. Education and physical capital are significant in all cases, confirming their role as engines of growth, as has been observed in other Latin American countries. The role of education in Ecuador's growth confirms the findings of Szeles and Mendieta Muñoz (2016) found with a panel data model for Ecuadorian provinces between 2007 and 2014. The importance of human capital in growth has also been demonstrated in other South American countries, such as Brazil (Cravo, Becker and Gourlay, 2015; Özyurt and Daumal, 2013; De Andrade Lima and Silveira Neto, 2016) and Mexico (Rodríguez-Pose and Villarreal, 2015).

Table 1
Empirical results

	Ordinary least squares	Spatial filtering	GWR spatial filtering
Intercept	0.16838*** (0.06307)	0.08086*** (0.06418)	-0.04610*** (0.05700)
Log (per capita GVA 2007)	-0.05421*** (0.00616)	-0.05696*** (0.00555)	-0.04803*** (0.00525)
Population growth	0.006587 (0.01050)	-0.01905*** (0.01425)	-0.03011*** (0.01431)
Education	0.11562*** (0.01713)	0.13553*** (0.01606)	0.15128*** (0.01455)
Capital	0.00230*** (0.00047)	0.00199*** (0.00042)	0.00159*** (0.00040)
Eigenvector 6		0.11816 (0.03262)	
Eigenvector 4		-0.12672 (0.03447)	
Eigenvector 2		0.11593 (0.03327)	
Eigenvector 28		-0.10626 (0.03354)	
Eigenvector 29		0.08457 (0.03278)	
Eigenvector 31		0.07799 (0.03304)	
Eigenvector 10		0.06993 (0.03350)	
Eigenvector 15		0.06609 (0.03313)	
Eigenvector 30		0.06161 (0.03296)	
Eigenvector 26		0.05558 (0.03281)	
Convergence coefficient λ	0.07107	0.07603	0. 60610
Residual sum of squares (RSS)	0.03720	0.03250	0.02634
R^2 (adjusted)	0.354 (0.342)	0.529 (0.496)	0.724 (0.669)
Akaike information criterion	-794.8351	-842.4925	-914.6238
Moran's I	0.09646***	-0.05453	-0.05572
Breusch-Pagan test	9.729** (df=4)	23.904** (df=14)	21.238 (df=35)
Jarque-Bera test	8.0539** (df=2)	4.0905 (df=2)	1.0163 (df=2)
Root mean square error (RMSE)	0.03673	0.03136	0.02402

Source: Prepared by the authors.
Note: ***significant at 1%; ** significant at 5%; * significant at 10%; Standard errors in parentheses.

In table 2 the three models are tested, one against another, using the analysis of variance (ANOVA) test. Upon analysing the p-value of the chi-squared test, the conclusion is that both spatial models are significant improvements on the ordinary least squares model. Upon comparing the model estimated using spatial filtering and the GWR-spatial filtering model, the latter can be seen to perform better than the two base models.

Table 2
Analysis of variance (ANOVA) test

	Sum of squared deviation	Degrees of freedom (df)
Ordinary least squares vs. spatial filters	0.1652***	31
Ordinary least squares vs. GWR spatial filters	0.0782***	10
Spatial filters vs. GWR spatial filters	0.0870***	21

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

According to Brunsdon, Fotheringham and Charlton (1998 and 1999), and Fotheringham, Brunsdon and Charlton (2002, p. 229), it is possible to ascertain the non-stationarity of GWR coefficients with two procedures that can be easily extended to GWR-spatial filtering (see table 3).

Table 3
Test for non-stationarity of parameters

Variable	Standard deviation $\beta_{GWR\text{-}SF}$	SE(β_{OLS})	SE(β_{SF})	Interquartile range $\beta_{GWR\text{-}SF}$	2×SE(β_{OLS})	2×SE(β_{SF})
Intercept	0.3331	0.0631	0.0642	0.2720	0.1261	0.1284
Log (GVA/population)	0.0526	0.0062	0.0055	0.0436	0.0123	0.0111
Population growth	0.0895	0.0105	0.0142	0.0864	0.0210	0.0285
Education	0.0947	0.0171	0.0161	0.0867	0.0342	0.0321
Capital	0.0025	0.0005	0.0004	0.0020	0.0009	0.0008

Source: Prepared by the authors.

The first step is to compare the variance of the GWR coefficients with the standard errors of the coefficients estimated with ordinary least squares. In table 3, all standard deviation values of the GWR-spatial filtering coefficients (second column) exceed the standard errors of the coefficients estimated with stationary models, ordinary least squares and spatial filtering (third and fourth columns). This suggests that there is justification for considering coefficients that vary in space for all coefficients. Secondly, the difference between the lower and upper quartile of the local coefficients (fifth column) must be compared with twice the standard deviations of the respective global estimate (sixth and seventh columns), that is to say ± 1 standard deviation of the mean. The fact that 68% of the values are expected to be within this interval, compared to 50% in the interquartile range, and that the interquartile range of the local coefficients is greater than that of 2 standard errors of the global mean, suggests that the relationship is non-stationary.

Table 4 shows the local values of the coefficients. To determine whether local coefficients are statistically different from zero, standard errors are calculated taking into account that the latter are derived from the interaction terms (Dawson and Richter, 2006). It is observed that the mean (global) value does not exactly coincide with the value of the coefficient estimated for the variables in table 1, since only local variables that are statistically different from zero are considered in table 4. For all variables there is a marked gap between the first and third quartiles, revealing a high degree of variability. In addition, 98% of cantons show a significant coefficient and about 10% diverge. With respect to the other variables included in the model, population growth rate is significant in 69% of cantons. Surprisingly, education and physical capital are significant in 93% and 77% of cantons, respectively, indicating that there are areas where these variables do not affect growth. This is probably the result of structural heterogeneity, which is reflected in concentration of production sectors in only a few areas; this is usually around the main cities (Mendieta Muñoz and Pontarollo, 2016). The last column represents the Moran's I of the local coefficients associated with each variable. All the Moran's Is are positive and significant, reflecting a well-defined spatial pattern, with cantons characterized by similar values located close in space.

Table 4
Local values of significant coefficients

Variable	Minimum	First quartile	Mean	Third quartile	Maximum	Percentage of cantons where significant	Percentage of cantons with values >0	Moran's I
Intercept	-1.7952	-0.3195	-0.0843	0.2395	0.9934	52.8	65.5	0.518***
Rate of convergence λ_i	0.0027	0.0539	0.0964	0.1191	0.6718	97.7	9.6	0.474***
Population growth	-0.3810	-0.0949	-0.0408	-0.0320	0.3487	69.2	78.4	0.478***
Education	-0.1762	0.1119	0.1602	0.190	0.4390	93.0	2.0	0.650***
Capital	-0.1762	0.1132	0.1593	0.1908	0.4390	77.1	3.6	0.432***

Source: Prepared by the authors.
Note: *** Significant at 1%, ** significant at 5%, * significant at 10%. Significance of Moran's I based on 1,000 randomizations.

The foregoing is apparent in table 5, which shows the eigenvectors associated with each variable, together with their geographical scale. These values are mainly used to measure the degree of spatial heterogeneity or spatial homogeneity. In fact, given that, as explained in section III, each eigenvector has an associated Moran's I, if the prevailing scale of the eigenvectors linked to a variable is the local one, this means that there is marked heterogeneity; that is to say, the phenomenon being studied has an impact on the dependent variable that varies significantly from one territory to another. On the contrary, if the prevailing scale is the global one, the impact of a regressor on the dependent variable does not strongly vary over space. A lack of associated eigenvectors for a variable indicates that the impact of the variable is not differentiated in space. In other words, the impact for each location is the same. In the specific case being analysed, all variables have associated eigenvectors with a predominantly local and regional scale, confirming the existence of well-defined clusters, especially in the mountainous areas, as shown by the local Moran's I in the maps in annex A3.[8]

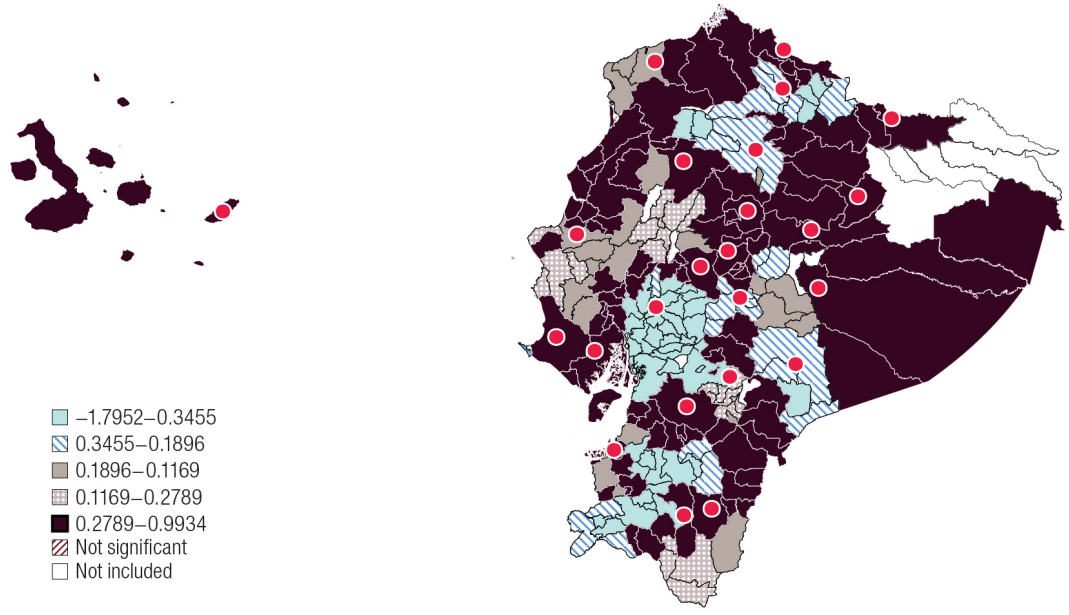
Table 5
Eigenvalues associated with each variable

	Local scale (0.50>MI>0.25)	Regional scale (0.75>MI>0.50)	Global scale (MI>0.75)
Intercept	3	1	1
Log (per capita GVA 2007)	2	3	1
Population growth	3	3	0
Education	3	2	1
Capital	7	1	0

Source: Prepared by the authors.

Map 2 shows the local variation in the coefficient associated with the intercept. The cantons where the structural factors considered by the local value of the intercept have the greatest impact are located in the south of the country and between the coastal and highland regions, in the north of Ecuador. The low-value clusters are in the provinces of Guayas and El Oro.

Map 2
Ecuador: local intercept coefficients



Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

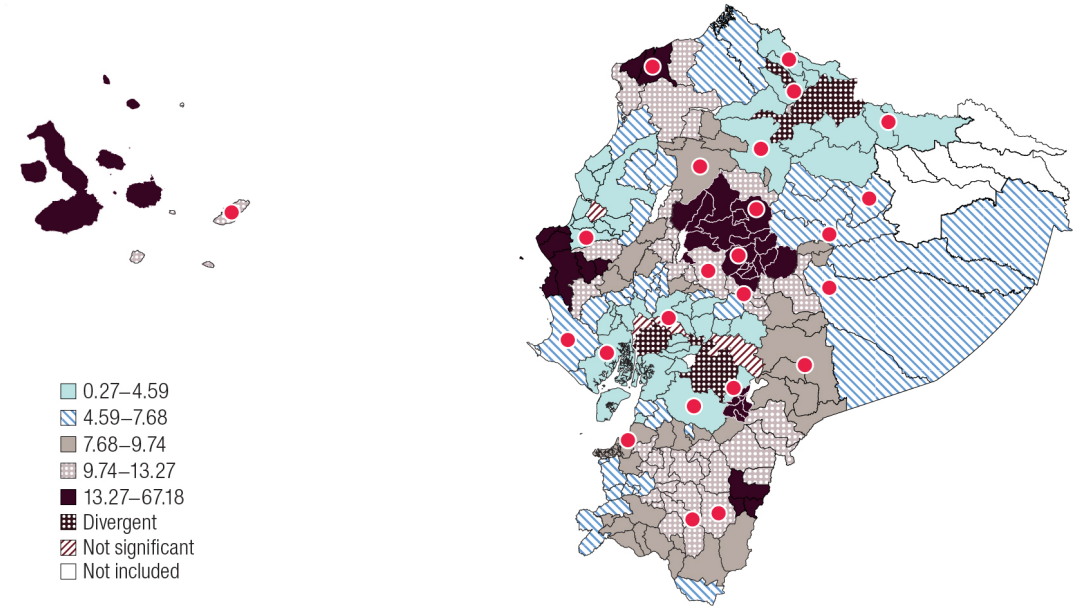
[8] See annex A1 for the distribution of provinces and areas.

Map 3 shows the local variation in the convergence rate. The areas with the highest speed of convergence are located in the hot spot of cantons in provinces south of Quito, in the southern part of the country, and on the coast, with the exception of the central-southern area. Lastly, the lowest convergence rates are found in the centre of the mountainous region. In addition, there are certain cantons that diverge (marked with dots), in the province of Cañar and in the north of the country, where clusters of cantons with low convergence rates are also located.

Map 3

Ecuador: rate of convergence λ_i

(Percentages)



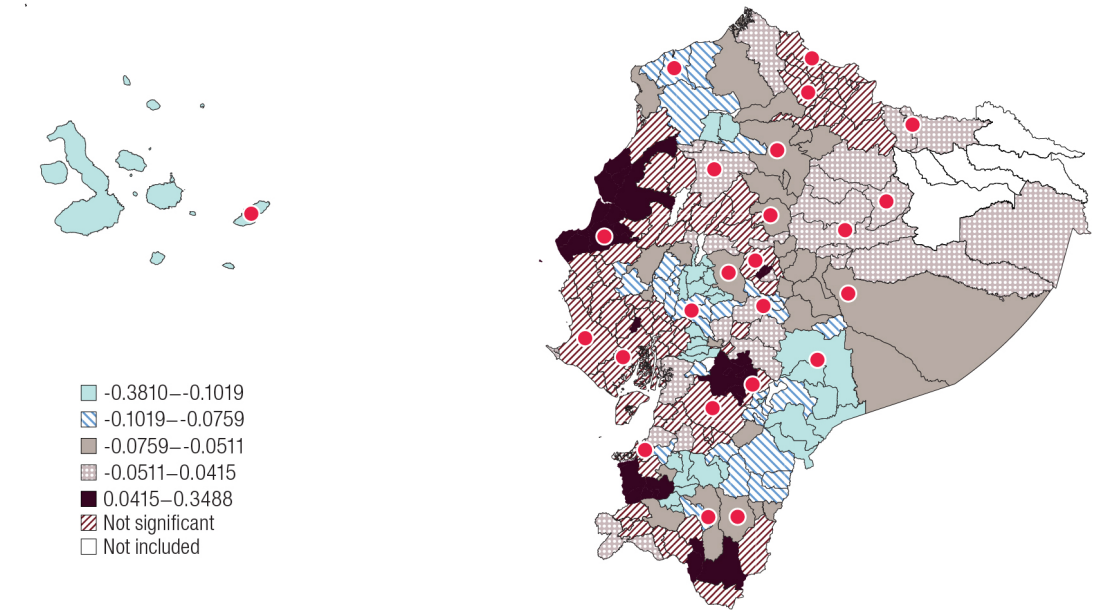
Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

Maps 4 and 5 show, respectively, the coefficients for and for physical capital. The first aspect that is apparent is that there are several cantons where coefficients are not significant. With respect to population growth, the cantons are generally located in the central part of the coast, on the border with Peru and on the border with Colombia. Physical capital is not significant in the northern part of the coast, in the Amazon region and in the province of Cañar.

For areas where the population growth rate is statistically significant, the highest coefficients are located in the north-west area. For capital, the impact is greater in the border cantons between the mountains and the coast.

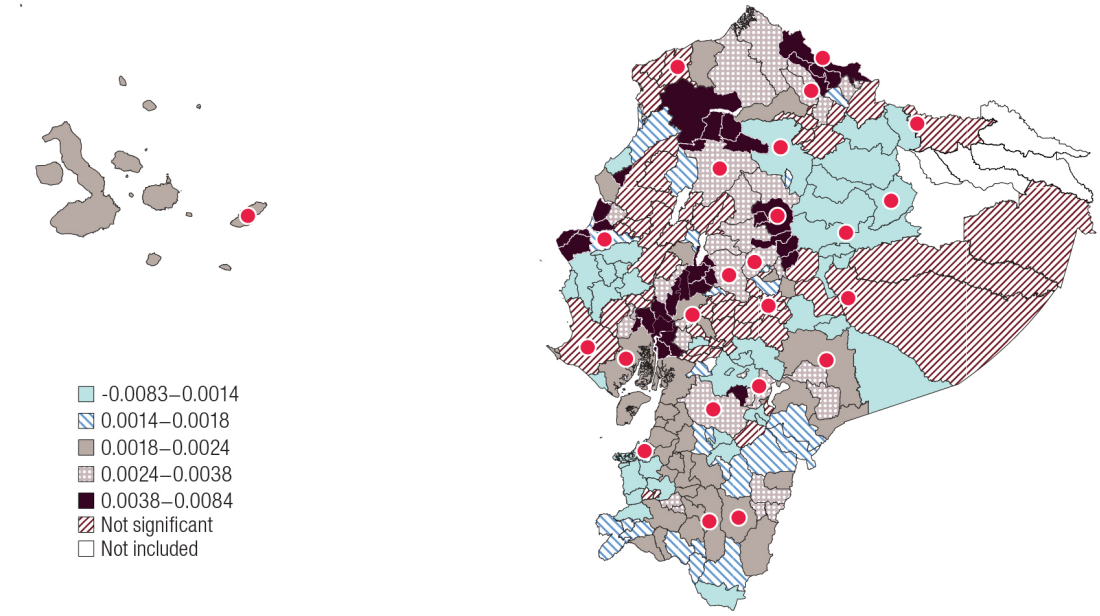
Lastly, map 6 shows how the greatest impact of education is seen in the southern part of the country and in the centre of the mountainous area, where there are statistically significant hot spots of cantons. In addition, clusters with very low impact are observed north of Quito and in Cañar and Azuay.

Map 4
Ecuador: local coefficients of the population growth rate



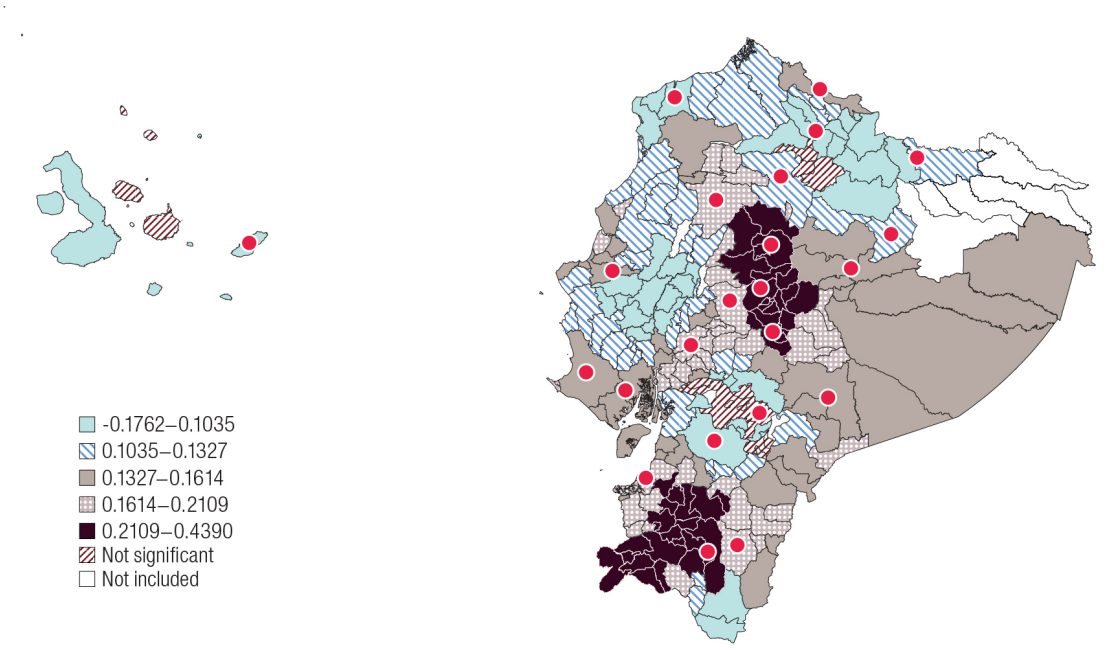
Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

Map 5
Ecuador: local capital coefficients



Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

Map 6
Ecuador: local education coefficients



Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

The correlation between the intercept coefficient and the rate of β-convergence is 0.472, indicating that there is a direct but moderate relationship between unobserved structural factors affecting growth and the canton convergence rate (see table 6). In this regard, around half of the cantons with high convergence rates also enjoy certain structural conditions that promote and drive their growth and vice versa. Correlation between the intercept term and the human and physical capital coefficients is negative and very low. In other words, the impact of education and physical capital on canton economic growth is greatest in the cantons where structural conditions are most adverse and vice versa. This shows that the return on investment in human and physical capital is lower in cantons that have achieved a certain degree of development.

Table 6
Correlation between local parameter values

	Intercept	λ_i	Population growth	Education	Capital
Intercept					
Rate of convergence λ_i	0.472				
Population growth	0.175	-0.104			
Education	-0.258	0.267	-0.099		
Capital	-0.260	0.257	-0.089	0.813	1

Source: Prepared by the authors.

Furthermore, the correlation between the impacts of human and physical capital shows a positive coefficient of 0.813, meaning that these two factors complement each other. Despite this result, in certain areas of the country —especially the central mountainous area and the Amazon— there is a compensatory effect between physical and human capital: the greater the impact of physical capital, the smaller that of human capital. This may be owing to the economic characteristics of these cantons, which make greater or lesser use of physical and human capital, depending on their production specialization.

V. Conclusions

This paper analyses the process of conditional convergence in Ecuador between 2007 and 2015 through a spatial econometric model that takes into account the structural heterogeneity of the cantons and spatial autocorrelation. Although the model used is an evolution of the GWR approach (Fotheringham, Brunsdon and Charlton, 2002), the GWR-spatial filtering approach does not require coefficients to be non-stationary, but does allow for non-stationarity. This means that in the same regression there may be global and local coefficients, as there would be in a mixed GWR, but with a solution for the problems of multicollinearity and of a lack of degrees of freedom. To assess convergence, per capita GAV is used. As demonstrated in this study, the variance of per capita GAV increases in conjunction with spatial autocorrelation, indicating increasing disparity and economic polarization among cantons.

This analysis differs from previous contributions (Mendieta Muñoz, 2015; Ramón-Mendieta, Ochoa-Moreno and Ochoa-Jiménez, 2013; Mendieta Muñoz and Pontarollo, 2016; Szeles and Mendieta Muñoz, 2016) in that it estimates the conditional β-convergence model using spatial filters, an econometric technique that allows instability of parameters to be taken into account. Therefore, it is not necessary to assume, as in previous studies, that all cantons respond in a similar manner to the factors that determine growth. Instead, the possibility is allowed that the variables in the model have a differentiated effect across space, depending on the particularities of each territory.

In this respect, it is demonstrated that the impact of education is concentrated in the central mountainous area, where there is a clear agglomeration of cities, and near the borders with Peru, which are the fastest-growing areas, where there are more flows of people and goods. Conversely, in the central coastal area, north of Guayaquil, in Cañar, and in the north of the country, education has little or no role with respect to growth. This may be because the cantons that are close to the major cities (Guayaquil, Quito and Cuenca) seem to be sapped by these cities since, according to Mendieta Muñoz and Pontarollo (2016), they absorb resources from nearby areas. The positive impact of physical capital, on the other hand, partially geographically overlaps the effect of human capital.

Lastly, in the context of conditional convergence, highly heterogeneous convergence coefficients indicate that some cantons are close to their own steady state.

The instability in the parameters associated with the spatial dimension shows that in Ecuador there are not only clear inequalities between territories, but also that this situation entails highly asymmetrical effects of factors on convergence. These differences appear to reflect the presence of an element of spatial contagion. This completely changes the connotations of analysis of the factors that affect convergence in the case of Ecuador, meaning that the utmost care must be taken when performing an overall analysis of the country.

It is therefore argued that, in terms of economic policy, emphasis should be placed the need for economic policies to be differentiated to reflect cantons' different structural characteristics, because regions are not countries and cannot simply replicate national policies at a regional scale (OECD, 2011, p. 19).

This relates to the evidence that, as several authors have highlighted (for example, Barca, McCann and Rodríguez-Pose, 2012), in order to draw on the growth potential of a territory there must be a detailed understanding of its socioeconomic structure, in order to adapt local public policy to its particular needs, finding the right combination of actions.

In this regard, the proposed tool, which allows for a deeper understanding of territorial dynamics, can be used to formulate policies that are appropriate to the territorial context and therefore more effective. In the case of Ecuador, which is characterized by marked structural differences, the wrong policies have the potential to harm the country's balanced development and lead to downward convergence (Szeles and Mendieta Muñoz, 2016), whereby the most developed cantons decline towards the level of the least developed, rather than the other way around.

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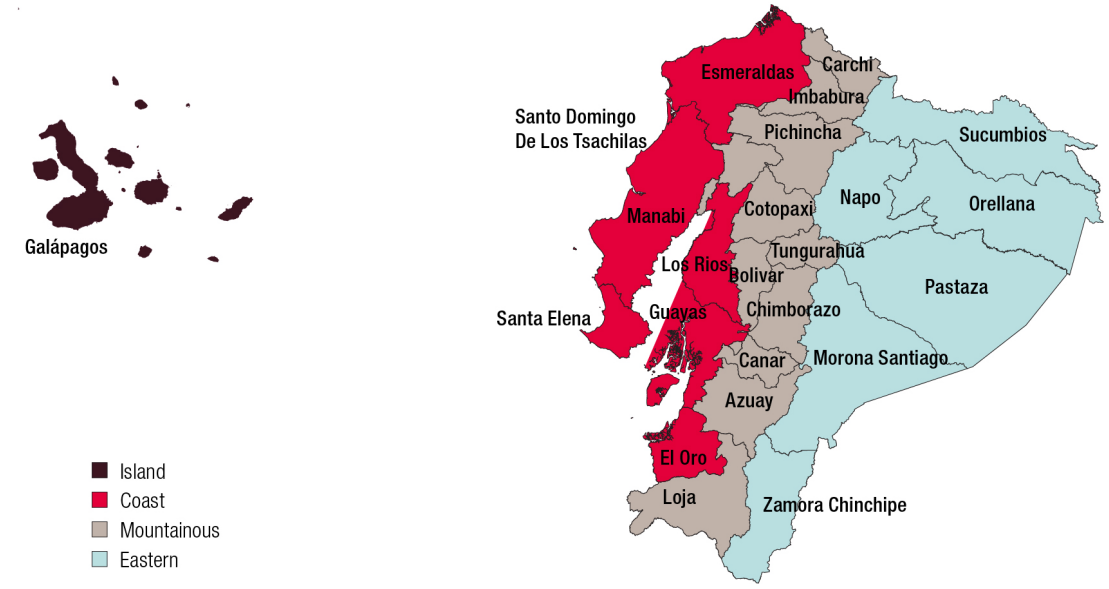
Annex A1

Map A1.1
Ecuador: map of the provinces

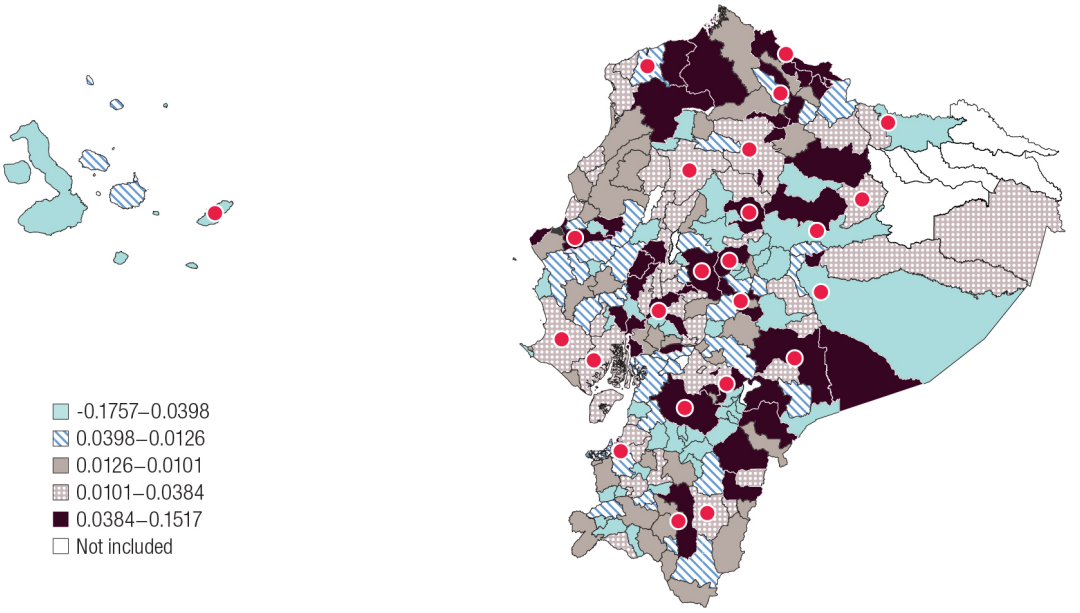


Source: Prepared by the authors.

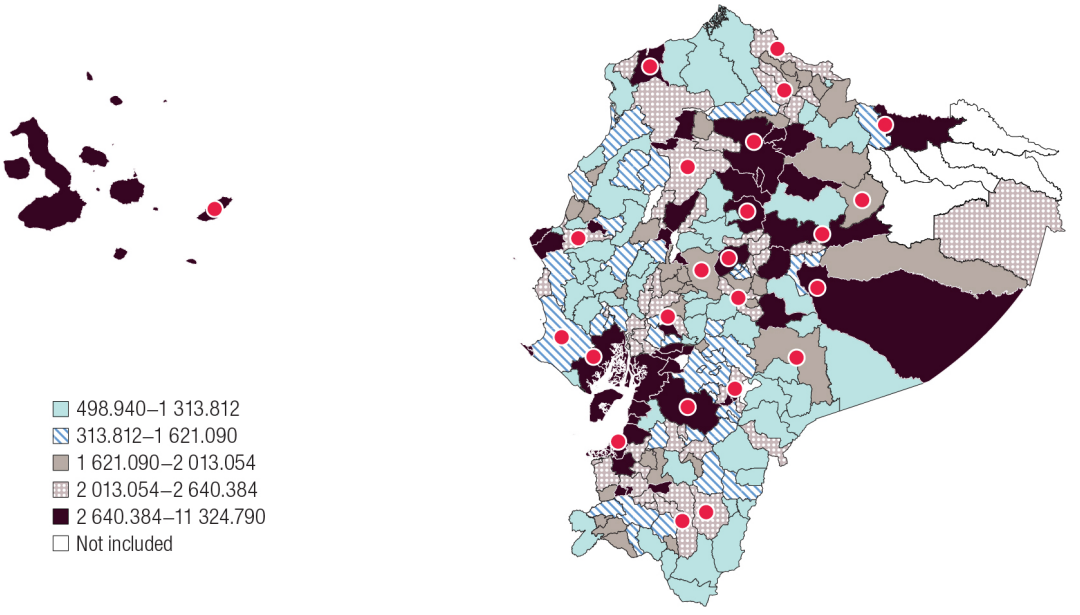
Annex A2

Map A2.1
Maps of model variables

A. Per capita GVA growth, 2007–2015

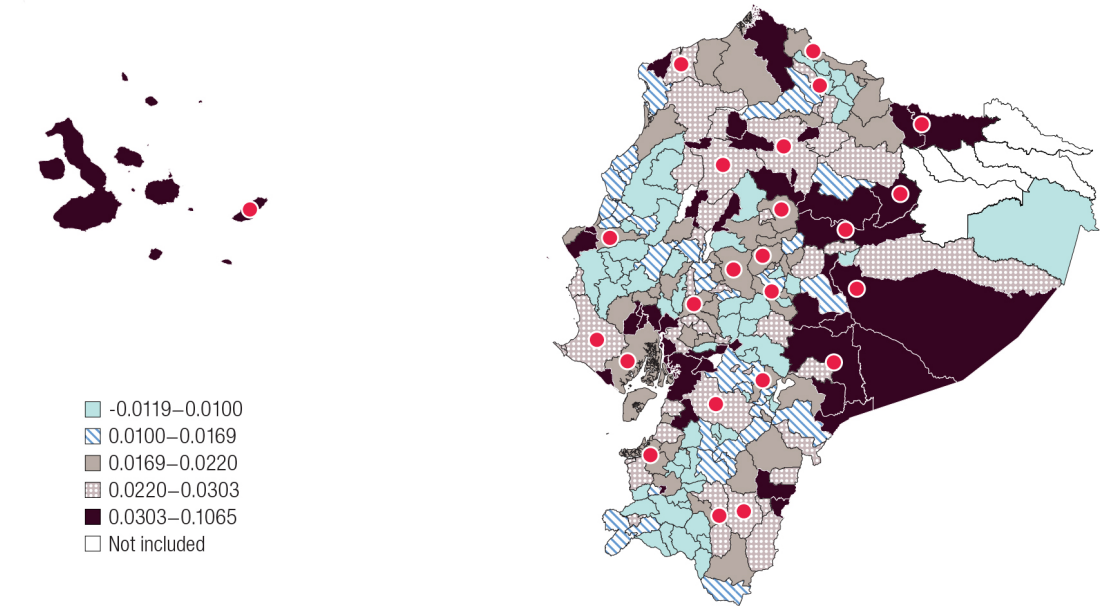


B. Per capita GVA, 2007

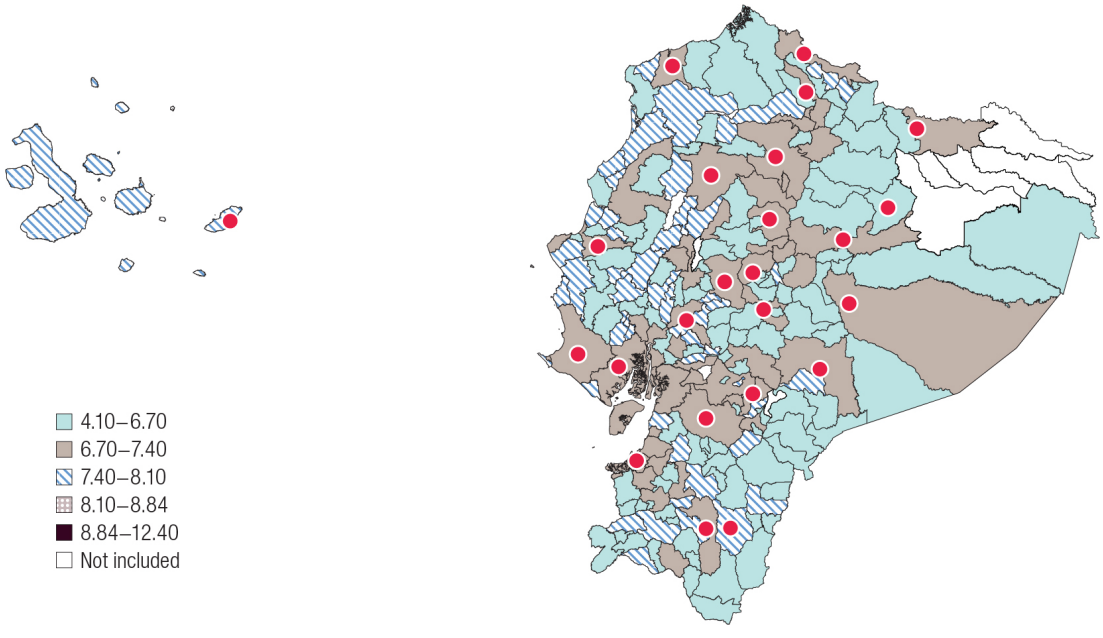


Map A1.1 (continued)

C. Population growth, 2007–2015

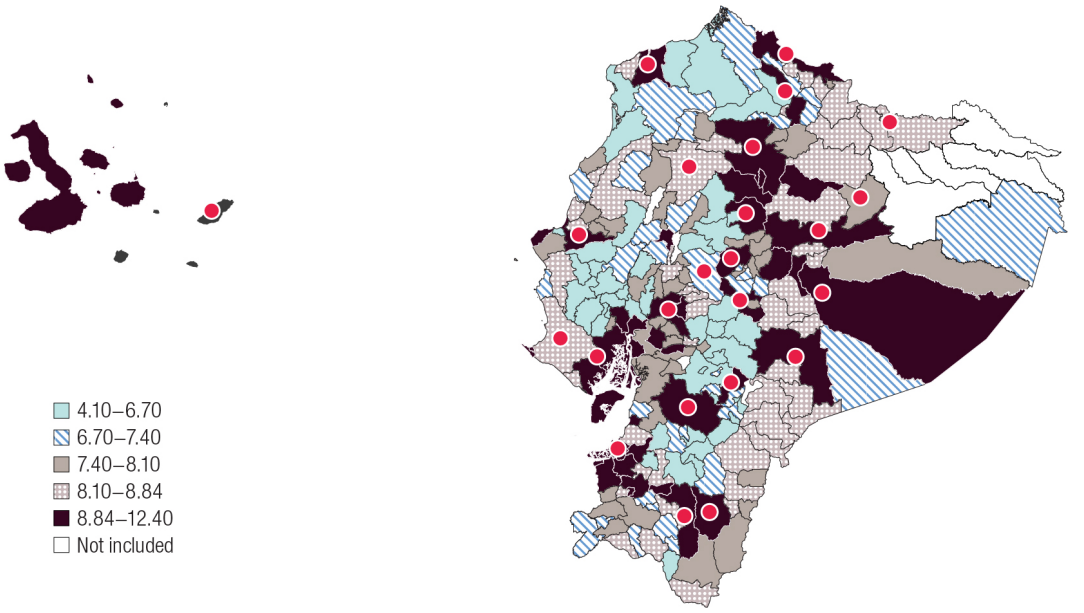


D. Capital, 2007



Map A1.1 (concluded)

E. Mean years of schooling, 2010 (education)

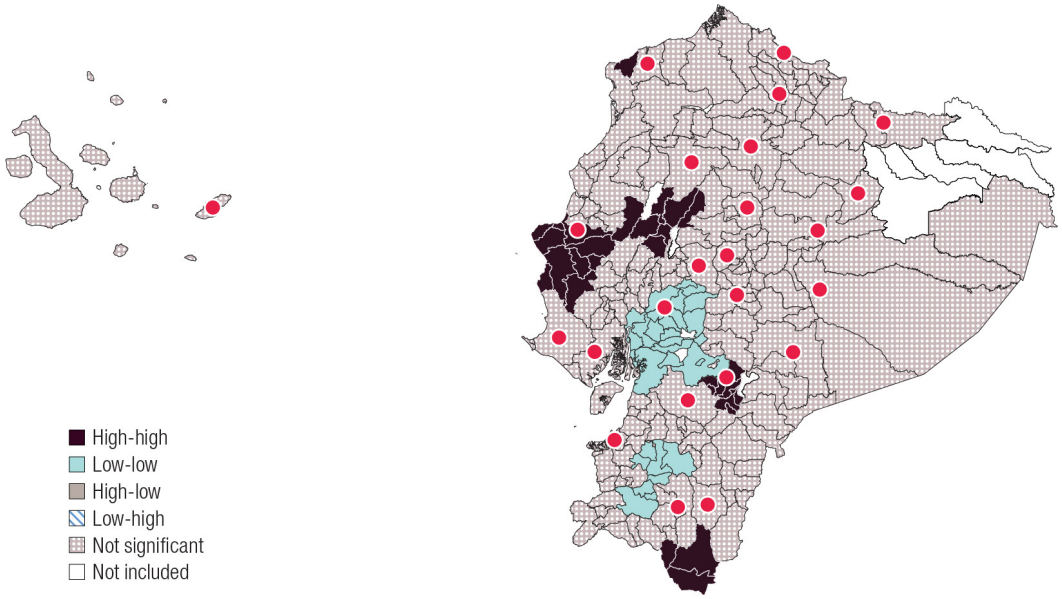


Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

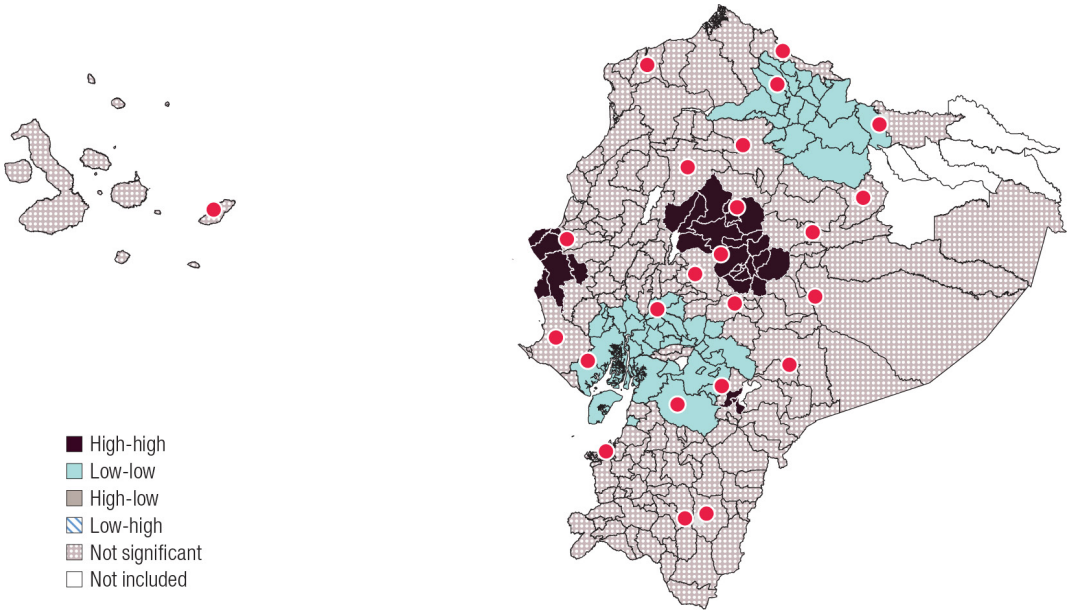
Annex A3

Map A3.1
Local Moran's I of coefficients

A. Local Moran's I of intercept

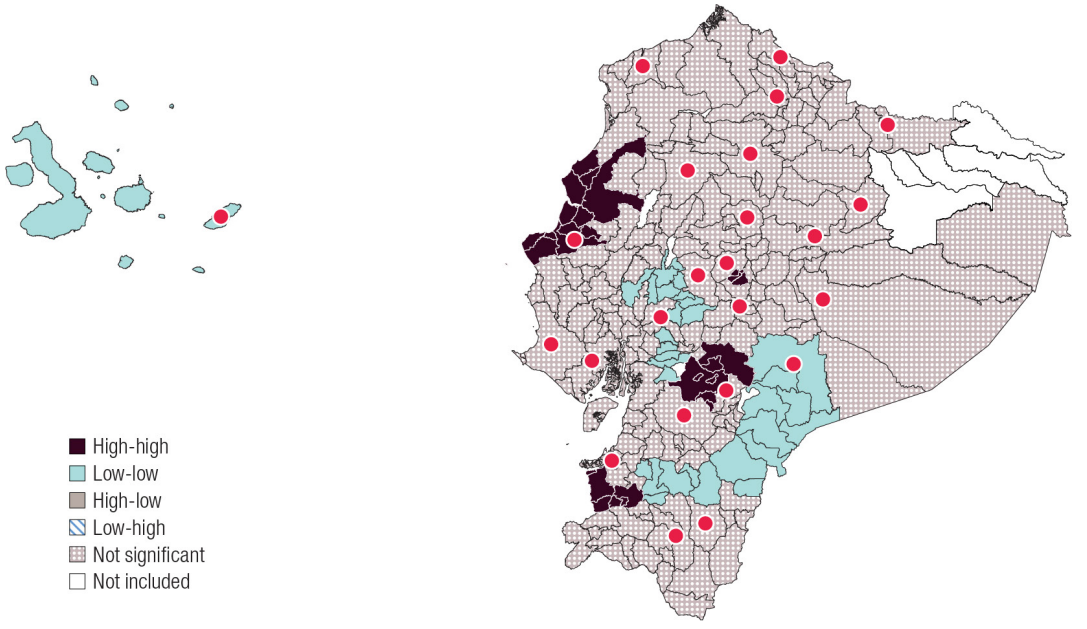


B. Local Moran's I of convergence rate

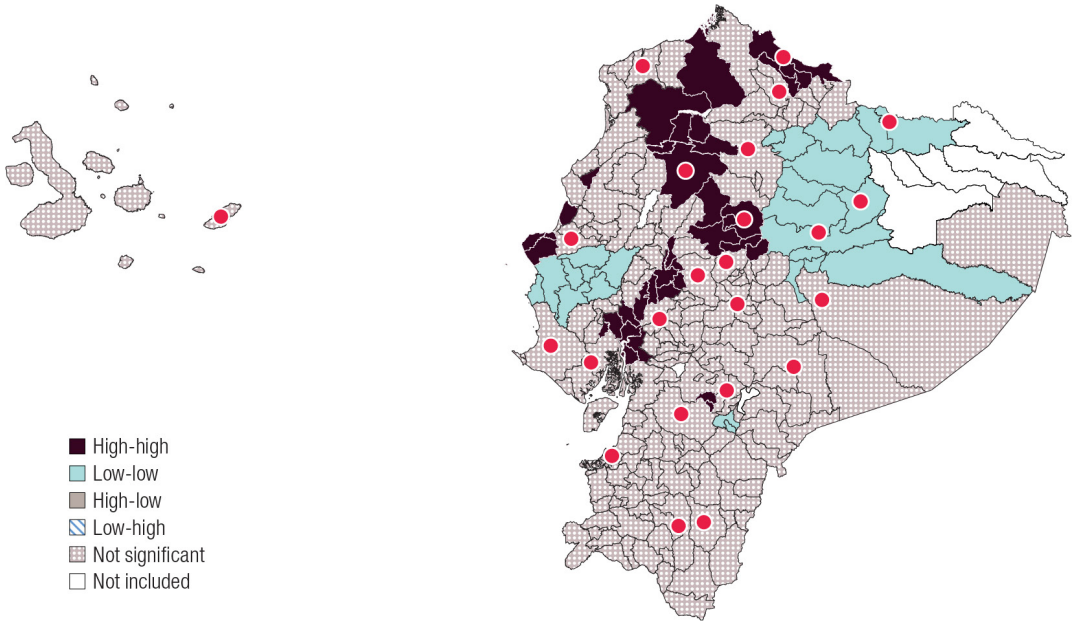


Map A3.1 (continued)

C. Local Moran's I of population coefficient

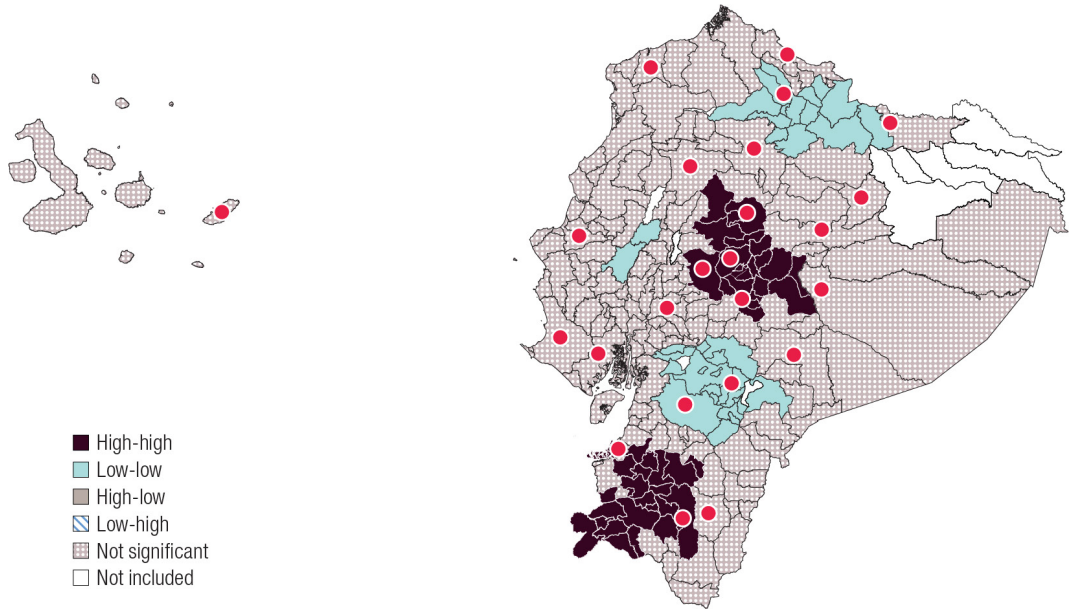


D. Local Moran's I of capital coefficient



Map A3.1 (concluded)

E. Local Moran's I of education coefficient



Source: Prepared by the authors.
Note: The dots represent the provincial capitals.

Industrial growth and consumer goods inflation in Mexico: an econometric analysis

Víctor Manuel Cuevas Ahumada
and Cuauhtémoc Calderón Villarreal[1]

Abstract

This paper employs a vector error correction methodology to investigate the long-term determinants of consumer goods inflation and industrial growth in Mexico during the 2001–2016 period. This is underpinned by a aggregate demand-aggregate supply model that brings new explanatory variables into play and keeps a priori restrictions on the data to a minimum. The evidence shows that cost-push and demand-pull inflation are both present and reveals the variables at work in each case. This study fills a gap in the empirical literature by showing that labour productivity not only spurs industrial growth, but also lowers consumer goods inflation in the long run. The policy implication of this finding is important given the need to attain faster economic growth without sacrificing price stability.

Keywords

Industrial production, inflation, consumer goods, economic analysis, econometric models, Mexico

JEL classification

C32, F41, J24

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I. Introduction

This paper uses a vector error correction (VEC) approach to study the long-run determinants of industrial growth and consumer goods inflation in Mexico during the 2001–2016 period. The VEC model embodies an aggregate demand-aggregate supply specification that includes a fairly wide range of variables to keep a priori restrictions on the data to a minimum. This specification is consistent with a small open economy with a flexible exchange rate. It also incorporates some previous findings in the field, while leaving room for new explanatory variables such as labour productivity, wages and foreign output in a theoretically plausible manner.

The importance of the industrial sector in Mexico stems from its contribution to output, employment and exports. In 2015, the industrial sector accounted for 33.2% of gross domestic product (GDP), 39.2% of total employment and 91.6% of total goods exports. Given that Mexico's industrial sector depends heavily on imported intermediate inputs, capital stock and technology, there is a strong link between exchange-rate depreciation and rising consumer goods prices (i.e. consumer goods inflation). Moreover, the reference point for choosing the study interval was the implementation of the inflation-targeting system in Mexico in January 2001. Under the inflation-targeting framework, the central bank is publicly committed to achieving a specific rate of inflation, with the more fundamental mission of providing price stability. In furtherance of this goal, the central bank is independent of the federal government and enjoys considerable discretion in the formulation and implementation of monetary policy measures. Another important feature of an inflation-targeting central bank is the obligation to meet high standards of transparency and accountability, mainly regarding the ends and means of monetary policy.

By the same token, to guarantee the central bank's credibility and the effectiveness of monetary policy, it is necessary not only to set feasible targets and realistic margins of error,[2] but also to periodically generate econometric studies on the determinants of price instability and output fluctuations. These empirical studies must also address problems such as the changing responsiveness of key variables to economic policy actions (e.g., the response of industrial output and consumer goods prices to an interest rate increase of a certain magnitude). Although this paper focuses on long-term econometric analysis using a VEC model, some attention is given to short-term dynamics as well. This approach, in conjunction with the set of variables included in the model, allows us to: (i) identify several empirical relationships consistent with economic theory and with some salient aspects of previous research; and (ii) offer some new insights into the behaviour of consumer goods prices and industrial output. Among other contributions, this paper shows that in the long run: (i) wage increases and exchange-rate depreciation give rise to cost-push inflation, as they raise consumer goods prices and lower industrial production; and (ii) a more productive workforce can play a major role not only in stimulating industrial production but also in stabilizing consumer goods prices. Macklem and Yetman (2001) show that, for the United States and Canada, the productivity growth rate influences the behaviour of prices, conceivably by changing the relationship between output and inflation. Thus, an important contribution of this paper is to show that, in a developing economy such as Mexico, higher labour productivity can be a significant factor not only in stimulating industrial output, but also in stabilizing consumer goods prices.

This study is organized as follows. Section II offers a brief review of the empirical literature on the topic. Section III develops the theoretical model. Section IV focuses on data management, econometric methodology and the presentation of empirical evidence. Lastly, section V concludes by interpreting the empirical evidence and their economic policy implications.

[2] Since January 2003, the Bank of Mexico's official target for the annual rate of inflation has been 3%, with a range of +/- 1 percentage point.

II. Literature review

A number of recent empirical papers have been devoted to analysing the determinants of inflation in Mexico and other Latin American countries, but only a small portion of these studies address the causes of output changes as well. Using a three-variable vector autoregression (VAR) model that includes the real budget deficit, real exchange rate and inflation, Dornbusch, Sturzenegger and Wolf (1990) provide empirical evidence on the responsiveness of inflation to fiscal and exchange-rate shocks in five Latin American economies: Argentina, Brazil, Mexico, Peru and the Plurinational State of Bolivia. These authors show that real exchange-rate depreciation is a major cause of price instability in all the countries except the Plurinational State of Bolivia. Real fiscal expansion, on the other hand, leads to inflation only in Mexico, Peru and the Plurinational State of Bolivia. Lastly, Brazil and Argentina display strong signs of inertial inflation, with prices heavily influenced by their own shocks.

Rogers and Wang (1995) estimate a VAR model for the Mexican economy with five variables (budget deficit, real money supply, real exchange rate, prices and output). They find that inflation is more responsive to fiscal and monetary shocks than to exchange-rate shocks. Moreover, output fluctuations stem from real and fiscal shocks and, to a lesser extent, from monetary and exchange-rate shocks. Thus, they conclude that monetary and exchange-rate policies are relatively ineffective when it comes to encouraging economic activity.

Agénor and Hoffmaister (1997) carried out an empirical study of inflation based on four developing economies, namely Chile, Mexico, the Republic of Korea and Turkey. The authors estimate a VAR model for each country, which indicate that a lax monetary policy leads to inflation. It is worth noting that in Mexico an increase in the money supply had a short-lived effect on output and a persistent effect on prices. Lastly, with the notable exception of the Republic of Korea, currency depreciation is inflationary in all the countries.

Using different econometric methodologies, Catalán and Galindo (2005) prove that there is a positive relationship between inflation and money supply in Mexico, and this finding is consistent across all four monetary aggregates. The evidence provided also supports the notion that output can be stimulated through monetary expansion, but the authors emphasize that the link between money and output is considerably more elusive than the link between money and prices.

Baqueiro, Díaz de León and Torres (2003) estimate the pass-through effect from exchange rates to prices. Using a sample of 16 small open economies (including Mexico) with flexible exchange-rate systems, they show that the pass-through effect weakens as these economies move from a high- to a low-inflation stage. Put differently, the inflationary impact of exchange-rate depreciation weakens as the stabilization process moves forward. In this context, several papers conclude that the Mexican pass-through effect declined from the 1990s to the 2000s (Capistrán, Ibarra and Ramos-Francia, 2012; Cortés, 2013; Guillermo and Rodríguez, 2014; Rodríguez, 2015). In particular, Rodríguez (2015) points out that the pass-through effect became so small after the implementation of inflation targeting in Mexico that sudden exchange-rate depreciations do not significantly change the trajectory of the price level.

The work of Hernández (2015), however, successfully casts doubt on the accuracy of the earlier findings, arguing that both Capistrán, Ibarra and Ramos-Francia (2012) and Cortés (2013) make use of monthly data for the annual growth rate of inflation and exchange-rate depreciation when estimating the VAR model and the accumulated impulse-response functions, thereby creating a mismatch between the frequency of the data and the periodicity of the growth rate of the variables being studied. In Hernández's view, this mismatch ultimately results in a downwardly-biased estimation of price elasticity with respect to the exchange rate.

In a parallel line of research, Carrasco and Ferreiro (2011) analyse the Mexican inflation stabilization process, concluding that the inflation-targeting framework made it easier for the Bank of

Mexico to bring inflationary expectations under control. In the case of Brazil, Caldas (2013) argues that private agents' inflationary expectations affect their economic decisions, thereby becoming a major source of price instability. Hence, a central bank that credibly targets inflation can reduce the negative impact of macroeconomic stabilization on real variables, mainly by inducing a downward trend in inflationary expectations.

To sum up, the recent empirical literature identifies the following variables as leading sources of inflation: budget deficits, money supply, the exchange rate and inflationary expectations. Furthermore, the econometric literature underlines the following aspects: (i) exchange-rate shocks were a powerful cause of price instability in high-inflation Latin American countries such as Argentina, Brazil and Mexico "in the 1980s" (Dornbusch, Sturzenegger and Wolf, 1990); (ii) more recently, fiscal and monetary expansion has become more inflationary than exchange-rate depreciation (Rogers and Wang, 1995); (iii) the pass-through effect decreases as the macroeconomic stabilization process moves forward (Baqueiro, Díaz de León and Torres, 2003; Capistrán, Ibarra and Ramos-Francia, 2012; Cortés, 2013; Guillermo and Rodríguez, 2014; Rodríguez, 2015); (iv) however, the pass-through effect from the exchange rate to prices, while smaller than before, has probably been underestimated (Hernández, 2015); and (v) inflation-targeting monetary policy has been useful in anchoring inflationary expectations in developing countries such as Brazil and Mexico (Carrasco and Ferreiro, 2011; Caldas, 2013). By the same token, economic activity responds to fiscal and real shocks and, to a lesser degree, to monetary and exchange-rate shocks (Rogers and Wang, 1995). Lastly, some authors state that an expansionary monetary policy yields a transitory increase in economic activity and a long-lived and stronger rise in prices (Agénor and Hoffmaister, 1997; Catalán and Galindo, 2005).

III. An aggregate demand-aggregate supply model

This section lays the foundation for a VEC model consisting of 10 variables: government spending, money supply, interest rate, exchange rate, wages, labour productivity, capacity utilization, prices, domestic output and foreign output. The recent econometric literature identifies most of these variables as key determinants of macroeconomic fluctuations, whereas the model itself allows new variables to be brought into play, in particular wages and labour productivity. It is very common in empirical economic studies to work with real rather than nominal variables. This paper, however, follows the standard recommendation made by Hoover, Johansen and Juselius (2008) and Juselius (2011, p. 350) in terms of not deflating nominal variables such as the money supply, the interest rate and the exchange rate, in order to "allow the data to speak freely". Adjusting such variables for inflation, according to these authors, can interfere with critical signals in the time series and thus undermine the reliability of the empirical evidence.[3] Moreover, Hoover, Johansen and Juselius (2008) suggest favouring empirical evidence over ex ante economic theory when working with VEC models, such as the one we estimate hereafter.

1. The aggregate demand equations

An open economy version of the IS-LM model is used to obtain the demand-side equations. The model is built upon two standard assumptions: (i) the exchange-rate system is flexible; and (ii) the national economy is small enough for foreign prices to be taken as given. Two behavioural relationships depict the dynamics of aggregate demand, one relating to the goods market and the other to the money market.

[3] It is also important to consider that Mexican inflation has been relatively low since the implementation of the inflation-targeting monetary policy in 2001.

The long-run equilibrium in the goods market is represented by the open economy version of the IS function:

$$y_t = a_0 + a_1 pb_t + a_2 i_t + a_3 q_t + a_4 y_t^* + \varepsilon_t^y \quad (1)$$

where y_t is the logarithm of domestic output, pb_t the logarithm of a scaled version of the public sector balance, i_t the interest rate, q_t the logarithm of the exchange rate, y_t^* the logarithm of foreign output and ε_t^y a stochastic error term. The public sector balance is scaled up so that it takes only positive values and can be stated in natural logarithms. This transformation in the public sector balance is illustrated in annex A1.

A conventional IS function makes use of government spending (g_t) rather than the public sector balance (pb_t), and g_t has a positive effect on domestic output (y_t). Nonetheless, as annex A2 shows, g_t turns out to be trend-stationary, which makes it inappropriate for cointegration analysis. In addition to being integrated of order 1 and thus suitable for cointegration testing, the public sector balance performs better in terms of model residual behaviour than government spending. The expected parameter signs in this modified IS function are: $a_1<0$, $a_2<0$, $a_3>0$ and $a_4>0$. Put differently, $a_1<0$ because a rise in pb_t equates to a fiscal contraction (i.e. a reduction in government spending, an increase in public revenues or both), whereas a decline in pb_t reflects a fiscal expansion (i.e. an increase in government spending, a fall in public revenues or both).

Tanzi and Zee (1997) argue that both the budget deficit and government spending have been used in empirical work and that there is no conclusive evidence favouring one fiscal policy indicator over the other.

A conventional LM equation depicts the long-term equilibrium in the money market:

$$m_t = b_0 + b_1 i_t + b_2 p_t + b_3 y_t + \varepsilon_t^m \quad (2)$$

where m_t is the logarithm of the money supply, p_t is the logarithm of the price level and ε_t^m is a disturbance term reflecting money demand shocks. Notice that the left-hand side of equation (2) represents the money supply, while the right-hand side represents the behaviour of demand for money. As a result, the expected parameter signs are: $b_0>0$, $b_1<0$, $b_2>0$ and $b_3>0$.

2. The aggregate supply equations

We draw on the seminal paper by Tobin (1972) to specify a wage-price mechanism consisting of a wage-setting equation and a markup equation (or price equation). As will be seen below, the price equation can be thought of as the inverse supply curve of firms insofar as it describes the behaviour of the price level.

$$w_t = c_0 + c_1 i_t + c_2 cu_t + \varepsilon_t^w \quad (3)$$

$$p_t = d_0 + d_1 w_t + d_2 \upsilon_t + d_3 cu_t + d_4 q_t + \varepsilon_t^p \quad (4)$$

Equation (3) is a modified version of the wage-setting equation developed by Tobin (1972). Broadly speaking, Tobin takes the nominal wage growth rate as a function of inflationary expectations and the unemployment rate, which is an indirect measure of labour demand or "a proxy for the level of output compared to capacity" (Blanchard and Fischer, 1990, p. 543). In contrast, our empirical specification states the variables in levels, as opposed to growth rates or first differences, the idea being to work with non-stationary variables so that cointegration analysis can be undertaken. Second, we shall, in

principle, assume that the Fisher equation[4] holds, so that inflationary expectations can be captured by the nominal interest rate. In this manner, we can specify nominal wages as an increasing function of the nominal interest rate (i_t). Third, capacity utilization (denoted by cu_t) is used in equation (3) as a proxy for labour demand. According to Blanchard and Fischer (1990, p. 543), econometric equations can include a number of measures that serve this purpose, such as capacity utilization and the output gap. Thus, an improvement in capacity utilization may shift the labour demand curve to the right, thereby bringing down unemployment and raising wages. Accordingly, all the parameters in equation (3) are expected to have a positive sign. Lastly, ε_t^w is a stochastic error term reflecting unexpected changes in other wage-related variables such as the degree of labour mobility, the size of the informal sector and the bargaining power of labour vis-à-vis management.

As pointed out earlier, equation (4) is a price-setting equation which can be regarded as the inverse supply curve of firms insofar as it depicts the behaviour of prices. In Tobin's 1972 paper, the rate of change in prices responds to the rate of change in unit labour costs and to the unemployment rate. Our specification differs in at least four respects: (i) the variables are in levels; (ii) unit labour costs are replaced by wages and labour productivity, on the grounds that unit labour costs go down when labour productivity grows faster than wages and vice versa; (iii) capacity utilization is used instead of the unemployment rate; and (iv) prices here are also a function of the exchange rate (q_t). Lastly, ε_t^p is an error term reflecting stochastic changes in price-related variables not explicitly considered. Along these lines, prices are assumed to bear a direct relationship to wages, capacity utilization (cu_t) and the exchange rate (q_t). Any of these variables, at a given juncture, could give rise to inflation. For instance, exchange-rate depreciation could raise the local currency cost of imported intermediate inputs, capital goods and technology, thereby generating cost-push inflationary pressure. Meanwhile, higher labour productivity (v_t) reduces inflationary pressure by bringing down unit labour costs, with d_2 thus being the only parameter in (4) with a negative sign. Hence, the intuition behind equation (4) is that: (i) the interplay between all the explanatory variables has an impact on per-unit production costs; and (ii) firms set prices above per-unit production costs and then meet whatever demand may emerge for their products subject to the capacity utilization constraint.

IV. Empirical analysis

1. Data description

This section contains the short- and long-term econometric analysis. To that end, first the information space of the model, given by the number and specific choice of variables, is outlined. On the basis of the literature review of section I, the theoretical model of section II, the availability of monthly data and a number of empirical tests and estimations, we selected 10 observable variables: public sector balance as a fiscal policy index; money supply; interest rate; exchange rate; wages; labour productivity; capacity utilization; prices; domestic output; and foreign output.

Hoover, Johansen and Juselius (2008) and Juselius (2011, p. 350), among others, point out that adjusting nominal variables for inflation undermines the reliability of the empirical results by distorting the signals embodied in the original time series and preventing those series from speaking freely. Furthermore, Hoover, Johansen and Juselius (2008) argue that, when working with multivariate time series models, empirical evidence must prevail over economic theory and not the other way around. In this context, it must be stressed that: (i) all the variables of the model are seasonally adjusted; (ii) with the exception of

[4] The ex ante version of the Fisher equation states that $i_t + r_t^e + \pi_t^e$, where r_t^e is the expected real interest rate and π_t^e is the symbol for the expected inflation rate for the period t.

the interest rate and capacity utilization, which are measured in percentages, the variables are stated in natural logarithms so that long-run elasticities can be estimated; and (iii) following the standard recommendation of Hoover, Johansen and Juselius (2008) and Juselius (2011), the nominal variables of the model (i.e. the public sector balance, money supply, interest rate, exchange rate and wages) are not adjusted for inflation. All that stated, each variable will now be described in detail:

1. As a fiscal policy index, we decided to use the public sector balance (pb_t), which is the gap between the revenues and expenditures of the federal government, the State-owned enterprises under budgetary control, and the non-budgetary sector. Government spending had to be discarded because it proved to be trend stationary, as we show in annex A2. Lastly, to be able to transform the public sector balance into logarithms, we applied a straightforward escalation procedure so that it would take only positive values (see annex A1). This enabled us to estimate long-term elasticities with no distortionary effect on the econometric results.
2. The monetary base was taken as a measure of money supply (m_t). We opted for this particular variable after comparing its performance with that of all other measures of money supply, mainly in terms of residual behaviour. A plausible explanation for the observed results is that the monetary base is more responsive to monetary policy changes than other measures of money.
3. To represent the interest rate (i_t), the interest rate on 28-day government bonds (CETES) was chosen from a number of alternatives, as it is a good source of information on current conditions in the money market as a whole.
4. The exchange rate (q_t) taken is the interbank exchange rate, given that most currency transactions involving Mexican pesos and United States dollars are carried out at this particular rate.
5. In view of data availability problems and testing results, we opted for the average nominal wage (w_t) earned by all workers affiliated to the Mexican Social Security Institute as a proxy for the cost of labour.
6. Labour productivity (v_t) in the manufacturing sector (the only measure of productivity available on a monthly basis) was included so that the effect of this variable on industrial production and consumer goods prices could be estimated.
7. Percentage capacity utilization (cu_t) in the manufacturing industry was taken as a proxy for labour demand given that, from the statistical standpoint, this variable seemed to work better than any other measure of the output gap.
8. To measure changes in the price level (p_t), we used the core index of consumer goods prices, so we left out energy and food prices to avoid having a biased measure of consumer goods inflation and to improve residual behaviour.
9. The Mexican industrial production index was used to measure domestic output (y_t), given that the focus of this paper is on the long-term determinants of Mexican industrial activity and consumer goods prices.
10. In view of the unavailability of monthly data for United States GDP, we used the United States industrial production index as a proxy for foreign output (y_t^*).

The model estimation is based on monthly data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico for each variable from December 2001 to May 2016 (174 observations for each variable in all). As we explain below, the sample span is one of three decision variables used to properly adjust the model. This sample period works fairly well with the information space and lag structure of the model. An important aspect to consider in this regard is that, as of January 2007, the National Institute of Statistics and Geography (INEGI) of Mexico broadened the coverage of the statistical

data for the manufacturing sector. The result is that the new time series for percentage capacity utilization (cu_t) and labour productivity (v_t) comprise 240 types of economic activity (as opposed to 205 types in the old time series) based on the North American Industry Classification System (United States Census Bureau, 2007). Nonetheless, we were able to apply a simple data chaining technique, known as retropolation, in view of three facts: (i) the old and new times series are closely related; (ii) they are measured at the same frequency; and (iii) they overlap over the period 2007–2008. Put briefly, the new time series were extended backward in levels by replicating the growth path of the old time series. Through this procedure, the data for capacity utilization and labour productivity became a mixture of two components: (i) the actual measure of each variable in the recent period (January 2007–May 2016); and (ii) a suitable proxy for each variable in the previous period (December 2001–December 2006). Most importantly, longer historical series for capacity utilization and labour productivity resulted not only in a more statistically appropriate model, but also in more reliable cointegration tests.

2. Breakpoint unit root and stationarity tests

This section aims to identify the long-term equilibrium relationships between the model variables. The first step in doing so is to establish the order of integration of the variables by means of two types of tests: augmented Dickey-Fuller (ADF) tests with structural breaks, and Kwiatkowski and others (1992) stationarity tests. Following Hamilton's (1994, p. 501) methodology, the test equation for each variable is specified so as to capture the behaviour of the time series under the null and alternative hypotheses. The breakpoint ADF tests have three characteristics. First, the break date is estimated from each time series. Second, 4 out of the 10 variables do not include a linear trend, so in these four cases structural changes can only take the form of a shift in the intercept of the test equation. Third, in the case of trending variables, two other possibilities were considered under the alternative hypothesis: (i) a change in the trend and (ii) a simultaneous change in the trend and the intercept. For simplicity, the test results reported here are for an intercept break alone (see table 1).[5]

The breakpoint unit root and stationarity tests are consistent in indicating that the following seven variables are integrated of order 1 (I(1)) in levels: public sector balance (pb_t), money supply (m_t), exchange rate (q_t), labour productivity (v_t), capacity utilization (cu_t), domestic output (y_t) and foreign output (y_t^*). However, it is not uncommon for unit root and stationarity tests to yield contradictory outcomes, just as happens with the other three variables, namely the interest rate (i_t), prices (p_t) and wages (w_t). In the case of prices and the interest rate, our conclusion is that both variables are I(1) on the following grounds:

1. Previous empirical evidence for Mexico suggests that the price level has been I(1) and that the inflation rate (i.e. the rate of change in the price level) has been stationary at least since late 2000 or early 2001 (Chiquiar, Noriega and Ramos-Francia, 2010, p. 4; Noriega and Ramos-Francia, 2009, pp. 9–14). For its part, the interest rate has been as volatile as the exchange rate and more volatile than any of the monetary aggregates (Torres, 2000, p. 15). We use a normalized and unbiased measure of dispersion, known as a variation coefficient,[6] to show that the interest rate (i_t) was also much more volatile than the inflation rate and the price level (p_t) over the reference period. The estimated variation coefficients (EVCs) for the interest rate, the inflation rate and the price level are 0.35, 0.21 and 0.04, respectively.

[5] The unit root tests applied also take account of the fact that structural breaks can occur suddenly or gradually. Additive outliers reflect sudden breaks, whereas innovation outliers reflect gradual breaks. Additive outliers were used in the specific cases of the interest rate, exchange rate, wages, capacity utilization and output, given that these variables underwent radical shifts at some point over the reference period. In the other cases, unit root tests were carried out with innovation outliers.

[6] The estimated variation coefficient (EVC) for a given variable, say Y, is obtained as follows: EVC = $(S/\bar{Y})(1+1/4T)$, where S is the sample standard deviation of Y, $\bar{Y}$ is the sample average of Y, and T is the sample size. Therefore, $(1+1/4T)$ is the small sample bias correction factor proposed by Rohlf and Sokal (1995). Accordingly, for a sample of size T we get an unbiased and normalized measure of dispersion.

Table 1
Unit root tests with structural breaks and stationarity tests, December 2001–May 2016

Variable	Specification of the test equation	ADF breakpoint unit root test statistic (H_0: unit root)	KPSS test statistic (H_0: stationarity)	Order of Integration
pb_t	C	-3.27	1.11***	1
Δpb_t	C	-12.72***	0.15	0
m_t	C and T	-3.31	0.25***	1
Δm_t	C	-8.89***	0.08	0
i_t	C	-4.16	1.4***	≥1
Δi_t	C	-6.21***	0.37*	?
$\Delta^2 i_t$	C	-7.52***	0.16	0
q_t	C and T	-4.07	0.18**	1
Δq_t	C	-11.86***	0.07	0
w_t	C and T	-1.83	0.43***	≥1
Δw_t	C	-21.03***	1.71***	?
$\Delta^2 w_t$	C	-14.5***	0.18	0
v_t	C and T	-2.92	0.22***	1
Δv_t	C	-14.82***	0.34	0
cu_t	C	-3.12	0.81***	1
Δcu_t	C	-14.74***	0.04	0
p_t	C and T	-3.66	0.32***	≥1
Δp_t	C	-4.28*	0.65**	?
$\Delta^2 p_t$	C	-16.21***	0.04	0
y_t	C and T	-4.0	0.12*	1
Δy_t	C	-7.32***	0.07	0
y_t^*	C	-3.65	0.54**	1
Δy_t^*	C	-6.98***	0.07	0

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.

Note: C stands for constant and T for trend. The symbols and are the first and second difference operators, respectively. The asterisks *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significance levels, respectively. The ADF breakpoint unit root test results rely on Vogelsang (1993) asymptotic one-sided p-values. The lag length of the test equation is determined by means of the Akaike information criterion. The break type reported here is a level shift, but other possibilities were explored. The break date is estimated from the time series to maximize the likelihood of the unit root null hypothesis being rejected. The KPSS (Kwiatkowski–Phillips–Schmidt–Shin) test results are based on the critical values proposed by Kwiatkowski and others (1992). The Newey-West bandwidth selection method and the Bartlett kernel are used to control the bandwidth.

2. Esquivel and Razo (2003, p. 189), using monthly data for the Mexican economy from January 1989 to October 2000, conclude that both the interest rate on 28-day government bonds (CETES) and the consumer price index are I(1). Using monthly data for the period January 1994–October 2006, Cavazos and Rivas-Aceves (2009, pp. 118–119) reach the same conclusion, meaning that both the interest rate and the price level in Mexico are I(1). Lastly, Garcés (2008, p. 688) shows the same thing, but with quarterly data for the period 1980–2000.
3. A replication of the tests with a larger sample (January 1994–May 2016) leads to the conclusion that both the interest rate and prices are I(1) in levels.

The data available for nominal wages are not sufficient to carry out breakpoint unit root and stationarity tests with larger samples, but this variable is also likely to be I(1) given that: (i) the unit root tests used here consistently point to this conclusion under different scenarios of structural change; (ii) other unit root tests, such as the Phillips-Perron and augmented Dickey-Fuller tests, produce results

in line with those of the breakpoint unit root tests; and (iii) other measures of wages indicate that this variable has exhibited the same order of integration as prices and the money supply since the last decade (i.e. has been I(1)). Thus, it is reasonable to conclude that all the variables of the model are I(1) in levels.

3. Johansen cointegration tests

To identify the long-term equilibrium relationships among the variables at hand, Johansen cointegration tests must be implemented (Johansen, 1995; Juselius, 2007). The first step in performing these tests is to estimate an unrestricted vector autoregression (VAR) model that is statistically appropriate. Three decision variables were utilized to improve residual behaviour as much as possible: the information space, the lag length and the time interval. It has already been explained that the information space of the model consists of the 10 non-stationary variables previously detailed and that the sample period runs from December 2001 to May 2016. As for the lag structure of the VAR model, we chose six lags for each variable in each equation. The model is represented by equation (5):

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} +, ..., + A_p Y_{t-p} + \psi X_t + \eta_t \quad (5)$$

where $Y_t = \left[pb_t, m_t, i_t, q_t, w_t, \upsilon_t, cu_t, p_t, y_t, y_t^*\right]'$ is a 10x1 vector of endogenous variables and X_t is a 2x1 vector of deterministic regressors that includes a 1 and a time trend, denoted t. The 1 is to designate the constant term in each equation, while the time trend, t, is to take account of the fact that some variables tend to grow over time. Moreover, η_t stands for a 10x1 vector of innovations, A_i is a 10x10 coefficient matrix with i = 1,2,…,6, Ψ is a 10x2 coefficient matrix, and the value of subscript p, denoting the lag length of the model, is equal to 6.

The first step in evaluating the statistical properties of this model is to carry out the multivariate serial correlation Lagrange multiplier (LM) tests. According to the LM statistics and probability values (p-values) reported in table 2, the null hypothesis of no serial correlation is not rejected at either the 5% or the 10% significance level up to lag order 10.

Table 2
Multivariate serial correlation Lagrange multiplier tests, December 2001–May 2016

Lag order *p*	Lagrange multiplier statistics	Probability[a]
1	103.3748	0.3886
2	96.36808	0.5842
3	116.3448	0.1262
4	77.56845	0.9530
5	117.0113	0.1176
6	113.1726	0.1736
7	91.04501	0.7276
8	113.6089	0.1664
9	82.93674	0.8916
10	99.76945	0.4877

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.

[a] H_0: there is no serial correlation at lag order p. Probabilities from chi-square distribution with 81 degrees of freedom.

Next, the White heteroskedasticity test in its multivariate version is performed. According to the joint test result shown in table 3, the null hypothesis of homoskedasticity cannot be rejected at either the 5% or the 10% level. Thus, it is reasonable to conclude that, by and large, VAR residuals are free of serial correlation and heteroskedasticity.

Table 3
White heteroskedasticity test for VAR residuals, December 2001–May 2016

Chi-square statistic (x^2)	Degrees of freedom	Probability[a]
6 713.739	6 655	0.3038

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.

[a] H_0: homoskedasticity. This result is for the joint test, which is performed in levels and squares only (no cross terms are included).

Due to volatility episodes, mostly during the years of the global economic crisis, VAR residuals depart from normality. Although the use of dummy variables of the 0, 1 form to account for outliers (stemming from these episodes of volatility) could be acceptable in this case (Patterson, 2000, p. 616; Clements and Mizon, 1991), this option did not yield the expected results. In these circumstances, it is worth recalling that while residual normality is necessary for a clear-cut application of the maximum likelihood (ML) theory to the identification and estimation of cointegrating vectors (Mackinnon, Haug and Michelis, 1999, p. 563), it is somewhat restrictive in empirical work (Cheung and Lai, 1993, p. 314). In this context, Gonzalo (1994) shows that the ML estimators used in cointegration analysis yield asymptotically valid inferences even when the normality assumption does not hold, whereas Johansen (1995, p. 20) relaxes the requirement of residual multivariate normality to perform cointegration tests.

The next step is to rewrite equation (5), representing an unrestricted VAR model, as a VEC model. This is necessary to carry out Johansen's cointegration tests:

$$\Delta Y_t = \Pi Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + ,..., \Gamma_{(p-1)} \Delta Y_{t-(p-1)} + \psi X_t + \eta_t \quad (6)$$

where $\Pi = \sum_{i=1}^{p} A_i - I, \Gamma_i = -\sum_{j=i+1}^{p} A_j$, and η_t is an *i.i.d.* vector of innovations with mean zero and variance Ω. As can be seen, a p order VAR model gives rise to a (p-1) VEC model, so cointegration tests are undertaken under a five-lag VEC model. The underlying foundation of the multivariate cointegration tests is the Granger representation theorem (Engle and Granger, 1987). The fourth implication of this theorem assumes that: (i) the variables of a k-dimensional vector are all I(1); and (ii) the rank of coefficient matrix Π is reduced (i.e. $r < k$, where r stands for the rank of Π and k for the dimension of Π, which is equal to the number of variables in the model). If those two assumptions are satisfied, it can be asserted that coefficient matrices α and β (both with dimension kxr and rank r) do exist and are such that: (i) $\Pi = \alpha\beta'$; and (ii) $\beta' Y_{t-1}$ is a stationary system. Therefore, equation (6) can be reformulated as:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + ,..., \Gamma_{(p-1)} \Delta Y_{t-(p-1)} + \psi X_t + \eta_t \quad (7)$$

where β is a long-run coefficient matrix and $\beta' Y_{t-1}$ is an rx1 stationary system. Moreover, α is a matrix of adjustment coefficients that, along with coefficient matrices $\Gamma_1, \Gamma_2, \ldots, \Gamma_{(p-1)}$, describes the short-term dynamic responses following a shock (i.e. an unexpected change in one of the elements of vector η_t).

To conduct Johansen's cointegration tests on the basis of equation (7), an intercept term is included in the cointegrating space so that the long-term economic relationships are not forced through the origin (Patterson, 2000, p. 625). The data space is given by the VAR model and is allowed to have

a time trend because most of the variables, when stated in levels, incorporate a constant and a linear trend. By the same token, Johansen cointegration tests consist of two different sorts of likelihood ratio (LR) tests: the trace test, whose statistics are represented by λ_{trace}; and the maximum eigenvalue test, whose statistics are denoted by λ_{max}.

At the 5% significance level, trace tests indicate that there are four cointegrating relationships, while maximum eigenvalue tests point to the conclusion that there are only three. When trace and maximum eigenvalue tests yield inconsistent results, Johansen's (1995) advice is to solve the contradiction by choosing the number of cointegrating equations that yields the most plausible economic interpretation. Another important consideration is that maximum eigenvalue tests are more powerful than trace tests (Patterson, 2000, pp. 620–621). Several normalizations of the cointegrating vectors were conducted, and the conclusion was that three of them were consistent with economic theory, which is in agreement with the results of the maximum eigenvalue tests. For the sake of brevity, we only present the results of the maximum eigenvalue tests (see table 4).[7]

Table 4
Johansen maximum eigenvalue tests for cointegration, December 2001–May 2016

Null hypothesis	Alternative hypothesis	$\lambda_{t\,max}$-statistic	5% critical value	Probability
$r = 0^*$	$r = 1$	114.8932	64.50472	0.0000
$r \leq 1^*$	$r = 2$	78.31435	58.43354	0.0002
$r \leq 2^*$	$r = 3$	57.33698	52.36261	0.0143
$r \leq 3$	$r = 4$	44.55066	46.23142	0.0750
$r \leq 4$	$r = 5$	24.82795	40.07757	0.7781
$r \leq 5$	$r = 6$	18.68832	33.87687	0.8405
$r \leq 6$	$r = 7$	15.41935	27.58434	0.7144
$r \leq 7$	$r = 8$	12.71395	21.13162	0.4789
$r \leq 8$	$r = 9$	9.951978	14.26460	0.2151
$r \leq 9$	$r = 10$	0.289676	3.841466	0.5904

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The letter r stands for the number of cointegrating equations. The lag length of the VEC model is 5. A constant in the cointegrating space and a linear trend in the data space are included, with MacKinnon and others (1999) p-values being utilized. Maximum eigenvalue tests indicate the existence of 3 cointegrating equations at the 5% significance level. An asterisk * denotes rejection of the null hypothesis at the 5% significance level.

4. The long-term equations

Concerning equations (6) and (7) and table 4, it is worth noting that the matrix $\Pi(= \alpha\beta')$ lacks a unique identification. This means that there are a number of combinations of α and β' that can give rise to Π and that economic theory must play a leading role in identifying not only the number, as has just been done, but also the form of the cointegrating equations. To depict the long-run economic relationships in a VEC framework, we must recall that the expression $\beta' Y_{t\text{-}1}$ of equation (7) is a stationary system or a vector of error correction terms (ECT). Formally, $\beta' Y_{t\text{-}1} = [ECT\,1_{t\text{-}1}, ECT\,2_{t\text{-}1}, ECT\,3_{t\text{-}1}]'$ where $ECT\,1_{t\text{-}1}$ has been normalized for consumer goods prices, $ECT\,2_{t\text{-}1}$ for industrial production and $ECT\,3_{t\text{-}1}$ for the public sector balance. Table 5 displays the estimates of these three cointegrating vectors.

[7] The results of the trace tests are available upon request.

Table 5
Maximum likelihood estimates of cointegrating vectors (β matrix), December 2001–May 2016

Variable	$ECT1_{t-1}$	$ECT2_{t-1}$	$ECT3_{t-1}$
p_{t-1}	-1	0	0
y_{t-1}	0	-1	0
pb_{t-1}	0	0	-1
cu_{t-1}	0.08***	0.01***	0.15*
m_{t-1}	1.74***	0.28***	1.36
i_{t-1}	-0.02***	-0.0002	-0.01
q_{t-1}	0.28***	-0.14***	-0.16
w_{t-1}	6.55***	-0.48***	-3.18
v_{t-1}	-5.93***	0.28**	-5.93
y^*_{t-1}	-0.52***	0.30***	1.09
Intercepts	26.55	-1.17	12.57

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: Significance levels for the intercept terms are not available. Asterisks *, **, and *** indicate that the long-term parameter estimate is statistically significant at the 10%, 5% and 1% levels, respectively.

In the long run, $ECT1_{t-1}$, $ECT2_{t-1}$ and $ECT3_{t-1}$ are all equal to zero (i.e. long-run equilibria hold), and these three error correction terms can be restated as long-term equations for prices, output and the public sector balance, respectively.

Parameter estimates should be regarded as long-term elasticities in view of the fact that all variables are stated in natural logarithms, with the exception of i_{t-1} and cu_{t-1}, which are measured in percentages. In the case of these two variables, the estimated coefficients should be viewed as semi-elasticities. All the parameter estimates that are statistically significant yield a reasonable economic interpretation. Table 5 shows that in the long term:

1. Higher capacity utilization (cu_{t-1}) raises consumer goods prices and industrial output, which is consistent with the notion of demand-pull inflation. Moreover, capacity utilization bears a positive relationship to the scaled version of the public sector balance (pb_{t-1}). It may be recalled that a straightforward escalation procedure was used, so that the public sector balance took only positive values that could then be transformed into natural logarithms. Annex A1 shows the behaviour of these transformed variables (i.e. the behaviour of pb_{t-1}) in millions of pesos at current prices and in natural logarithms. The transmission mechanism is taken to work as follows: higher economic activity (i.e. higher capacity utilization) strengthens government revenues, thereby increasing the scaled version of the public sector balance. In the original non-scaled version of the public balance, government revenues increase and the budget deficit diminishes (or the budget surplus increases). Conversely, lower economic activity (i.e. lower capacity utilization) weakens government revenues, thereby driving down pb_{t-1}. In the original non-scaled version of the public balance, government revenues fall and the budget deficit increases (or the budget surplus diminishes).
2. Monetary expansion (i.e. an increase in m_{t-1}) has a positive impact on both industrial output and prices, suggesting that money is not neutral.
3. Interest rates seem to be an effective tool for maintaining price stability, given that the interest rate on 28-day government bonds (CETES) displays a negative relationship with consumer goods prices.

4. Both exchange-rate depreciation and wage increases represent a source of cost-push inflation. As is well known, exchange-rate depreciation raises the local currency cost of imported intermediate inputs, capital stock and technology, which in turn accelerates consumer goods inflation while depressing industrial output. All else being equal, rising wages tend to put pressure on per-unit production costs, producing a similar effect on prices and production.
5. Higher labour productivity lowers consumer goods prices and stimulates industrial production. Macklem and Yetman (2001) find this to be the case for the United States and Canada and explain that productivity growth stabilizes the price level by improving the relationship between economic activity and inflation. $ECT1_{t\text{-}1}$ and $ECT2_{t\text{-}1}$ in table 5 provide evidence for the important long-term role that labour productivity can play in Mexico. As will be seen, this particular finding suggests that a more qualified and productive workforce can make a definite contribution to the task of ensuring price stability, as well as raising output.
6. United States industrial production has a bearing not only on Mexican industrial production but also on consumer goods prices. $ECT1_{t\text{-}1}$ and $ECT2_{t\text{-}1}$ indicate that increased industrial activity in the United States lessens inflationary pressures in Mexico, in addition to encouraging industrial production.

When a shock occurs, the variables in , $ECT1_{t\text{-}1}$, $ECT2_{t\text{-}1}$ and $ECT3_{t\text{-}3}$ depart from their cointegrating relationships, i.e. from their long-run equilibria. This departure is assumed to be transitory, however, given the adjustment process that comes into play through coefficient matrix α, which in this particular case is a matrix of dimension 10x3 (see table 6).

Table 6
Matrix of estimated adjustment coefficients (α matrix), December 2001–May 2016

Equation	$ECT1_{t\text{-}1}$	$ECT2_{t\text{-}1}$	$ECT3_{t\text{-}1}$
Δp_t	-0.01***	0.06***	-0.00001
Δy_t	-0.05***	-0.33***	-0.00002
Δpb_t	0.39	-1.85	-2.06***
Δcu_t	1.49	21.07*	0.37
Δm_t	-0.07**	0.40*	-0.004
Δi_t	0.30	7.66	-0.004
Δq_t	-0.06	-0.95**	0.01
Δw_t	0.01**	-0.02	0.0003
Δv_t	-0.08***	0.59***	0.005
Δy_t^*	0.06***	0.13	0.004*

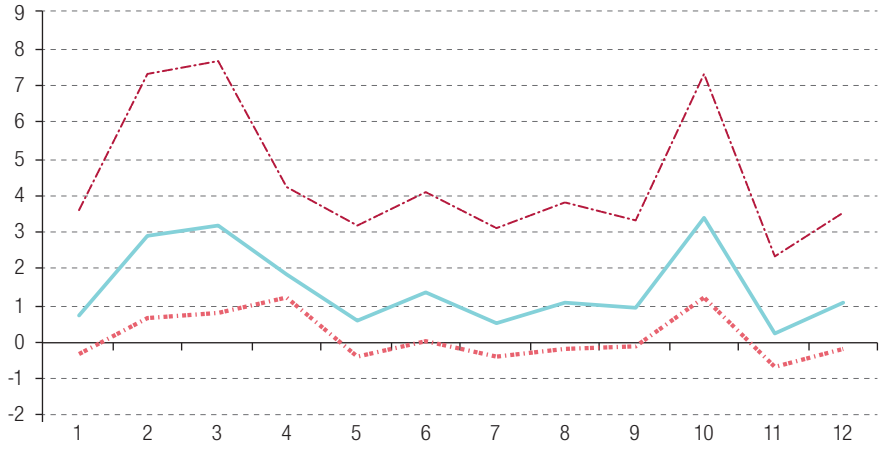
Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: Asterisks *, **, and *** indicate that the parameter estimate is statistically significant at the 10%, 5% and 1% levels, respectively.

Broadly speaking, the picture emerging from table 6 is that every variable adjusts to some kind of long-run equilibrium after a shock, except for the interest rate (i_t). Therefore, this particular variable should be treated as weakly exogenous for the relevant parameters α and β. The weak exogeneity of the interest rate is due to the fact that all the estimated adjustment coefficients in matrix α lack statistical significance, which means that this variable is unaffected by lagged disequilibria (i.e. by deviations from $\beta' Y_{t\text{-}1}$). Another implication is that, under the Johansen standard methodology, this variable is still part of the cointegrating equations but cannot be part of the impulse-response analysis, which is undertaken on the basis of a partial system (Johansen, 1995; Patterson, 2000, pp. 674–676).

5. Short-term sensitivity analysis

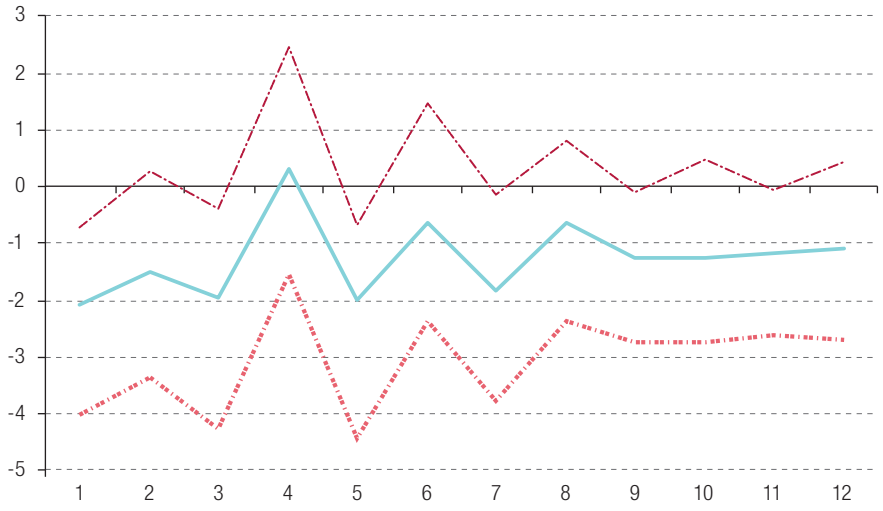
The next step is to estimate the short-term dynamic responses of consumer goods prices and industrial output to unexpected changes in the variables of the VEC model. This task is undertaken through a set of VEC model orthogonal impulse responses with 95% confidence intervals. Impulse responses and confidence intervals are estimated by way of the bootstrap replication method developed by Hall (1992). We present only those impulse response functions (IRFs) that are meaningful from a theoretical standpoint and that achieve statistical significance at some point over a 12-month horizon. Figures 1 and 2 depict the effect of a United States industrial production shock on Mexican industrial production and prices, respectively. A shock to a given variable should be regarded as an unexpected one-standard deviation increase lasting only one month. Thus, it can be seen that a United States industrial production shock raises Mexican industrial production between the first and the fifth month and between the ninth and the eleventh month, and that it tends to lower the price level around the first, third and fifth months. The IRFs achieve statistical significance during those periods. Moreover, figure 3 shows that exchange-rate depreciation (i.e. a shock to the exchange rate) puts pressure on the price level around the second month, whereas figure 4 shows that a wage increase has a small but positive impact on prices around the second and the fourth months. Lastly, according to figure 5, a capacity utilization shock yields an inflationary effect around the fourth month. In summary, all these IRFs are consistent with the cointegrating equations.

Figure 1
Response of industrial production in Mexico to a shock in United States industrial production
(Percentage points over a 12-month horizon)



Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The dotted lines denote a 95% confidence interval.

Figure 2
Response of prices to a shock in United States industrial production
(Percentage points over a 12-month horizon)

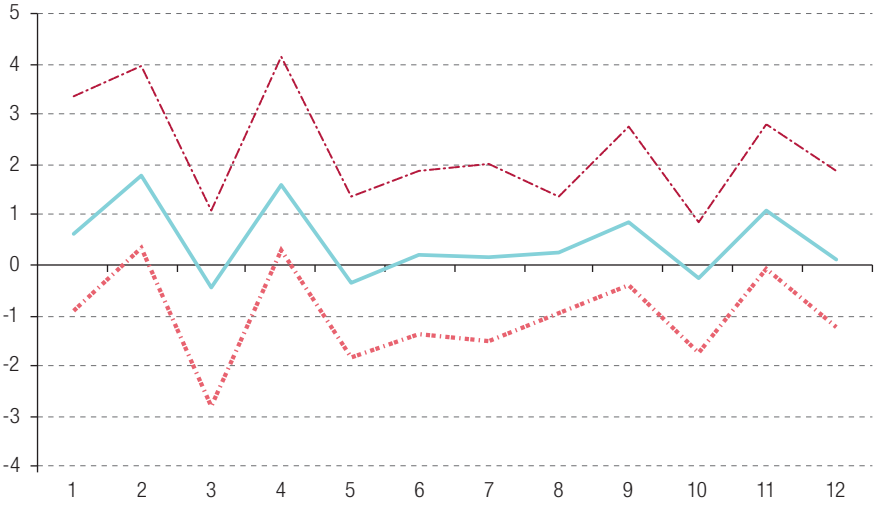


Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The dotted lines denote a 95% confidence interval.

Figure 3
Response of prices to exchange-rate depreciation
(Percentage points over a 12-month horizon)

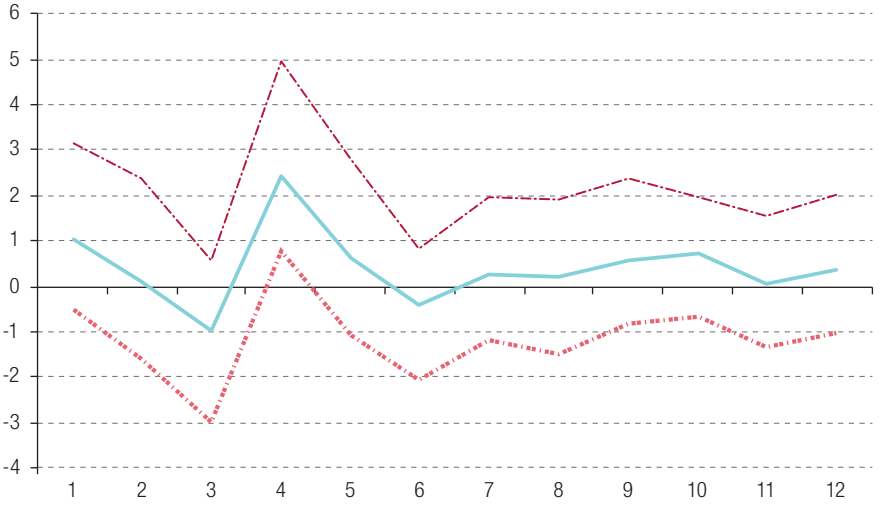
Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The dotted lines denote a 95% confidence interval.

Figure 4
Response of prices to a wage shock
(Percentage points over a 12-month horizon)



Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The dotted lines denote a 95% confidence interval.

Figure 5
Response of prices to a capacity utilization shock
(Percentage points over a 12-month horizon)



Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.
Note: The dotted lines denote a 95% confidence interval.

V. Conclusions

This paper makes use of an aggregate demand-aggregate supply VEC model to study the long-term drivers of consumer goods prices and industrial output, as well as analysing short-term dynamics. By including a relatively wide range of variables and adopting a long-term approach, we are able to: (i) identify several empirical relationships consistent with economic theory and with some findings of previous research; and (ii) offer new insights into the behaviour of the variables of interest, mainly by bringing labour productivity, wages and United States industrial output into the picture.

The previous empirical literature indicates that the budget deficit, the money supply and the exchange rate, among other variables, are major sources of inflation in Mexico. This research finds that demand-pull and supply-side inflationary pressures are present in the Mexican economy and that higher labour productivity can play a key role in reducing inflation as well as raising output. The long-term evidence on demand-pull inflation is that increased capacity utilization and monetary expansion (i.e. an increase in the monetary base) have a positive impact on prices and production.

The cointegration analysis also shows that raising interest rates is an effective measure for lessening inflationary pressure, given that consumer goods inflation falls as the 28-day rate on government bonds (CETES) goes up. Furthermore, the long-term elasticities indicate that wage increases and exchange-rate depreciation not only raise consumer goods prices but also discourage industrial activity. With regard to exchange-rate depreciation, the implication is that a persistently undervalued exchange rate increases the local currency costs of imported intermediate inputs, capital goods and technology, thereby generating cost-push inflation. The short-term sensitivity analysis, derived from a set of impulse responses with 95% bootstrapping confidence intervals, is consistent in indicating that exchange-rate depreciation is a source of inflationary pressure. The pass-through effect from the exchange rate to prices, while smaller than in the 1990s, should still be a cause for long-term concern in view of the recurrent speculative attacks on the Mexican peso. A well-known policy recommendation in this regard is to reduce the import content of domestic production by: (i) improving production capacity and efficiency in import-substituting industries; and (ii) strengthening supply- and demand-side chains between these industries and the rest of the economy, especially the export market-oriented sector. Furthermore, exchange-rate policy should be aimed at reconciling the stability required to keep inflation low with the leeway needed to deal with external shocks.

Another important contribution of this paper is to provide significant long-term evidence that labour productivity improvements not only stimulate industrial activity but also reduce inflationary pressures. As stated earlier, Macklem and Yetman (2001) reach a similar finding for the United States and Canadian economies, explaining that productivity growth stabilizes the price level by improving the relationship between economic activity and inflation. Although further research is needed to establish the channel or channels through which workers' productivity influences prices, one possible interpretation of this effect is that a more productive and qualified workforce enhances international competitiveness, thereby making the economy less vulnerable to internal and external shocks. In order to have a more productive workforce, among other measures, Mexico should invest more rather than less in long-term formal schooling, short-term training programmes and the entire knowledge transfer process. Consistent labour productivity growth should be regarded as a means not only to increase industrial activity, but also to enhance price stability in the Mexican economy.

Lastly, United States industrial production exerts a strong influence on Mexican industrial production in both the short and long term. Table 5 and figure 1 show United States industrial output to be the main driver of domestic industrial activity, which reflects the scope and strength of the production chains and trade flows between the United States and Mexico.

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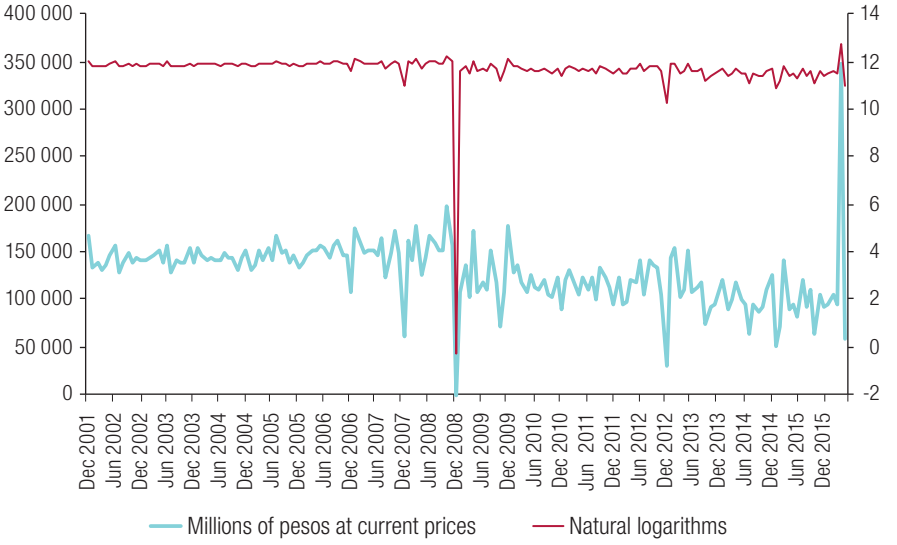
Annex A1

The purpose of this annex is to show the transformation of the public sector balance described earlier (see figure A1.1).

Figure A1.1
Scaled version of the public sector balance
(Millions of pesos at current prices and natural logarithms)

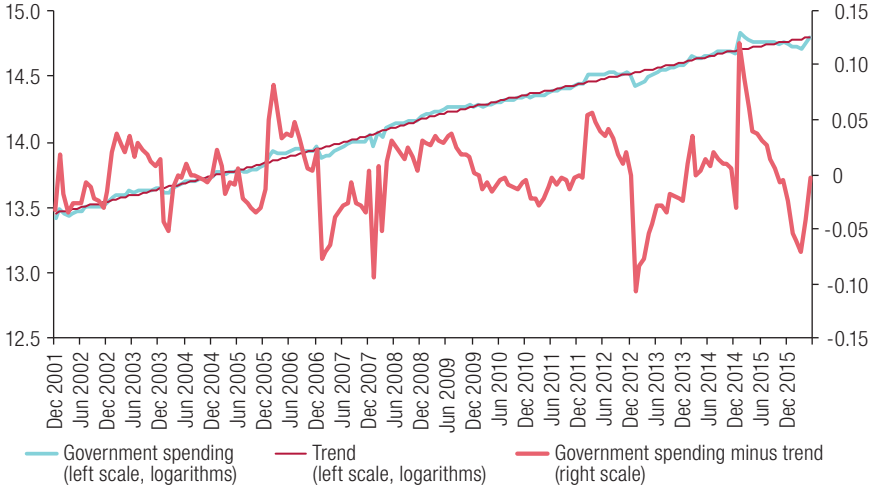


Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) of Mexico.

Annex A2

To show that government spending (g_t) is a trend stationary variable, we must first decompose the trend and cyclical components of this variable using the Hodrick-Prescott (HP) filter. If government spending is a trend stationary variable, then its long-run trend is deterministic, and its cyclical component, which is obtained by suppressing the trend from the time series, must be stationary or I(0). When a time series is difference stationary, conversely, it needs to be differentiated once to achieve stationarity (see figure A2.1).

Figure A2.1
Estimation of trend and cyclical components of government spending using the Hodrick-Prescott filter



Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) of Mexico.

The next step is to perform breakpoint unit root and stationarity tests on government spending and on its cyclical component, which is referred to as $\left(g_t^{cycle}\right)$. As table A2.1 shows, although the two types of tests yield conflicting results when applied to government spending (g_t) they point to the same conclusion when it comes to the cyclical component of that spending $\left(g_t^{cycle}\right)$. The breakpoint unit root test suggests that government spending is stationary, but the stationarity test is inconsistent with this result, given that the null hypothesis of stationarity is rejected for government spending. However, the breakpoint unit root and stationarity tests are consistent in indicating that the cyclical component of government spending $\left(g_t^{cycle}\right)$ is stationary or I(0). The null hypothesis of a unit root is rejected at the 1% level in the first test while the null hypothesis of stationarity is far from being rejected in the second test. Therefore, it is reasonable to conclude that government spending is a trend stationary variable.

Table A2.1
Unit root tests with structural breaks and stationarity tests, December 2001–May 2016

Variable	Specification of the test equation	ADF-breakpoint unit root test statistic (H_0: unit root)	KPSS test statistic (H_0: stationarity)	Order of integration
g_t	C and T	-5.6***	0.19**	?
$\left(g_t^{cycle}\right)$	C	-6.16***	0.02	0

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics and Geography (INEGI) and the Bank of Mexico.

Note: C stands for constant and T for trend. $\left(g_t^{cycle}\right)$ stands for the cyclical component of government spending. The ADF breakpoint unit root test results rely on Vogelsang (1993) asymptotic one-sided p-values. The lag length of the test equation is determined using the Akaike information criterion. The break type reported here is a level shift, but other possibilities were explored. The break date is estimated from the time series to maximize the likelihood of the unit root null hypothesis being rejected. The KPSS test results are based on the critical values proposed by Kwiatkowski and others (1992). The Newey-West bandwidth selection method and the Bartlett kernel are used to control the bandwidth. Asterisks *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significance levels, respectively.

Fiscal disparities in Uruguay's regions: the role of a new system of intergovernmental equalization transfers

Leonel Muinelo-Gallo, Joana Urraburu Bordon and Pablo Castro Scavone

Abstract

This article conducts an empirical analysis of the role of intergovernmental transfers in a group of regions (departments) in Uruguay during the period 2006–2014. It examines the structure and evolution of regional fiscal disparities and the equalizing effects of the current transfer system. It then proposes an innovative methodology for simulating the effects of a new system of equalization transfers. The main finding is that implementing this new system would help to consolidate greater territorial fiscal homogeneity in Uruguay.

Keywords

Fiscal policy, tax administration, regional disparities, tax revenues, regional development, Uruguay

JEL classification

C33, H77, R11

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I. Introduction

The present article conducts an empirical analysis of the macroeconomic role of intergovernmental transfers in Uruguay.

One of the fundamental purposes of intergovernmental transfers is to lessen fiscal imbalances between units of government at the same level; more specifically, to reduce or remove any differences in the ability of units at the same level of government (e.g., different subnational governments) to generate resources of their own and execute spending.

Intergovernmental transfers are an extremely important tool for promoting regional fiscal cohesion in developed countries. The European Union's model of territorial cohesion, embodied in its European Structural and Investment Funds programme, is a clear example of this (Böhme, 2009). Likewise, most Organization for Economic Cooperation and Development (OECD) countries use redistribution programmes to reduce fiscal disparities at the regional level. In this way, these countries manage to reduce regional fiscal disparities by an average of more than two thirds (Martínez-Vázquez, 2015). The importance of designing an equalization transfer system lies in the fact that having a more fiscally homogeneous territory makes it possible to attain a minimum standard of subnational public service provision of a similar quality, thus avoiding inefficient migrations of resources within the country (Martínez-Vázquez and Sepúlveda, 2011). Likewise, such an equalization system can provide considerable support to an orderly fiscal decentralization agenda. Lastly, greater fiscal cohesion results in more balanced territorial development, with deconcentration of political power and economic activity (Martínez-Vázquez and Sepúlveda, 2012).

Uruguay has been seeking to move towards a greater degree of territorial decentralization since its constitutional reform of 1996.[1] It is important to realize that this process could lead to an increase in horizontal fiscal disparities by disadvantaging subnational governments with large spending needs or limited local revenue sources. In fact, although Uruguay is a small country, there are large fiscal differences between its different departmental governments. Map 1 shows these disparities, going by the different levels of per capita expenditure executed by the 19 departmental governments in the period under analysis.[2]

Map 1 reveals significant differences in per capita expenditure. Since all departmental governments in Uruguay must provide exactly the same public services, these differences would be expected to have considerable effects on the quantity and quality of public services provided by each of these governments.

Bearing in mind the context, this article conducts an empirical analysis of the effect of intergovernmental transfers on regional fiscal disparities in the group of 19 departments in Uruguay for the period 2006–2014. The statistical information available limits the analysis to this period because the departmental government of Montevideo began to receive transfers from central government only in 2006. However, this is a period of nine years, which we consider long enough to evaluate the relationships posited in this article.

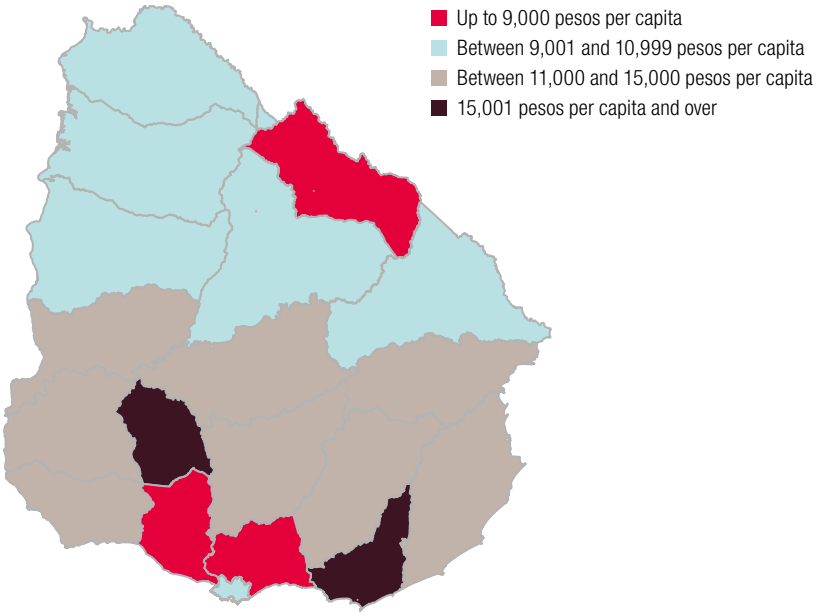
Two types of analysis are performed here. First, the equalizing impact of the intergovernmental transfer system currently operating in Uruguay is assessed. Second, the effects of implementing a new equalization transfer system in the country are posited and discussed.

There are two essential rationales for the research presented here. The first is the lack of earlier studies adequately analysing these regional fiscal relationships in a middle-income country such as Uruguay. The second is that a sound empirical treatment of the statistical information available will provide a basis for considering what an optimal design of subnational fiscal structures in the country fundamentally entails.

[1] Uruguay is still a highly centralized country, however. During the period under review (2006–2014), some 90% of public expenditure was carried out directly by central government, with departmental governments accounting for only 10%.

[2] Uruguay is divided into 19 departments, which are the second level of government below the central government. See annex 1 for details of Uruguay's political subdivisions.

Map 1
Uruguay: departmental governments' expenditure per capita, 2006–2014 average
(At constant 2014 prices)



Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.

The paper is structured as follows. Section II discusses studies that have analysed both the determinants of different government transfer regimes and any effects intergovernmental transfers might have on regional disparities. Section III considers the current system of intergovernmental fiscal relationships in Uruguay, after which section IV evaluates the equalizing effects of the transfers involved. Then, for the first time in a study on Uruguay, section V develops an innovative methodology to simulate the effects of implementing a new equalization transfer system. Lastly, section VI presents some brief conclusions and policy recommendations.

II. Regional disparities and intergovernmental transfers

The traditional literature on regional public finances provides prescriptive guidance on how intergovernmental transfers should be distributed to improve both efficiency in the provision of local public goods and equality in the allocation of resources within a country (Musgrave, 1959; Oates, 1972).

In the interests of efficiency, the transfer regime should correct the underprovision of certain local public services. Subnational or regional governments may tend to underdeliver certain local public services, such as education, because they cannot harness all the benefits from them. Accordingly, when the provision of these local services creates positive externalities, central government could increase intergovernmental transfers in response to greater local expenditure needs (reflected, for example, in the number of school-age children in each region) in the interests of economic efficiency.

The second policy objective is to achieve an equitable distribution of public resources among the country's population. Thus, equalization transfer systems are often used to implement policies aimed at ensuring equal access to subnational public services at the regional level. Intergovernmental equalization

transfers play an important role within this framework by helping to meet the fiscal needs of fiscally disadvantaged regions (Martínez-Vázquez and Sepúlveda, 2012). More specifically, it is the principle of interjurisdictional equity that confers economic rationality on a system of equalization transfers. According to a general formulation of this principle, people in comparable circumstances should have access to similar public services in all geographical localities of a given territory (Boadway, 2015; Brosio and Jiménez, 2015; Muñoz and Radics, 2015). The equity framework of intergovernmental transfers implies that citizens' place of residence should not create differences between them, either in access to public services or in their unit cost. In this context, equity is achieved in the most advanced interjurisdictional equalization systems (Canada, for example) when intergovernmental equalization transfers provide subnational governments with sufficient revenues to ensure that people in similar circumstances can have access to comparable public services in all geographical locations.

A growing body of recent work has empirically analysed both the main determinants and the regional effects of intergovernmental transfers.[3] For example, Muinelo-Gallo, Rodríguez and Castro (2016) assess the effect of different economic, demographic and political variables on the level of intergovernmental transfers per capita in Uruguay. The authors point out that the level of these transfers is positively affected by the level of public spending implemented in the past by regional governments and negatively affected by the population size of the regions (departments). The first finding could reflect the impact of the fiscal needs of departmental governments, but it could also demonstrate the bargaining power of those governments when they demand resources from central government in the form of regional transfers. The negative effect of departmental population could be a response to the presence of economies of scale in the provision of subnational public services, or could be explained by the potentially disproportionate lobbying power of smaller subnational jurisdictions. Their estimates also show that regional inequalities have a large and negative impact on transfers. This result is also reflected in the fact that a department's GDP per capita has a positive and considerable effect on intergovernmental transfers. Lastly, the authors do not find transfers to have a substantial impact in reducing regional economic inequalities: in Uruguay, these intergovernmental transfers do not have a significant regional equalizing effect.

III. The system of intergovernmental fiscal relationships in Uruguay

1. Regional resources and public services

The powers formally assigned to Uruguay's departmental governments, which constitute the second level of government, are set out in the basic law on the government and administration of departments (Law No. 9515), which has not been amended since 1935. Under this statute, consistently with international practice, the departmental governments of Uruguay are responsible for carrying out activities of a typically municipal character. More specifically, formal competences are limited to the provision of basic services: road surfacing and maintenance; organization of traffic (including vehicle and driving licence fees); public transport; cleaning; street lighting; cemeteries; sanitary controls; and spatial planning.

[3] See Solé-Ollé and Sorribas-Navarro (2008) and Curto-Grau, Solé-Ollé and Sorribas-Navarro (2012) for examples from high-income countries.

The fiscal resources available to departmental governments, meanwhile, can be divided into two major categories:

(i) Local revenues: those originating within the department,[4] or taxes set by central government but collected and spent by the departmental governments.[5]

(ii) Transfers from central government to the departmental governments. These transfers may be of two kinds: conditional or unconditional.

2. The legal framework regulating the system of regional transfers in Uruguay

Of the two types of transfer revenues received by the departmental governments of Uruguay, conditional transfers, consisting of modest transfers from the different central government ministries, including the Ministry of Transport and Public Works and the Ministry of Tourism, and from other public agencies, are the lesser component. The great bulk of departmental revenue originating at the national level (90%) comes in the form of unconditional transfers. Table 1 details the composition of intergovernmental transfers by department and by degree of conditionality.

Although intergovernmental transfers are stipulated in the National Budget Act, laws adding supplementary items to the transfer legislation were enacted during the different periods of government analysed (2006–2014). In many cases, these additional transfers were justified by particular circumstances, such as financial crises in particular departmental governments, droughts or flooding. However, these one-off transfers often ended up as permanent budget items because of pressure from departmental governments to maintain or even increase resources in the next period of government (Muinelo-Gallo, Rodríguez and Castro, 2016).

The National Budget Act for the periods 2001–2005 and 2006–2010 incorporated the 1996 reforms into the national constitution, the hope being to improve the transfer system and forestall further ad hoc transfers not included in the National Budget Law. The new national constitution established two types of transfer mechanisms, set out in articles 214 and 298.

Article 214 stipulates that in each period of government a share of the total national budget must be distributed among the departmental governments. This share was 3.18% in 2001 and progressively increased to 3.54% in 2005 before being set at 3.33% from 2006. A large part of this share is financed by the municipal infrastructure and rural road maintenance programmes (both administered by central government). The remaining funds are distributed among departmental governments on the basis of two criteria. One is a formula involving population indicators, land area, the inverse of regional GDP and the percentage of households with unmet needs (25% each). The other criterion is the percentage distribution between departmental governments in the previous period of government. The final distribution of these transfers is arrived at by averaging out the two criteria in some way, although the distribution method is by no means clear. The percentage of remaining funds (published in National Budget Acts No. 17296 for 2001–2005 and No. 17930 for 2006–2014) is determined by political negotiations between the central government and the Congress of Mayors of the departmental governments.[6]

[4] The main revenues raised locally are from property taxes on urban and suburban real estate, vehicle licence fees, minor taxes (the tax on unused sites and inappropriate construction and contributions for improvements to properties benefiting from public works), levies, tariffs, profits and charges for the use of departmental goods or services.

[5] These include in particular the rural property tax and the tax on livestock sales (Law 12700 of 1960).

[6] The Congress was established by the 1996 constitution as a council representing the departmental governments.

Table 1
Uruguay: composition of intergovernmental transfer revenues by departmental government, 2006–2014 average
(At constant 2014 prices)

Department	Conditional transfers		Unconditional transfers	
	(thousands of 2014 pesos)	*(percentage of departmental GDP)*	*(thousands of 2014 pesos)*	*(percentage of departmental GDP)*
Artigas	51 117	0.302	352 560	2.130
Canelones	91 023	0.084	836 011	0.808
Cerro Largo	70 281	0.343	422 327	2.043
Colonia	45 775	0.085	316 667	0.607
Durazno	32 937	0.226	378 029	2.524
Flores	26 529	0.304	188 317	2.245
Florida	42 757	0.197	321 186	1.536
Lavalleja	30 810	0.184	346 930	1.873
Maldonado	213 865	0.329	511 705	0.858
Montevideo	508 798	0.084	1 064 770	0.190
Paysandú	49 369	0.161	454 127	1.444
Río Negro	108 262	0.380	300 256	1.165
Rivera	68 412	0.312	391 290	1.682
Rocha	8 877	0.055	420 386	2.022
Salto	62 376	0.218	492 114	1.684
San José	32 483	0.103	309 951	1.008
Soriano	35 591	0.142	381 748	1.520
Tacuarembó	8 838	0.050	424 911	1.928
Treinta y Tres	26 645	0.183	335 870	2.368

Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.

The other article of the national constitution regulating intergovernmental transfers is No. 298 on the Fund for the Development of the Interior (FDI). The objectives of the Fund are local and regional development and decentralization, and it is formed from a share (about 11%) of the taxes that central government collects from the different departments of the country, excluding Montevideo. However, only 33.5% of Fund resources go directly to departmental governments, with the remaining 66.5% executed directly by central government.

In short, the mechanisms used to allocate intergovernmental transfers in Uruguay under the different governments from 2006 to 2014 were unclear. There were some guiding criteria, but they were far from constituting clear formulas with technical definitions, which implies a great deal of political bargaining between the central government and the departmental governments. At the same time, there was a degree of inertia over time in most of the transfer allocation criteria (population, land area and even GDP per capita), quite apart from the explicit consideration given to the way resources had been allocated between departmental governments in the previous period of government. In view of all this, it may be said that fiscal equity does not seem to have played a prominent role in the system of intergovernmental transfers operating in Uruguay thus far.

Table 2 shows the revenues of departmental governments and calculates different measures of fiscal inequality between them. This analysis provides the basis for a preliminary assessment of the possible equalizing effects of the system of transfers currently operating in Uruguay.

Table 2
Uruguay: composition of departmental government revenues and equalizing effects, 2006–2014
(At constant 2014 prices)

Department	Local revenues			Local revenues and conditional transfers			Local revenues and unconditional transfers			Total revenues[a]		
	(thousands of 2014 pesos)	*(2014 pesos per capita)*	*(percentage of departmental GDP)*	*(thousands of 2014 pesos)*	*(2014 pesos per capita)*	*(percentage of departmental GDP)*	*(thousands of 2014 pesos)*	*(2014 pesos per capita)*	*(percentage of departmental GDP)*	*(thousands of 2014 pesos)*	*(2014 pesos per capita)*	*(percentage of departmental GDP)*
Artigas	385 228	5 028	2.39	436 345	5 698	2.69	737 787	9 639	4.52	788 905	10 308	4.82
Canelones	2 411 329	4 515	2.35	2 502 353	4 683	2.43	3 247 341	6 078	3.16	3 338 364	6 247	3.24
Cerro Largo	365 176	4 097	1.78	435 457	4 886	2.13	787 502	8 834	3.83	857 784	9 623	4.17
Colonia	985 357	7 775	1.86	1 031 132	8 136	1.94	1 302 023	10 277	2.46	1 347 799	10 637	2.55
Durazno	464 890	7 835	3.19	497 827	8 389	3.41	842 919	14 211	5.71	875 856	14 765	5.94
Flores	347 484	13 194	4.16	374 013	14 200	4.46	535 800	20 343	6.40	562 329	21 349	6.71
Florida	444 799	6 409	2.14	487 556	7 025	2.34	765 986	11 037	3.68	808 743	11 654	3.88
Lavalleja	392 354	6 466	2.19	423 164	6 970	2.37	739 284	12 198	4.06	770 094	12 703	4.24
Maldonado	3 091 817	18 465	5.22	3 305 682	19 704	5.55	3 603 522	21 511	6.08	3 817 387	22 750	6.41
Montevideo	11 896 980	8 682	2.15	12 405 777	9 052	2.23	12 961 750	9 458	2.34	13 470 548	9 828	2.42
Paysandú	608 747	5 197	1.97	658 116	5 618	2.14	1 062 874	9 071	3.42	1 112 243	9 493	3.58
Río Negro	376 338	6 708	1.50	484 600	8 635	1.88	676 594	12 057	2.67	784 856	13 983	3.05
Rivera	444 053	4 159	1.92	512 465	4 801	2.23	835 343	7 823	3.60	903 755	8 465	3.92
Rocha	756 862	10 356	3.73	765 739	10 479	3.78	1 177 248	16 101	5.75	1 186 125	16 224	5.80
Salto	748 458	5 822	2.63	810 834	6 306	2.85	1 240 572	9 645	4.32	1 302 948	10 129	4.53
San José	595 807	5 423	1.99	628 290	5 718	2.09	905 758	8 238	3.00	938 241	8 533	3.10
Soriano	525 706	6 185	2.14	561 297	6 604	2.28	907 453	10 679	3.66	943 044	11 098	3.80
Tacuarembó	528 658	5 676	2.41	537 495	5 771	2.46	953 568	10 239	4.34	962 406	10 334	4.39
Treinta y Tres	258 139	5 107	1.87	284 784	5 634	2.05	594 009	11 751	4.24	620 653	12 278	4.42
Average	1 348 852	7 216	2.51	1 428 575	7 806	2.70	1 783 018	11 536	4.06	1 862 741	12 126	4.26
Highest	11 896 980	18 465	5.22	12 405 777	19 704	5.55	12 961 750	21 511	6.40	13 470 548	22 750	6.71
Lowest	258 139	4 097	2.00	284 784	4 683	2.00	535 800	6 078	2.00	562 329	6 247	2.00
Highest/lowest	46.09	4.51	3.48	43.56	4.21	2.95	24.19	3.54	2.74	23.95	3.64	2.77
Standard deviation *(in logarithms)*	0.93	0.39	0.32	0.91	0.38	0.29	0.77	0.31	0.29	0.76	0.31	0.29
Coefficient of variation	0.97	0.49	0.37	0.94	0.47	0.36	1.59	0.35	0.30	0.58	0.35	0.29
Gini index	0.61	0.23	0.18	0.60	0.22	0.16	0.51	0.17	0.16	0.50	0.17	0.16
Theil index	0.87	0.09	0.06	0.85	0.09	0.05	0.61	0.05	0.04	0.60	0.05	0.04

Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.
[a] Total revenues include conditional and unconditional transfers and revenues raised locally.

The statistical measures provided in table 2 indicate that transfers (conditional and unconditional) have reduced the disparity in tax revenues between departmental governments. It should be noted that the lesser impact of conditional transfers (which reduce the Gini index by 1 percentage point, whereas unconditional transfers reduce it by 6 percentage points) is explained by the simple fact that these types of transfers are much smaller than unconditional transfers (see second from last row of table 2). This reduction in the per capita income disparities between departmental governments is also observed when other disparity indicators such as the standard deviation (in logarithms), coefficient of variation and Theil index are used. A variation in the highest/lowest ratio is observed, whereby the difference in per capita revenues between the departments with the highest and lowest per capita revenues falls from 4.5 to 3.6 when transfers are included.

Although there is some equalizing effect in terms of departmental governments' revenues, fiscal equalization is not explicitly and clearly provided for in the regulations governing the distribution of intergovernmental transfers in Uruguay. The lack of an appropriate and explicit regulatory regime of equalization transfers, based exclusively on technical criteria, is due to several causes. First, there has been a degree of historical inertia in the political negotiations between the central government and departmental governments, which has prevented progress towards greater autonomy for the different departmental governments. The reluctance of the central government to grant regional governments greater autonomy could be important here. Mention should be made too of the inertial behaviour of departmental governments, which often obtain resources from central government through political negotiation without incurring the economic and political costs a greater fiscal effort would entail. A second reason is the existence of serious technical limitations in both central government and, principally, departmental governments, reflected in a lack of technical personnel and adequate databases with which to construct and update the technical indicators needed to design an objective and equalizing transfer scheme.

With this context in mind, the following two sections will detail the data and empirical methodology we have used to explore the implementation of a new system of intergovernmental equalization transfers in Uruguay.

IV. Horizontal fiscal disparities and the equalizing effect of the current transfer system in Uruguay

This section identifies and analyses horizontal fiscal disparities between departmental governments in Uruguay. The ability of these governments to generate local revenue is illustrated by indicators of its distribution among them, including per capita estimates. On the expenditure side, indicators of disparities in per capita spending between departmental governments are included.

When these fiscal indicators are analysed (see table 3), large horizontal fiscal disparities can be detected by observing the great differences in revenue, transfer and spending levels between the different departmental governments. Since all departmental governments are required by law to provide the same services, the large differences in total per capita expenditure can be assumed to have significant implications for the quantity and quality of the services provided (for example, per capita expenditure is 3.5 times as high in Maldonado as in Canelones). There are also large differences in total per capita revenue (almost 4 times as high in Maldonado as in Canelones).

Table 3
Uruguay: per capita revenues, transfers and spending by department, 2006–2014
(Constant pesos and averages)

Department	Local revenues per capita (1)	Percentage of Uruguayan average (2)	Transfers per capita (3)	Percentage of Uruguayan average (4)	Total revenues per capita (5)	Percentage of Uruguayan average (6)	Total spending per capita (7)	Percentage of Uruguayan average (8)	Per capita GDP Uruguay=100
Artigas	5 028	70	5 280	108	10 308	85	9 781	81	73
Canelones	4 515	63	1 732	35	6 247	52	6 655	55	66
Cerro Largo	4 097	57	5 526	113	9 623	79	9 908	82	78
Colonia	7 775	108	2 862	58	10 637	88	11 064	91	141
Durazno	7 835	109	6 931	141	14 765	122	14 176	117	86
Flores	13 194	183	8 155	166	21 349	176	21 657	179	109
Florida	6 409	89	5 245	107	11 654	96	11 533	95	103
Lavalleja	6 466	90	6 237	127	12 703	105	12 451	103	103
Maldonado	18 465	256	4 285	87	22 750	188	23 562	195	121
Montevideo	8 682	120	1 147	23	9 828	81	9 879	82	139
Paysandú	5 197	72	4 296	87	9 493	78	9 999	83	91
Río Negro	6 708	93	7 275	148	13 983	115	13 694	113	168
Rivera	4 159	58	4 306	88	8 465	70	8 657	72	75
Rocha	10 356	144	5 868	119	16 224	134	14 988	124	95
Salto	5 822	81	4 307	88	10 129	84	10 734	89	78
San José	5 423	75	3 109	63	8 533	70	8 785	73	96
Soriano	6 185	86	4 913	100	11 098	92	11 198	93	103
Tacuarembó	5 676	79	4 657	95	10 334	85	9 668	80	80
Treinta y Tres	5 107	71	7 171	146	12 278	101	11 622	96	95
Uruguay	7 216	100	4 911	100	12 126	100	12 106	100	100

Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.

To analyse these differences in total per capita revenue more thoroughly, it is necessary to examine the situation with local revenues and transfers. Departmental governments are found to differ greatly in the total per capita revenue they raise themselves, with some raising almost five times as much as others (Maldonado relative to Cerro Largo, for example). If information on per capita transfers from central government is added, large differences are again observed, although they are not as great as those detected in the case of local revenues. In addition, these intergovernmental transfers seem to bear little relation to levels of GDP per capita. For example, although Maldonado has considerably greater local revenues and per capita GDP than Canelones, the transfers it receives per capita, while considerably lower than the national average, are more than double those received by Canelones.

Following the same line of argument, we can find quite wealthy departments with similar levels of revenue (Maldonado and Colonia) that spend very different amounts. Likewise, if the comparison is between departments that are poorer but have similar revenues (Durazno and San José) or between departments that have per capita GDP levels close to the national average (Rocha and Flores), they can be seen to have very different levels of total revenue or expenditure, as well as very different levels of transfers.

In conclusion, there is very marked fiscal heterogeneity in levels of expenditure, local revenues and intergovernmental transfers that do not seem to bear any relation to the departments' per capita GDP and, consequently, to the tax-gathering potential of the different departmental governments.

Lastly, we shall present fiscal disparity indicators for each of the departmental governments and their relationship with the level of unconditional intergovernmental transfers, since it is these transfers that should theoretically have the greatest equalizing effect. To this end, the following fiscal disparity indicator is calculated for each departmental government i (DG_i):

$$Fiscal\ disparity_i = Spending\ needs_i - Fiscal\ capacity_i \quad (1)$$

In the absence of more suitable information, the national average per capita expenditure actually executed by departmental governments during the period 2006–2014 is taken as an indicator of spending needs. The per capita revenue raised locally by each of the departmental governments during the period will serve as an indicator of fiscal capacity.

The analysis in table 4 reveals a clear upward trend in both spending needs and fiscal capacity. At the same time, there was an even greater increase in the fiscal disparity per capita over the period under review.[7] In addition, there was a marked increase in the level of unconditional transfers expressed in per capita terms (with a growth rate of 61% over the period). This result suggests that, in dynamic terms, unconditional transfers do not appear to have had any equalizing effect in Uruguay. In other words, there is no sign that transfers reduced the level of fiscal disparity for departmental governments in the aggregate over the period analysed. In fact, we observe that fiscal disparities increased at a faster rate than intergovernmental transfers. This result could reflect a degree of fiscal indiscipline on the part of departmental governments. More specifically, because they receive resources in the form of intergovernmental transfers without having to bear the economic or political costs of raising their own revenue, these governments seem to take a cavalier attitude to spending.

Table 4
Uruguay: spending needs, fiscal capacity, fiscal disparity and unconditional transfers, 2006–2014
(At constant 2014 prices)

	Spending needs per capita	Fiscal capacity per capita	Fiscal disparity per capita	Unconditional transfers per capita
2006	9 978	6 713	3 265	3 475
2007	10 615	6 868	3 747	3 537
2008	11 396	7 214	4 182	3 824
2009	12 004	6 831	5 173	4 096
2010	11 389	6 975	4 414	4 128
2011	12 076	7 254	4 822	4 485
2012	12 442	7 418	5 024	4 632
2013	13 942	7 717	6 225	5 117
2014	15 111	7 951	7 160	5 592

Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.

Table 5 presents information on the above variables, but disaggregated by department. This table reveals a generalized increase in the level of fiscal disparities measured in per capita terms, accompanied by a generalized increase in unconditional transfers per capita. Unconditional transfers had no very noticeable equalizing effect. Although the indices of disparity between the total revenues of the different departmental governments declined, they did so by less than a third, which can be considered a small effect, especially considering that, as Martínez-Vázquez (2015) points out, the OECD countries manage to reduce fiscal disparities by more than two thirds with their equalization transfers.

Again, although there has been an upward trend in the amount of intergovernmental transfers per capita in Uruguay, they have not played more of an equalizing role. On the contrary, the equalizing role of intergovernmental transfers diminished slightly during the period under analysis.

[7] For example, the simple rate of change in the fiscal disparity level was 119% for the period 2006–2014.

Table 5
Uruguay: spending needs and fiscal capacity by department, selected years
(At constant 2014 prices)

Department	Spending needs per capita			Fiscal capacity per capita			Fiscal capacity including unconditional transfers per capita		
	2006	2009	2014	2006	2009	2014	2006	2009	2014
Artigas	9 978	12 004	15 111	4 735	5 024	5 134	8 114	9 178	11 494
Canelones	9 978	12 004	15 111	4 411	3 971	5 072	5 642	5 577	7 034
Cerro Largo	9 978	12 004	15 111	3 990	3 505	4 670	7 866	7 439	10 842
Colonia	9 978	12 004	15 111	5 210	7 364	9 892	7 259	9 634	13 076
Durazno	9 978	12 004	15 111	7 328	7 125	7 970	12 297	13 261	15 720
Flores	9 978	12 004	15 111	11 658	11 361	15 665	17 780	17 942	24 699
Florida	9 978	12 004	15 111	6 085	6 411	8 068	10 421	10 656	14 151
Lavalleja	9 978	12 004	15 111	6 560	6 713	6 521	11 030	11 169	14 259
Maldonado	9 978	12 004	15 111	18 049	18 146	18 904	21 022	21 647	22 622
Montevideo	9 978	12 004	15 111	8 491	8 993	9 678	9 354	9 733	10 656
Paysandú	9 978	12 004	15 111	5 164	5 072	5 248	8 579	8 424	10 153
Río Negro	9 978	12 004	15 111	6 444	6 279	7 027	10 903	11 746	14 651
Rivera	9 978	12 004	15 111	3 634	3 917	4 514	6 776	7 315	9 230
Rocha	9 978	12 004	15 111	7 752	9 258	11 093	10 929	15 376	19 242
Salto	9 978	12 004	15 111	5 759	5 584	5 921	8 697	8 944	10 507
San José	9 978	12 004	15 111	5 538	5 446	5 606	8 077	8 158	9 243
Soriano	9 978	12 004	15 111	5 860	5 516	6 951	9 810	10 429	12 574
Tacuarembó	9 978	12 004	15 111	5 492	4 787	8 139	9 086	9 126	13 907
Treinta y Tres	9 978	12 004	15 111	5 380	5 324	4 998	9 921	11 866	13 261
Average	9 978	12 004	15 111	6 713	6 831	7 951	10 188	10 927	13 543
Highest	9 978	12 004	15 111	18 049	18 146	18 904	21 022	21 647	24 699
Lowest	9 978	12 004	15 111	3 634	3 505	4 514	5 642	5 577	7 034
Highest/Lowest	1	1	1	5.0	5.2	4.2	3.7	3.9	3.5
Standard deviation *(in logarithms)*	0	0	0	0.373	0.396	0.403	0.309	0.323	0.311
Coefficient of variation	0	0	0	0.49	0.495	0.482	0.361	0.356	0.334
Gini index	0	0	0	0.213	0.227	0.234	0.171	0.179	0.172
Theil index	0	0	0	0.09	0.095	0.094	0.049	0.055	0.049

Source: Office of Planning and Budget (OPP), on the basis of accounts submitted by departmental governments.

V. Reform options and projections

A regime of equalization transfers seeks to ensure that all subnational governments can provide services of similar quality with an equivalent tax effort (Martínez-Vázquez and Sepúlveda, 2012). Different options for designing a system of equalization transfers can be distinguished:

(a) The first option is to equalize the spending needs of subnational governments without regard to their differing capacity to raise revenues locally. This option applies in countries where subnational governments do not have their own sources of revenue.

(b) The second option is to equalize the capacity of subnational governments to generate revenues locally. This approach seeks to ensure that all subnational units obtain the same revenues with the same level of tax effort. It is the best option when the cost of providing the different local public services is very similar throughout the country.

(c) The third option is to equalize the difference between subnational governments' capacity to generate revenues locally and their spending needs, considering both the potential revenues and the spending needs of the different subnational governments, as is done in countries such as Australia, Denmark, China and Ethiopia.

The analysis in this paper centres on the third option, that of equalizing the difference between the revenues regional governments can raise themselves and their spending needs. The set of fiscal disparities of Uruguay's departmental governments provides the information needed to distribute the hypothetical equalization transfers fund.[8]

The criterion for distributing transfers between departmental governments remains to be defined. A starting point is to establish that resources can only benefit departmental governments whose fiscal disparity is positive. In our case, this criterion was considered appropriate because it improves the equalizing capacity of transfers by excluding from the group of beneficiaries those departmental governments with sufficient fiscal resources to cover their spending needs. As regards fiscal capacity (the ability of departments to raise their own revenues), the three main sources of revenue for departmental governments are considered separately: the rural property tax, the urban and suburban property tax, and the vehicle licence fee. All other departmental government revenues are grouped under "other".[9]

The vehicle licensing tax base was estimated from 2014 data on vehicle licensing debt issuance,[10] taking an average rate of 4.5% of vehicles' market value (tax base) to obtain the vehicle licensing amount payable (debt issuance). The tax base for calculating the urban and rural property tax in 2014 was the aggregate taxable value of urban, suburban and rural properties as supplied by the National Directorate of Cadastre (DNC).[11] Lastly, the variety of the levies and prices in the "others" category meant that the tax base could not be measured directly, so each department's GDP was used as a proxy.

To estimate the potential revenue of the different departmental governments, the country's average tax rate was applied to the relevant tax base, on the assumption that this rate matched the fiscal effort required for each tax. With this information on potential revenue from the main local revenue sources of the departmental governments of Uruguay as a base, the methodology of the typical tax system of these regional governments was employed. The data on tax bases by type of tax and effective tax rates are detailed in tables 6 and 7, respectively.

Given that departmental governments in Uruguay perform functions of a municipal nature, it is not appropriate to use the age distribution of the departmental population to estimate their spending needs. At the same time, nor is exhaustive, homogeneous information available on expenditure levels by function in the different departmental governments. In view of this, the spending needs of these governments were estimated from the nationwide per capita expenditure standard during the period 2006–2014. It was also considered that the per capita cost of providing these services varied between the different departments by population density. The higher the population density in a department (inhabitants per square kilometre), the lower the cost of the service was assumed to be.

[8] See annex 3 for more detail on the fiscal equalization methodology used.

[9] The "others" category comprises a wide range of smaller levies, particularly taxes on foodstuffs and administration and municipal services charges.

[10] Vehicle licensing debt issuance is calculated from the tax base (vehicles by year and model) and a differential rate. The relevant tax base was estimated using debt issuance information from the Single Vehicle Revenue Collection System (SUCIVE [online] https://www.sucive.gub.uy/), assuming an average rate of 4.5%.

[11] See [online] http://catastro.mef.gub.uy/.

Table 6
Uruguay: tax base by type of tax, 2014
(Per capita)

Department	Tax base			
	Rural property tax	Urban and suburban property tax	Vehicle licensing fee	GDP (as proxy for all other taxes in the absence of specific information)
Artigas	147 719	101 196	35 417	271 696
Canelones	21 671	152 215	33 276	222 471
Cerro Largo	144 388	119 710	40 659	274 954
Colonia	87 191	234 410	138 602	490 967
Durazno	231 476	92 526	77 963	318 157
Flores	294 025	175 647	237 147	396 049
Florida	202 656	33 531	80 543	369 517
Lavalleja	164 964	145 774	49 848	377 115
Maldonado	23 437	722 437	130 833	409 574
Montevideo	4 620	344 286	41 212	487 462
Paysandú	135 909	140 369	50 705	329 880
Río Negro	240 600	129 280	58 499	616 314
Rivera	83 783	117 460	39 132	270 444
Rocha	120 669	154 112	47 757	342 635
Salto	105 601	154 265	46 721	282 289
San José	93 914	37 617	76 682	343 711
Soriano	188 106	167 995	60 388	393 306
Tacuarembó	155 466	123 548	56 237	280 089
Treinta y Tres	150 203	132 747	53 361	333 809
National average	61 765	250 199	54 258	386 826

Source: For the rural and the urban and suburban property taxes: National Directorate of Cadastre (DNC); for the vehicle licensing fee: Single Vehicle Revenue Collection System (SUCIVE); for GDP: Central Bank of Uruguay (BCU), Institute of Economics (IECON) and Office of Planning and Budget (OPP).

Table 7
Uruguay: estimated effective tax rates, by type of tax, 2014
(Percentages)

	Effective tax rate
Rural property tax	0.8
Urban and suburban property tax	0.7
Vehicle licensing fee	3.6
Other	1.1

Source: Prepared by the authors.

1. Equalization exercises

The demographic situation in the different departments of Uruguay means that population densities are low (most departments have fewer than 20 inhabitants per km^2) and that residents are very dispersed in small towns. Because services are situated in specific locations, the costs of per capita provision when potential demand is low and dispersed could be higher in such departments than in those with highly developed urban or semi-urban spaces. The existence of agglomeration economies could affect the costs of providing goods and services, with costs per user declining as population density increases. In other words, a greater dispersion of the population in the territory means that less advantage can be taken of economies of density associated with service provision, which inefficiently increases costs (Carruthers and Ulfarsson, 2003; Hortas-Rico and Solé-Ollé, 2010). A higher population density should

reduce the cost of producing these services, either because it would reduce the number of centres needed to provide a given level of service, because it would lower the transport costs associated with the service, or because it would reduce the average distance between potential users and the centre where the service was provided. Taking these assumptions into account, local spending needs were recalculated on the basis of the population densities of the different departments. The inverse of the logarithm of density was used, on the basis that as population density increases, costs decrease, but less than proportionately. The values were also normalized in the range from 1 to 2. When this adjustment factor is applied, the department with the highest population density, Montevideo, is found to have an adjustment factor of 1, and is therefore taken as a benchmark because its spending needs are not modified, whereas the spending needs of all other departments increase as a consequence of their lower population densities (see table 8).

Table 8
Uruguay: population density by department

Department	Density (inhabitants/km^2)	Correction factor
Artigas	6.30	1.843
Canelones	116.80	1.170
Cerro Largo	6.53	1.833
Colonia	20.64	1.417
Durazno	4.86	2.000
Flores	5.12	1.997
Florida	6.67	1.822
Lavalleja	6.06	1.879
Maldonado	34.54	1.317
Montevideo	2 554.50	1.000
Paysandú	8.37	1.703
Río Negro	5.87	1.881
Rivera	11.43	1.172
Rocha	6.93	1.800
Salto	9.20	1.670
San José	21.87	1.403
Soriano	9.46	1.654
Tacuarembó	5.83	1.882
Treinta y Tres	5.45	1.981

Source: Prepared by the authors, on the basis of data from the National Institute of Statistics (INE) of Uruguay.

Incorporating this information into the equalization exercise makes it possible to consider different per capita spending needs by department and thence obtain different fiscal gaps (see table 9).

Under the methodology used here, eight departmental governments would receive a greater amount in transfers than they do at present. They are: Canelones, Rivera, Tacuarembó, Artigas, Salto, Paysandú, San José and Cerro Largo. At the other extreme, the departmental governments that would see the amount of their transfers reduced are Montevideo, Florida, Lavalleja, Rocha, Soriano, Durazno, Treinta y Tres, Río Negro, Colonia, Flores and Maldonado. These last three are the ones that would undergo the greatest reductions in the amount of transfers received, since they are departments with a relatively large fiscal capacity. Maldonado, in particular, is able to cover all its spending needs without recourse to transfers (see last column of table 10).

Table 9
Uruguay: estimated fiscal gaps by department, corrected for population density, 2014

Department	Spending needs		Revenues			Gap
	Per capita spending		Departmental		National[d]	
	Current	Standard[a]	Current[b]	Standard[c]		
	(1)	(2)	(3)	(4)	(5)	(2) – (4) – (5)
Artigas	9 764	19 408	5 026	5 298	667	13 443
Canelones	6 657	12 319	4 525	4 483	171	7 665
Cerro Largo	9 912	19 308	4 098	5 777	789	12 742
Colonia	11 088	14 918	7 795	11 410	362	3 146
Durazno	14 166	21 061	7 834	7 694	555	12 811
Flores	21 678	21 031	13 205	14 627	1 008	5 396
Florida	11 529	19 185	6 408	7 609	616	10 959
Lavalleja	12 438	19 787	6 466	7 155	508	12 125
Maldonado	23 604	13 868	18 472	13 630	1 278	-1 039
Montevideo	9 882	10 530	8 682	8 252	371	1 907
Paysandú	10 002	17 936	5 197	6 618	421	10 896
Río Negro	13 705	19 987	6 709	10 247	1 930	7 810
Rivera	8 661	16 671	4 160	5 147	641	10 883
Rocha	15 004	18 958	10 359	6 637	122	12 199
Salto	10 745	17 586	5 822	5 918	485	11 184
San José	8 806	14 792	5 422	6 665	296	7 831
Soriano	11 187	17 415	6 183	7 769	419	9 228
Tacuarembó	9 668	20 047	5 677	6 421	95	13 531
Treinta y Tres	11 622	20 743	5 107	6 880	527	13 336
Total	10 530	10 530	7 541	7 541	446	2 544

Source: Prepared by the authors, on the basis of Office of Planning and Budget (OPP), "Clasificador de ingresos y gastos" [online] https://otu.opp.gub.uy/sites/default/files/finanzas/clasificador_ingresos_egresos.pdf.

[a] The 2006–2014 national per capita average in 2014 Uruguayan pesos, adjusted for population density, is taken as the standard.

[b] Excludes equalization transfers and revenues originating at the national level, subsection II of the document "Clasificador de ingresos y gastos" (earmarked funds).

[c] Calculated on the basis of potential revenue from vehicle licensing fees, rural, urban and suburban property taxes and "other" taxes and charges at the relevant national average effective rate.

[d] Revenues originating at the national level, paragraphs 2.1 and 2.3 of the document "Clasificador de ingresos y gastos" (resources established under provisions of the Constitution and resources established under other provisions).

Table 10
Uruguay: distribution of intergovernmental transfers in terms of fiscal gaps, corrected for population density, 2014

Department	Gap index	Population weighting factor	Coefficient of distribution	Equalizing distribution	Current distribution	Change	
	a	b	c=a*b	*(millions of pesos)*		*(millions of pesos)*	*(percentage)*
Artigas	5.28	0.02	0.12	416	353	63.14	18
Canelones	3.01	0.16	0.47	1 648	836	811.88	97
Cerro Largo	5.01	0.03	0.13	458	422	35.85	8
Colonia	1.24	0.04	0.05	160	317	-156.18	-49
Durazno	5.04	0.02	0.09	307	378	-71.25	-19
Flores	2.12	0.01	0.02	57	188	-131.02	-70
Florida	4.31	0.02	0.09	307	321	-14.25	-4
Lavalleja	4.77	0.02	0.09	297	347	-50.07	-14
Maldonado	0.00	0.05	-	-	512	-511.70	-100
Montevideo	0.75	0.40	0.30	1 054	1 065	-10.29	-1
Paysandú	4.28	0.03	0.15	515	454	60.89	13
Río Negro	3.07	0.02	0.05	177	300	-123.50	-41
Rivera	4.28	0.03	0.13	469	391	77.47	20
Rocha	4.80	0.02	0.10	360	420	-60.77	-14
Salto	4.40	0.04	0.17	580	492	88.02	18
San José	3.08	0.03	0.10	347	310	37.30	12
Soriano	3.63	0.03	0.09	317	382	-65.13	-17
Tacuarembó	5.32	0.03	0.15	508	425	83.51	20
Treinta y Tres	5.24	0.01	0.08	272	336	-63.87	-19

Source: Prepared by the authors.

Lastly, the same equalization exercise is performed on the assumption of a 10% (Δ UCT=10%) and 20% (Δ UCT=20%) increase in the volume of unconditional transfers, respectively (see annex 4). Gradually increasing the volume of unconditional transfers has two advantages. First, it solves the cash flow problem, at least in the short term, of some departmental governments that would receive less in the way of transfers when the new system was implemented. With a 10% increase in unconditional transfers, the departments of Florida and Montevideo would receive 5% and 9% more in transfers, respectively, than they do at present. If the increase were 20%, three departmental governments, namely Lavalleja, Rocha and Soriano, would receive more in transfers than under the equalization scenario with no increase in transfers. Secondly, increasing the volume of unconditional transfers would bring progress towards greater fiscal homogeneity. If the amount were to increase by 10% or 20%, the reduction in fiscal disparity would be 30% or 32%, respectively (see table 11).

Table 11
Uruguay: horizontal fiscal disparities

Inequality measures	Before equalization	After equalization		
		Δ UCT=0[a]	*Δ UCT*=10%	*Δ UCT*=20%
Coefficient of variation	0.34763	0.25057	0.23926	0.22939
Standard deviation (in logarithms)	0.31423	0.22548	0.21892	0.21343
Gini index	0.17386	0.12434	0.12089	0.1178
Theil coefficient	0.05204	0.02731	0.02521	0.02346
Maximum/Minimum	3.64037	2.53571	2.43888	2.34916

Source: Prepared by the authors.
[a] UCT: unconditional transfers.

VI. Conclusions

This article has analysed the equalizing role of intergovernmental transfers by means of an empirical analysis applied to a group of regions in Uruguay during the period 2006–2014. More specifically, two types of analysis have been carried out. First, the equalizing impact of the system of intergovernmental transfers currently operating in Uruguay was evaluated. Second, the effects of implementing a new system of equalization transfers in the country were discussed. The proposed system, based on objective criteria linked to the values of certain variables, would clearly reduce the level of horizontal fiscal disparities. Transfers from central government would play a more important role in terms of their egalitarian or equalizing effects.

It should be noted that the proposal formulated here results in greater per capita transfers for a certain number of departments, which of course might not contribute to the objective of a better territorial balance of economic activity. Nonetheless, it should be stressed that the amount of decentralized resources controlled by departmental governments is still very small in Uruguay (around 10% of public expenditure) and that these resources are earmarked for the provision of basic and very specific local public services, whose quality might be expected to be fairly uniform throughout the country. Thus, if policies to reduce territorial imbalances in economic activity were desired, it would probably be more effective for the central government to design more specific and powerful instruments for improving territorial cohesion. For example, programmes of investment in transport and communications infrastructure and strategies to encourage business investment in certain areas or regions could be used for this purpose.

As already indicated, the design of a financing system for departmental governments should be grounded in the debate on technical criteria such as those proposed here, which should not be subject to the uncertain outcomes of political negotiation between departmental governments and central government authorities. Within this framework, the most important reform, one that would strengthen the tax position of departmental governments by stimulating their fiscal effort, is to set clear, objective and simple rules for the transfer system. Such rules should be established for a period of time long enough to prevent them being periodically subject to political changes. It is also extremely important to have a few clearly defined economic policy objectives, since the costs in terms of efficiency or equity when policy effects conflict can be large. For example, one objective would be to cover the spending needs involved in providing the services assigned to departmental governments, while other objectives would be to increase regional convergence and reduce the dispersion of population.

When it comes to implementing the new system of equalization transfers, the most appropriate strategy is judged to be a process of gradual implementation based on the "hold harmless" principle, which, as in the case of Mexico, would enable costs to be spread over time, thus reducing potential political resistance to the reform process.

Lastly, we consider the most important reform to be the establishment of a transparent system for quantifying intergovernmental transfers. As already indicated, this would require far-reaching political negotiations with the different actors. However, in the process of implementing this reform, and on a temporary basis, certain immediately applicable measures may be considered. These include increasing the fiscal capacity of departmental governments with less administrative capacity by creating support agencies that enable them to optimize revenues from property taxes and other fiscal instruments if deemed necessary. Attention could also be paid to possible differences in the costs of providing public goods and services in the different departments, with per capita spending needs calculated in a way that takes the dispersion of the population into account. If possible, the total amount of transfers should be increased so that departmental governments can afford to provide the goods and services for which they have been made responsible. These proposals do not require major political negotiation or long transition periods, since they can be implemented with little delay. However, it should be stressed once again that the greatest reform required is the creation of a clear, transparent, simple and generally accepted system for calculating equalization transfers.

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Annex A1

Map A1.1
Political subdivisions of Uruguay

Source: Prepared by the authors.

Annex A2

List of departments

- Artigas
- Canelones
- Cerro Largo
- Colonia
- Durazno
- Flores
- Florida
- Lavalleja
- Maldonado
- Paysandú
- Salto
- San José
- Soriano
- Río Negro
- Rivera
- Rocha
- Tacuarembó
- Treinta y Tres
- Montevideo.

Annex A3

Equalization exercise: methodology

The procedure is to assess departmental governments' capacity for generating their own revenues relative to their spending needs and reassigning intergovernmental transfers on that basis with a view to equalization.

The procedure for determining equalization transfers will now be summarized. For explanatory purposes, it is divided into six steps.

The first step is to calculate the fiscal capacity or standard revenue per capita of a given departmental government (DG_i). This standard revenue (SR_i) is defined as the potential capacity of a departmental government to raise its own revenue, given its tax base and assuming that the tax rate is the same for all the departments in the country:

$$SR_i = \sum_{i=1}^{i=19} TB_{i,j} * AETR_j \quad (1)$$

Where $TB_{i,j}$ is the per capita tax base of revenue item j in department i, while $AETR_j$ is the annual effective tax rate of revenue item j:

$$AETR_j = \frac{Total\ local\ revenue_j}{Tax\ base_j}$$

The second step is to calculate the spending needs or adjusted standard expenditure (ASE_i) of each DG_i. Here it is assumed that scale plays a determining role in the provision of public goods, giving advantages in public goods provision to departments with greater population density by reducing fixed costs (agglomeration economies). Greater population density may lower costs by reducing the number of centres needed to provide a given service, transport costs or the average distance between potential users and the centre providing the service (Carruthers and Ulfarsson, 2003).

Given the importance of scale in the provision of departmental public goods, an adjustment to standard expenditure by department is proposed, with average spending needs (SN) being adjusted by a factor reflecting population density. The $DENS_i$ factor is calculated as the inverse of the logarithm of normalized population density between 1 and 2. We thus obtain adjusted standard expenditure (ASE_i).

$$ASE_i = SN * DENS_i \quad (2)$$

The third step is to calculate the standardized fiscal gap of each DG_i (Gap_i). The standard revenue of each DG_i is deducted from its standard expenditure, as are the conditional transfers (CT_i) received by it, on the basis that these transfers also cover part of the spending needs of departmental governments.

$$Gap_i = ASE_i - IE_i - CT_i \quad (3)$$

This indicator provides the basic information needed to distribute a hypothetical fund of equalization transfers.

The fourth step is to construct the gap index (GI_i), which captures the relative size of the fiscal imbalance of each DG_i as a percentage of the aggregate fiscal imbalance of all the country's departmental governments:

$$GI_i = \frac{Gap_i}{Average\ gap} \tag{4}$$

It is assumed that the reallocation of transfers will only benefit departmental governments whose fiscal gap is positive, enhancing the equalization capacity of transfers. Thus, departments with a negative fiscal gap will be assigned a GI_i of zero.

The fifth step is to calculate the weighted relative need index ($WRNI_i$) with a view to arriving at an equalizing conditional transfer coefficient of distribution. This is a factor that serves to evaluate the departmental gap index in terms of the average weighted gap and the population of each department.

$$WRNI_i = \frac{GI_i * \left(\frac{Population_i}{Total\ population}\right)}{\sum_{i=1}^{i=19} INRP_i} \tag{5}$$

Lastly, the system's equalization transfers (ET) are calculated by multiplying the total amount of unconditional transfers (UCT) by the weighted relative need index for the DG_i ($WRNI_i$). This yields the amount of transfers per capita for each DG_i:

$$ET_i = WRNI_i * UCT \tag{6}$$

Annex A4

Calculation of gaps when total transfers are increased

Table A4.1

Uruguay: distribution of intergovernmental transfers considering gaps corrected for population density (increase of 10%), 2014

Department	Gap index	Population weighting factor	Coefficient of distribution	Equalizing distribution	Current distribution	Change	
	a	b	c=a*b	*(millions of pesos)*		*(millions of pesos)*	*(percentage)*
Artigas	5.28	0.02	0.12	457	353	104.71	30
Canelones	3.01	0.16	0.47	1 813	836	976.67	117
Cerro Largo	5.01	0.03	0.13	504	422	81.66	19
Colonia	1.24	0.04	0.05	177	317	-140.13	-44
Durazno	5.04	0.02	0.09	337	378	-40.58	-11
Flores	2.12	0.01	0.02	63	188	-125.29	-67
Florida	4.31	0.02	0.09	338	321	16.44	5
Lavalleja	4.77	0.02	0.09	327	347	-20.38	-6
Maldonado	0.00	0.05	-	-	512	-511.70	-100
Montevideo	0.75	0.40	0.30	1 160	1 065	95.16	9
Paysandú	4.28	0.03	0.15	567	454	112.39	25
Río Negro	3.07	0.02	0.05	194	300	-105.82	-35
Rivera	4.28	0.03	0.13	516	391	124.35	32
Rocha	4.80	0.02	0.10	396	420	-24.81	-6
Salto	4.40	0.04	0.17	638	492	146.03	30
San José	3.08	0.03	0.10	382	310	72.02	23
Soriano	3.63	0.03	0.09	348	382	-33.47	-9
Tacuarembó	5.32	0.03	0.15	559	425	134.35	32
Treinta y Tres	5.24	0.01	0.08	299	336	-36.67	-11

Source: Prepared by the authors.

Table A4.2
Uruguay: distribution of intergovernmental transfers considering gaps corrected for population density (increase of 20%), 2014

Department	Gap index	Population weighting factor	Coefficient of distribution	Equalizing distribution	Current distribution	Change	
	a	b	c=a*b	*(millions of pesos)*		*(millions of pesos)*	*(percentages)*
Artigas	5.28	0.02	0.12	499	353	146.28	41
Canelones	3.01	0.16	0.47	1 977	836	1 141.46	137
Cerro Largo	5.01	0.03	0.13	550	422	127.48	30
Colonia	1.24	0.04	0.05	193	317	-124.08	-39
Durazno	5.04	0.02	0.09	368	378	-9.90	-3
Flores	2.12	0.01	0.02	69	188	-119.57	-63
Florida	4.31	0.02	0.09	368	321	47.13	15
Lavalleja	4.77	0.02	0.09	356	347	9.31	3
Maldonado	0.00	0.05	-	-	512	-511.70	-100
Montevideo	0.75	0.40	0.30	1 265	1 065	200.61	19
Paysandú	4.28	0.03	0.15	618	454	163.89	36
Río Negro	3.07	0.02	0.05	212	300	-88.14	-29
Rivera	4.28	0.03	0.13	563	391	171.22	44
Rocha	4.80	0.02	0.10	432	420	11.15	3
Salto	4.40	0.04	0.17	696	492	204.04	41
San José	3.08	0.03	0.10	417	310	106.74	34
Soriano	3.63	0.03	0.09	380	382	-1.81	0
Tacuarembó	5.32	0.03	0.15	610	425	185.19	44
Treinta y Tres	5.24	0.01	0.08	326	336	-9.47	-3

Source: Prepared by the authors.

The social and economic effects of introducing reverse mortgages in Chile

José Luis Ruiz, Pablo Tapia and José Donoso

Abstract

This study simulates the social and economic effects of introducing reverse mortgages in Chile. It uses the 2009 Social Protection Survey and recent simulation methodologies to analyse the monetary gain associated with taking out such a loan, which is paid in periodic instalments over the homeowner's lifetime. Eligible individuals are retired homeowners, who account for 70% of the older population. Monies received increase exponentially depending on the age at which the reverse mortgage is taken out. Lastly, the increase in liquidity has significant social potential, as it could reduce the poverty rate in the target group by 15%.

Key words

Housing, housing finance, mortgages, pensions, retirement, prices, economic aspects, mathematical models, social aspects, Chile

JEL classification

G21, G22, G28

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I. Introduction

In recent decades, global population trends have shown increases in longevity and in the share of older persons as a percentage of the total population. Data from the National Institute of Statistics (INE) of Chile show that in 1950, persons aged 65 and over accounted for 4% of Chile's population, a number that has continued to grow and is projected to reach 22% in 2025. Consequently, persons in this age group are gaining increasing importance in the design of public policy and place pressure on the funding of pension systems. This situation becomes urgent when one considers that the pensions received by Chileans are lower than other countries in the Organization for Economic Cooperation and Development (OECD) and that 70% of the population considers them insufficient to maintain an adequate standard of living (Presidential Advisory Commission on the Pension System, 2015).

One alternative that can help to improve pensioners' living standards is the reverse mortgage. Broadly speaking, a reverse mortgage is a financial product aimed at retired homeowners, whereby a financial institution agrees to pay homeowners a monthly amount for as long as they live; upon their death, ownership of the property passes to the lender unless the heirs return the full amount paid. The main purpose of this instrument is to free up some of the illiquid wealth tied to homes without the owners having to vacate their property. This brings with it a series of economic benefits, such as increased household liquidity and the acquisition of resources that complement pensions and help to reduce poverty among older persons. However, as reverse mortgages are not available in Chile, the aim of this study is to simulate their possible economic and social benefits.

We follow the methodology proposed by Ma and Deng (2013) and Wang and Kim (2014) to model monthly reverse mortgage payments for a given a house price.[1] Using the revenue generated by reverse mortgages, we analyse their contribution to the household income and, at per capita level, how the payments vary depending on the age at which pensioners take out a reverse mortgage and to what extent this instrument affects the poverty rate of the target group.

Reverse mortgages have been analysed in Chile by Muñoz (2011) and by Alonso, Tuesta and Lamuedra (2013). This study focuses on the social potential of the reverse mortgage through simulations based on updated models, using variants such as the loan-to-value (LTV) ratio, changes in real estate prices and mortality rates, among others. This innovative approach adds to the interest of this study: the fact that this subject is widely documented in the literature it offers a reliable basis against which to compare our findings.

Our analysis shows that monthly payments from a reverse mortgage would amount to 62,508 Chilean pesos on average for contracting parties, which is an increase of 107% over the average monthly pension of 58,245 pesos received by the individuals in the sample. The monetary gain from the instrument leads to an increase in liquidity corresponding to 57% of per capita income. In addition, the evidence suggests that the older individuals are when they take out a reverse mortgage, the higher the payments they receive, as interest rates also increase with age. This means that if all eligible persons were to take out a reverse mortgage upon retirement, the poverty rates in this population group would fall by approximately 15%. Raising the retirement age for women to 65 —the same age as for men— would reduce poverty even further, leading to a 19% decline.

This article is divided into six sections. Following this introduction, section II provides details on the pension situation in Chile. Section III reviews the theoretical and empirical literature on reverse mortgages and their social potential. Section IV presents the analytical framework and the simulation data and section V discusses the findings of the simulations. Lastly, section VI concludes.

[1] Prices correspond to the 2009 Social Protection Survey; see [online] https://www.previsionsocial.gob.cl/sps/biblioteca/encuesta-de-proteccion-social/bases-de-datos-eps/.

II. Pensions in Chile

Until 1980, Chile had a pay-as-you-go pension system, in which pensions were funded through different institutions called "cajas de pensión", with differentiated rules and benefits. With population ageing and declining rates of active workers paying into the pension system rendering it insolvent, a new pension system was created in 1981. This new system comprised fully funded individual accounts for workers entering the labour market, with workers already in the old system able to opt in. Those who remained in the old system continued to contribute to it, but their were pensions financed out of general tax revenue. Workers enrolled in the new pension system pay into individual accounts managed by Pension Fund Administrators (AFPs), responsible for collecting, registering and investing pension contributions. AFPs also pay benefits through programmed withdrawals,[2] while lifetime income payments are made by life insurance companies.[3]

The main objective of any pension system is to guarantee a stable income for workers at the end of their working life, and this income should correspond to their earnings during their active life. The former pay-as-you-go system offered replacement rates of around 70% to those meeting the requisite conditions.[4] The current system has a number of advantages over the pay-as-you-go system; however, this model alone cannot resolve the issue of financing old age in countries where income distribution is unequal, as is the case in Chile (Office of the Superintendent of Pensions, 2010).

After three decades of the fully funded system, it was observed that a significant portion of the population had insufficient savings to afford a decent living in their old age. This can be explained by the low density of contributions to individual accounts (Office of the Superintendent of Pensions, 2006) and by payment differentials related to gender and other factors. The current pensions system underwent a key reform in 2008 with the introduction of a solidarity pillar that aims to fight poverty and is funded through general taxation (Office of the Superintendent of Pensions, 2010). This improvement, however, proved insufficient. The Presidential Advisory Commission on the Pension System was established in 2015 and tasked with reviewing and the pension system and proposing improvements thereto. It reported that 50% of retirees received pensions below 82,650 pesos, with a significant gender gap: the median pension for women stood at 42,561 pesos, while for men that figure was 112,333 pesos. Half of Chilean retirees receive at most 34% of their average income for the last 10 working years. This includes retirees under the pre-1980 pension system. Thus, it is estimated that taking into account only workers in the fully funded system retiring between 2025 and 2035, half of pensioners would earn no more than 37% of their average income for the last 10 working years. Moreover, this is extremely low compared to the average replacement rate for OECD countries which stands at 66%.

Lastly, the above is closely related to the fact that 70% of Chileans believe that pension incomes are insufficient to cover adequate living standards (OECD, 2013). This led to protests in 2016, in a demand for changes to the pension model that would offer better benefits (*The Economist*, 2016).

III. Literature on reverse mortgages

One of the main dilemmas facing retired homeowners is whether to remain in their homes and accept a low retirement income, or to sell their home and use some of the proceeds for rented accommodation, using the rest as a stream of income (Bartel and Daly, 1980). Economically speaking, the latter is option is rational; however, there are significant psychological costs associated with renting and moving homes

[2] See [online] https://www.spensiones.cl/portal/institucional/594/w3-propertyvalue-9924.html#faqs.

[3] See [online] https://www.spensiones.cl/portal/institucional/594/w3-propertyvalue-9924.html#faqs.

[4] Persons who contributed for less than 15 years are not entitled to pension payments.

(Davidoff, 2010). Reverse mortgages offer a possible solution to this conundrum. This financial product, which emerged in the United States in the 1980s and has since spread to a number of countries (including Canada, Australia, Spain and Japan), allows retired homeowners to borrow money, using their homes as collateral, without having to give up residence.

Phillips and Gwin (1993) identify three categories of reverse mortgages: term reverse mortgages, which entail payments of a fixed sum for a determined period, after which the loan is repaid through the sale of the property; split-term reverse mortgages, which are similar to the first but with the difference that homeowners continue to live in the property after the prescribed term of payments, which are to be repaid when the homeowner changes residency, sells the property or dies; and lastly, tenure reverse mortgages, which are considerably more common than the previous two and consist in payments of a fixed sum until the individual, moves, sells the house or dies, for a loan amount that has a positive correlation with the age of the borrower and value of the property and a negative correlation with interest rates (Fornero, Rossi and Urzi, 2016).

It is suggested that individuals who take out reverse mortgages are older persons who are asset-rich but cash-poor, i.e. who have substantial wealth (represented by home equity) but have liquidity constraints (Moulton and others, 2015). In this sense, Nakajima and Telyukova (2017) find that take-up rates of the instrument are higher among those with low income, who own expensive homes, have outstanding mortgages, live on their own and are in poor health.

Simulations of reverse mortgages were carried out in different countries to determine their potential before they were put into effect. The results have been mixed. One of the most relevant studies with regard to reverse mortgage simulations is Mayer and Simons (1994), conducted in the early stages of the use of this instrument in the United States, in which the authors claim that reverse mortgages could reduce poverty in the target group by about three quarters. The authors convert the value of the house to a lifetime annuity with monthly payments (tenure). However, owing to a lack of data and advanced methodologies, the authors assumed random property values and loan-to-value ratios. The latter variable, which corresponds to the percentage of the home that can be used as collateral, is the most questionable: the authors set the value at 75%, while subsequent studies calculate it mathematically, resulting in lower values.

Kutty (1998) conducts a study of reverse mortgages already contracted in the United States. Using tenure reverse mortgages as a basis, he argues that if all households in the target group were to contract such a loan, less than one-third would be lifted out of poverty. In the United Kingdom, Hancook (1998) uses the same methodology as Kutty (1998) to model the effect of the implementation of reverse mortgage schemes and concludes that poverty would be reduced by less than 5%. The differences in findings can be partially attributed to the fact that reverse mortgage income is tax-free in the United States but is subject to taxation in the United Kingdom (Ong, 2008).

Moscarola and others (2015) analyse the potential social gain to be obtained from the development of reverse mortgages in European countries where the instrument has yet to be introduced. The authors use three scenarios with arbitrarily-selected interest rates and two scenarios each with a different percentage of the property used as collateral to simulate the reduction in vulnerability in the target group. Spain and Belgium have the greatest potential, with poverty reduction peaking at close to 25%. Poverty could be reduced by more than 10% in France and Italy, but that rate would be lower in the other countries studied (Switzerland, Austria, the Netherlands, Germany and Denmark).

In Chile, Muñoz (2011) argues that if the entire target group took out a reverse mortgage, poverty would fall by 88%. However, this study is not based on a tenure reverse mortgage, but a split-term reverse mortgage. Furthermore, it does not take into account the increased liquidity created by the instrument in per capita terms, as most international studies do, nor does it include a disagreggation of the findings in distinct target groups. Fuentes and Moris (2014) examine the legal feasibility of introducing

reverse mortgages in Chile, concluding that the current legal environment, which lent itself to effective drafting of contracts, and the existence of suitable legal mechanisms to protect contracting parties created favourable conditions.

The present study is based on the methodology applied by Ma and Deng (2013) and Wang and Kim (2014), who introduce the principle of insurance pricing. This principle involves a simulation that avoids losses to the lender in the event that the borrower's loan balance exceeds the value of the home at a given time, as occurs when the property value appreciates less than expected or the contracting party lives longer than estimated: this takes into account the relationship between mortgage insurance premiums and expected losses to the lender. As previous studies have not addressed this relationship, its importance has been overlooked. If financial institutions are allowed to define monthly payments at the equilibrium point where the expected values of the insurance premiums received are equal to the value of expected losses, monthly payments would be more realistic, which plays a key role in motivating financial institutions to participate in this type of market. However, as the simulation method used by these authors was not intended to analyse the social impact of reverse mortgages, the present study is ground-breaking in this regard.

Lastly, despite the theoretical potential of reverse mortgages, demand for and use of the instrument are lower than expected (Davidoff, Gerhard and Post, 2017). In the United States, only 2.1% of eligible homeowners had reverse mortgage loans in 2011, the highest level of demand to date (Nakajima and Telyukova, 2017). Davidoff, Gerhard and Post (2017) argue that this is because target groups may find the instrument difficult to understand. This is upheld by Moulton and others (2015), who maintain that the take-up of reverse mortgages is low because seniors shy away from complicated financial instruments or do not fully understand what they entail.

IV. Methodology and data

1. Analytical framework

We use a tenure reverse mortgage, which is widely documented and provides a reliable platform for comparing our findings, to calculate monthly payments. We then follow Ma and Deng (2013) and Wang and Kim (2014), in which monthly payments are calculated using the house price at the time the loan is contracted. A random house price is selected in order to model the change in monthly payments depending on the age group to which the homeowner belongs when a reverse mortgage is taken out, for a property of the same value. We apply the same method, instead using the real value of the home that is being used as collateral.

House prices were based on the 2009 Social Protection Survey (EPS), which is representative of the population and has detailed and reliable information on the pensioners making up the target group. Notwithstanding the above, the value of the property at the time of each individual's retirement is required for the model. To this end, we apply the simulation used in Ma and Deng (2013) and Wang and Kim (2014), adding one prior step to obtain the home price at retirement by using the 2009 values for each individual. This study presents the methodology used by those authors for calculating monthly payments, with extensive use of life tables (Office of the Superintendent of Pensions, 2009a).

The algorithm used to simulate the monthly payments includes the following:

(i) the house price according to the 2009 Social Protection Survey.

(ii) the estimated house price at the time of retirement.

(iii) the estimated house price at the term of the mortgage.

(iv) the loan-to-value ratio.

(v) the estimated monthly payments (using life tables).

The simulation begins with the house price based on 2009 values as the base variable, which is obtained as described in section IV.3. We then proceed as follows:

(a) Based on the 2009 house for individual i, ($P_{2009,i}$), the price of the home at the time of each individual's retirement ($P_{j,i}$)is estimated based on the methodology developed by Szymanoski (1994). For a description of this methodology, see annex A1.

$$P_{J,i} = \frac{P_{2009,i}}{exp\left(\mu \cdot t_i + 0{,}5 \cdot \sigma^2 \cdot t_i\right)} \tag{1}$$

Where μ corresponds to the average annual growth of property prices (Central Bank of Chile) in the economy and σ^2 represents the variation in that growth rate, while t_i indicates the number of years elapsed between the retirement of individual i and 2009, according to information obtained from 2009 Survey.

(b) Once the house price at the time of retirement has been obtained, we calculate the price at the term of the contract ($P_{T,i}$), approximate to the price of the property when the individual i meets his or her life expectancy (in accordance with Szymanoski, 1994).

$$P_{T,i} = P_{J,i} \cdot exp\left(\mu \cdot T_i + 0{,}5 \cdot \sigma^2 \cdot T_i\right) = \frac{P_{2009,i} \cdot exp\left(\mu \cdot T_i + 0{,}5 \cdot \sigma^2 \cdot T_i\right)}{exp\left(\mu \cdot t_i + 0{,}5 \cdot \sigma^2 \cdot t_i\right)} \tag{2}$$

In this case, T_i represents the expected duration of the contract in years —that is, the life expectancy of i— less the retirement age, which is obtained by combining data from the National Institute of Statistics (2010a) and the mortality tables from the Office of the Superintendent of Pensions. Similarly, values for life expectancy and age at retirement will depend on the sex of the individual.

(c) We obtain the loan-to-value (LTV) ratio, which is the maximum percentage of the home's value at the age of retirement that can be used as collateral, as seen in equation (3).

$$LTV_i = \frac{P_{T,i} / \left(1 + r\right)^{T_i}}{P_{J,i}} \tag{3}$$

Where r is the discount rate of the loan, which comprises the linear sum of the country's risk-free interest rate[5] (i_{lr}), the insurance premium[6] (IP_m) and the lender's margin[7] (LM). These are the elements that typify the national economy.

(d) We calculate the current loan value (CLV), understood as the loan amount disbursed by the financial institution when only a lump sum is paid on signature of the contract. This is described in equation (4), which includes the up-front insurance premium[8] for the loan (IP_0).

$$CLV_i = P_{J,i} \cdot \left(LTV_i - IP_0\right) \tag{4}$$

[5] Monthly average of secondary market 10-year interest rates of peso-denominated bonds (BCP) tendered by the Central Bank of Chile (see [online] https://si3.bcentral.cl/Boletin/secure/boletin.aspx?idCanasta=1MRMW2951).

[6] The 0.5% rate in effect in the United States market is used (Rodda and others, 2003). The same rate is used in the papers establishing the methodology applied (Wang and Kim, 2014; Ma and Deng, 2013).

[7] Variable that usually ranges between 1% and 2% (Rodda, Herbert and Lam, 2000). We use 1%, following Wang and Kim (2014).

[8] The 2% rate in effect in the United States market is used (Rodda and others, 2003). The same rate is used in the paper establishing the methodology applied (Wang and Kim, 2014).

(e) According to Wang and Kim (2014), monthly payments are determined as in equation (5), where represents the expected duration of the loan in months.

$$LM_i = \frac{CLV_i}{\sum_{n=0}^{n=(\tau_i-1)} (1+r)^{-n}} \quad (5)$$

Equation (5) gives the value of monthly payments assuming that all individuals live out their life expectancy. However, this figure is merely theoretical, as borrowers may die before or after that date. As this could give an inaccurate estimate of monthly payments, to improve the scope of the simulation, we expand equation (5) by including a discount factor that considers the probability of i being alive to receive the payment in month N, ($p_{N,i}$), assuming the individual was alive at the time the reverse mortgage was taken out, as expressed in equation (6).

$$LM_i = \frac{CLV_i}{\sum_{N=0}^{N=T} \left[(1+r)^{-N} \cdot (p_{N,i}) \right]} \quad (6)$$

Where the term T represents the period in which the probability of survival falls to 0.

Regarding equation (6), it is important to bear in mind that in this study we obtain $p_{N,i}$ from the life tables of the Chilean pension system for 2009 (see annex A2), where the probability of dying is given in annual intervals and not monthly intervals as required by the model. We will therefore assume that the probability that an individual is alive in a given year is equal to the probability that the same individual is alive in every month of that year. The Chilean pension system life tables to 2009 are the basis for determining the threshold value T (110 years for both sexes). This corresponds to a loan duration of T = 540 months for an individual retiring at 65 and T = 600 months for an individual retiring at 60.

2. Economic parameters

Knowledge of specific parameters of the Chilean economy is required for our model:

Discount rate on reverse mortgages

In the specialized literature, the discount rate used to calculate reverse mortgage payments is obtained by adding a risk-free interest rate, usually for a 10-year period, together with a differential representing the lender's margin and another to cover a monthly insurance premium paid over the life of the loan. The Central Bank of Chile 10-year interest rate in pesos (BCP-10), with an annual average of 5.67% in 2009, was used as the risk-free rate. Annual rates of 1% and 0.5% (Rodda, Hebbert and Lam, 2000) will be used for the lender's margin and monthly insurance premium, respectively, as practised for reverse mortgages in the United States.

Initial cost of the loan

This corresponds to the value of the property at the time of borrowing, multiplied by an up-front insurance premium of 2% (used in Ma and Deng (2013) and in Wang and Kim (2014)).

Mean and standard deviation of percentage change in house prices

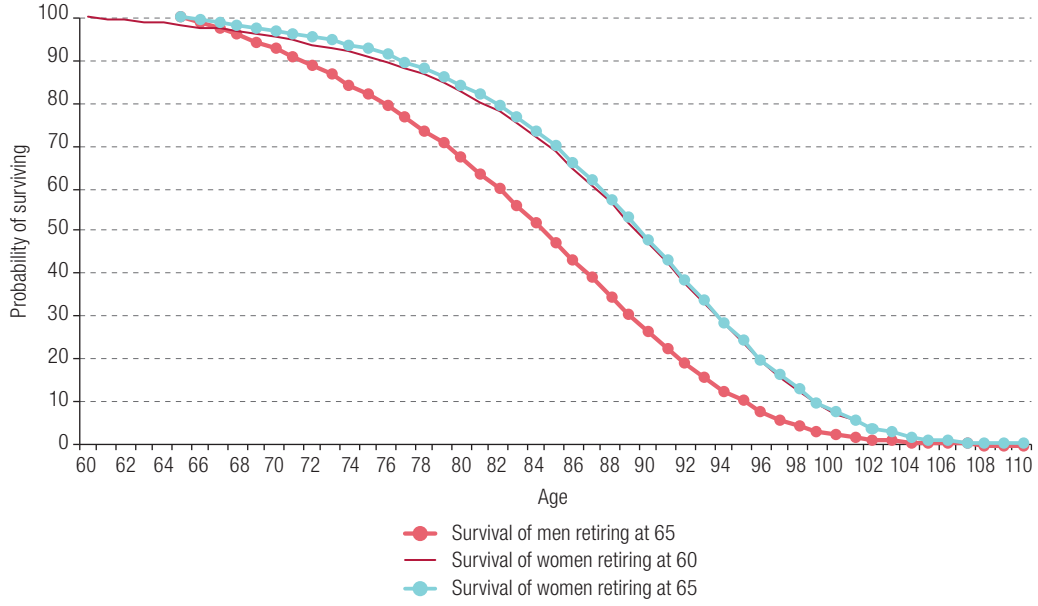
The variables related to movement in house prices are obtained using the real estate price index provided by the Central Bank of Chile, available from 2003 to 2014. To that end, we use the simple average of the variation in the annual index and the standard deviation over the period, which previously stood at 4.4% and 2.9%, respectively.

Life expectancy and life tables

The life tables for Chile as of 2009 were used to determine the life expectancy of the individuals in our sample. The life expectancy for men is 76 years, while for women it is 81 years (INE, 2010b). The survival probabilities of individuals over the term of the loan are estimated using the life tables for lifetime income pensions in Chile in 2009, disaggregated by sex. These tables are included in annex A2.

There are gender differences in the probability of survival. Data on the probability of survival for men retiring at 65 and for women retiring at 60 and 65, taking 110 as the upper age limit for both genders, show that at each age men are less likely to be alive than women. This difference is greatest in the median ages of the life span analysed (see figure 1).

Figure 1
Survival probability, by sex and age at retirement
(Percentages)



Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w3-propertyvalue-4350.html.

3. Data

The Social Protection Survey (EPS) is a longitudinal survey that is representative of the population; its 2009 edition compiles various observations on some 16,000 households throughout Chile. It has played a key role in the analysis and design of public policies in Chile,[9] specifically those on pensions, and is therefore a vital source of information for our study. The sample population, comprising only the target group for reverse mortgages —namely homeowners of retirement age (women aged 60 and over and men aged 65 and over)— was extracted from this Survey.

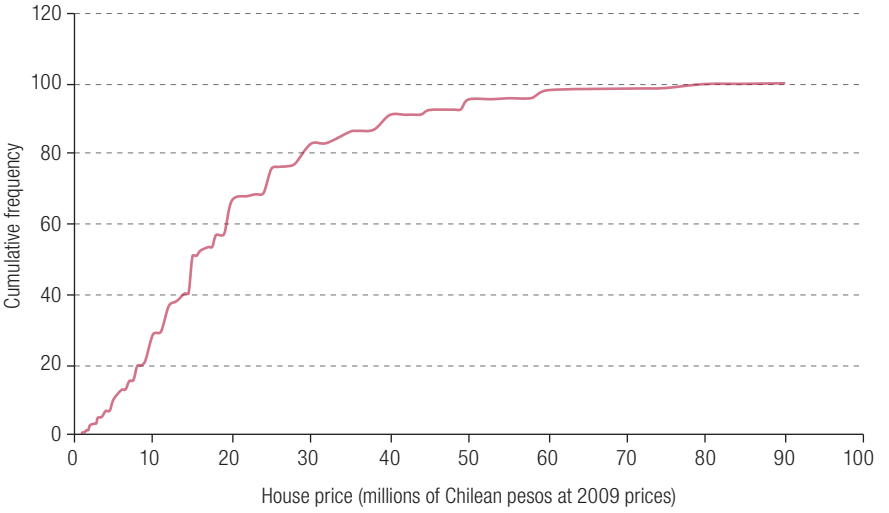
The following question was asked in the Survey to determine the price of homes: "If you were to sell your house today, how much would it be worth?"[10]The answer to that question is hereinafter

[9] The Presidential Advisory Council for Pension Reform (2015) was able to identify shortcomings in pension policy thanks to the Survey.

[10] Question D17 of the 2009 Social Protection Survey.

referred to as the "house price". However, because it is based on a personal appreciation, it may be biased. To correct this bias, we assume that individuals' mobility between regions is low and we thus classify individuals by their region of birth and by deciles according to the expansion factor, forming homogeneous groups based on property value. Thus, for each individual, the average value for the corresponding segment is imputed as the house price. This solves possible bias and also covers the observations of individuals who did not know or did not answer the question on the value of their home. In addition, the values given to the homes in the sample are not normally distributed. This is corrected by removing data for house prices above percentile 97.5, which corresponds to house prices above 100 million pesos. The resulting distribution is shown in figure 2. This is also represented in table 1 showing a comparison between the variables house price and imputed house price, which is the value of the house based on the aforementioned adjustments.

Figure 2
Distribution of house prices in Chile
(Percentages)



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

Table 1
Comparison of house prices and imputed house prices

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
House price *(millions of pesos at 2009 prices)*	1 752	20.60	15.00	1.00	90.00
Imputed house price *(millions of pesos at 2009 prices)*	2 627	20.40	4.11	2.50	50.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Lastly, 2,627 observations were selected from this process, representing a population of 1,623,326 households; women make up 59.1% of the population and the average age is 71 years. Of the respondents, 65% are heads of household with an average household income of 103,749 pesos. The average per capita income is 34,724 pesos (see table in annex A3). In light of the above, 86.25% of the sample are below the poverty line.[11]

[11] Urban poverty line in terms of people living in income (absolute) poverty in Chile (see [online] http://observatorio.ministeriodesarrollosocial.gob.cl/casen/casen_def_pobreza.php), which stands at 64,134 pesos per capita.

V. Empirical section

To simulate the monthly payments, we must first establish house prices at the time of retirement and at the term of the loan, and the initial price of homes imputed to 2009 in the Social Protection Survey, in line with the modelling in Szymanoski (1994). We note that the average property price at the time of retirement is 14 million pesos, while the average for the expected property value at the term of the contract is slightly more than 30 million pesos (see table 2). From the above, we obtain the loan-to-value (LTV) ratio, the average of which is 59.42%. This value can be broken down by sex, where the average LTV for women is 53.92% and for men 72.36%. The above figures are consistent with the fact that the expected duration of mortgages is lower for men, because of their later retirement age and shorter life expectancy than women.

Once we have obtained the LTV ratio, we can calculate the current loan value (CLV), understood as the amount the financial institution disburses in a lump sum to the homeowner at the time the reverse mortgage is taken out, as opposed to making monthly payments. The average CLV is 8 million pesos, which is used to calculate monthly payments, assuming that all eligible individuals take out a reverse mortgage. The average for monthly payments is 62,508 pesos, with a standard deviation of 29,760 pesos. However, when taking into account self-funded pensioners[12] in the sample, the average pension income is 145,808 pesos. That income could rise by 43% if we included reverse mortgage payments. When we consider in the sample retirees receiving the solidarity pension (non-self-funded), the average pension amounts to 58,245 pesos; the addition of monthly payments from the reverse mortgages would see this income rise by 107%. These large increases can be explained by the low pensions in Chile but they also show that older persons possess high volumes of illiquid wealth.

It is also appropriate to analyse reverse mortgage payments by gender, as this determines retirement age and life expectancy, bases on which the duration of the mortgage and the loan amount available to pensioners are calculated. Gender also determines the amount of the basic pension, which in turn defines the initial wealth base, since the average pension for women is 51,174 pesos, while that for men is 89,185 pesos (see table 2). This is attributable to differences in labour participation and the existing wage gap between women and men in Chile (Sáez, 2010).

Table 2
Estimate of reverse mortgage parameters

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
House price at retirement *(millions of pesos at 2009 prices)*	2627	14.00	5.40	1.12	47.80
House price at term of loan *(millions of pesos at 2009 prices)*	2627	31.6	13.60	1.83	122.00
Loan-to-value ratio *(percentages)*	2627	59.42	8.44	53.92	72.36
Current loan value *(millions of pesos at 2009 prices)*	2627	8.07	3.43	0.79	33.10
Monthly payments *(pesos)*	2627	62 508	29 760	6 807	285 512
Monthly payments for women *(pesos)*	1552	51 174	20 539	7 883	178 732
Monthly payments for men *(pesos)*	1075	89 158	31 053	6 807	285 512

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

As we have mentioned, there is a five-year difference in retirement age between women and men, which affects the execution of the reverse mortgage contract because its duration is determined by age at retirement. Chilean women currently retire at 60 —we use this as the standard scenario in this study but have also analysed an alternative scenario in which women retire at the same age as men (65 years). As expected, raising women's retirement age resulted in a 55% increase (28,221 pesos) in

[12] This means the State does not contribute to their pensions. This applies to 1093 individuals (41% of the sample).

monthly reverse mortgage payments and a narrowing of the gender gap by 74.3%, as shown in table 3. Therefore, financial conditions being equal, the amount received from a reverse mortgage will also be equal; this must be taken into account if this instrument is to be incorporated in public policy design.

Table 3
Analysis of monthly payments by sex and retirement age
(Chilean pesos)

Status	Retirement age for women	Retirement age for men	Total monthly payments	Monthly payments for women	Monthly payments for men
Standard scenario	60	65	62 508	51 174	89 158
Alternative scenario	65	65	82 308	79 395	89 158
Variation			19 800	28 221	0

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

On the basis of the above results in the standard scenario, monthly payments from reverse mortgages would be a valuable addition to household income. They have the potential to increase the household income of the target group by about 60% on average, from 103,749 pesos to 166,258 pesos. Consequently, per capita income also increases by approximately 57%, from 34,724 pesos to 54,537 pesos, as seen in table 4. This affects not only the distribution of wealth but also plays a role in improving the quality of life in those households thanks to increased income.

Table 4
Impact of reverse mortgages on income (standard scenario)
(Chilean pesos)

Variable	Mean	Standard deviation	Minimum	Maximum
Household income without reverse mortgage	103 749	136 576	0	2 000 000
Household income with reverse mortgage	166 258	141 879	7 883	2 121 002
Mean variation of household income	60.25%			
Per capita income without reverse mortgage	34 724	49 533	0	450 000
Per capita income with reverse mortgage	54 537	57 525	2 037	519 441
Mean variation of per capita income	57.06%			

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

After simulating the monthly payments and assuming that all eligible individuals take out a reverse mortgage, its effects on poverty in the sample can be analysed. We observe that reverse mortgages could generate a 15% reduction in poverty rates for the sample as a whole (see table 5).

Table 5
Potential effect of reverse mortgages on poverty (standard scenario)
(Percentages, except for figures in left column)

Variable	Observations	Poverty rate		Percentage reduction in poverty
		Without reverse mortgage	With reverse mortgage	
Total	2 627	86.25	73.17	15.17
Contributors to pension fund administrators (AFPs)	434	90.71	83.77	7.65
Respondent is head of household	1 935	81.30	65.24	19.75
Respondent is not head of household	692	95.48	87.95	7.89
Women	1 552	88.40	79.64	9.91
Men	1 075	81.18	57.94	28.63

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Table data based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

In this sense, the potential effect is low compared to studies conducted in the United States (Mayer and Simons, 1994; Kutty, 1998), Spain and Belgium (Moscarola and others, 2015), but greater than that detected in the United Kingdom (Hancock, 1998), Denmark, Germany, Holland, Austria and Sweden (Moscarola and others, 2015). The reduction in poverty seen in our simulation falls between the levels reported for Italy and France (Moscarola and others, 2015), as shown in table 6. This indicates that our simulation model is reliable, since the projected poverty reduction is within the ranges defined in the specialized literature and this also confirms the accuracy of the economic parameters selected.

Table 6
Potential effect of reverse mortgages on poverty, by country
(Percentages)

Country	Percentage reduction in poverty	Data year	Author
Sweden	3	2012	Moscarola and others, 2015[a]
United Kingdom	4	1995	Hancock, 1998
Austria	4	2012	Moscarola and others, 2015[a]
Netherlands	5	2012	Moscarola and others, 2015[a]
Germany	6	2012	Moscarola and others, 2015[a]
Denmark	8	2012	Moscarola and others, 2015[a]
France	14	2012	Moscarola and others, 2015[a]
Italy	16	2012	Moscarola and others, 2015[a]
Belgium	25	2012	Moscarola and others, 2015[a]
Spain	27	2012	Moscarola and others, 2015[a]
United States	29	1991	Kutty, 1998
United States	74	1990	Mayer and Simons, 1994

Source: Prepared by the authors.
[a] Values correspond to the upper limit for each country listed in the document.

If we consider only persons paying into to the AFP system, poverty is reduced by 7.65%, which is a significantly smaller decrease than in the sample as a whole. This is because, although the monthly payments to AFP contributors would be 20% higher than the sample average, their initial income is close to two-thirds of the average income of the entire sample (see table 5). Poverty reduction as a result of reverse mortgages is greater among heads of household than the sample average and slightly more than twice that among other household members. The instrument's effect would therefore be smaller than initially estimated, comparable to that seen in Denmark and Germany (Moscarola and others, 2015). The impact is small but positive for just over 100,000 households.

Lastly, it is possible to isolate the gender indicator. Initial poverty is almost 10% higher among women because men's per capita income is 50% higher than women's. As table 7 shows, in the standard scenario women receive much lower reverse mortgage payments than their male counterparts, resulting in poverty reduction of 9.91% among women compared with 28.63% among men. Therefore, if taking out a reverse mortgage is included in the decision to retire, it becomes imperative to ensure equal financial conditions for both men and women, because although the instrument will improve the well-being of retirees and their households, it could also accentuate gender-based wealth gaps.

When women's retirement age is raised, the instrument's social potential leads to a 5.31% fall in poverty among women, which is greater than the standard scenario but still lower than that among men. This widens the percentage reduction in poverty across the sample by 3.81%.

Table 7
Potential effect of reverse mortgages on poverty by sex and age at retirement
(Percentages in the three rightmost columns)

Status	Retirement age for women	Retirement age for men	Percentage reduction in total poverty	Percentage reduction in poverty among women	Percentage reduction in poverty among men
Standard scenario	60	65	15.17	9.91	28.63
Alternative scenario	65	65	18.98	15.22	28.63
Variation			3.81	5.31	0.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Our findings may seem encouraging, but it must be borne in mind that they were obtained assuming that all qualifying persons took out reverse mortgages, which is unrealistic. Indeed, the likely outcome of reverse mortgages on poverty reduction is not as expected. Davidoff, Gerhard and Post (2017) and Nakajima and Telyukova (2017) argue that only 1.7% of eligible individuals in the United States do, in fact, take out reverse mortgages; furthermore, they are far more popular among homeowners who are alone, low-income, in poor health, and whose properties are more expensive than the average. Therefore, if we focus on this group only —that is, those most likely to take out reverse mortgages— the present study shows that poverty is reduced by close to 2%. This is because the individuals in this segment are so poor to begin with that monthly payments are insufficient to lift many of them out of poverty, but they do increase liquidity and, thus, the well-being of those who take out reverse mortgages. However, consideration must be given to the fact that our calculations are based solely on conditions observed in the present and not what could occur in the future, such as future income, family support networks or possible subventions.

1. Analysis by age group

Our above analysis is based on the assumption that individuals take out a reverse mortgage upon retirement, but they are free to do so at any time after their retirement date. However, the older the individual entering into the contract, the more effects there are on the monthly payments. First, taking out a reverse mortgage at an older age reduces the number of payment periods that can be expected, therefore increasing the amount of each payment. This, in turn, reduces the discount on the loan-to-value (LTV) ratio, which rises as individuals present a lower risk to the lender. Both lead to an increase in the monthly payment. This is nevertheless offset by a lower appreciation of the property, thus decreasing the LTV ratio.

In the specialized literature, there is a positive relation between the age at which the transaction is originated and the monthly payments (Ma and Deng, 2013). The aim of this section is therefore to simulate how monthly payments would vary depending on the age group to which a representative individual taking out a reverse mortgage in Chile belongs. For this purpose, a non-gender-specific life table is used, as shown in table A2.1 of annex A2.

Two cases are presented: in the first (see table 8), the price of the home at origination of the reverse mortgage is the average house price at the time of retirement of the individuals in the sample, i.e. 14 million pesos at 2009 prices. We then analyse how the monthly payments would vary if a representative individual owning a property of this value took out a reverse mortgage at 65, 70, 75 or 80 years of age (see table 8).

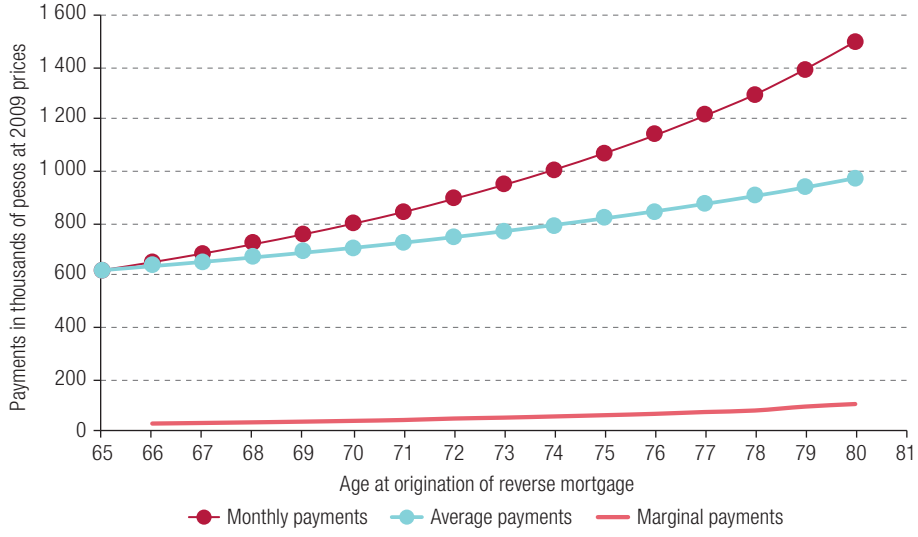
Table 8
Case 1: analysis of reverse mortgages by age group

Imputed house price of 14 million pesos at 2009 prices				
Age when taking out reverse mortgage	65	70	75	80
Imputed house price *(millions of pesos at 2009 prices)*	14.00	14.00	14.00	14.00
Expected house price at term of loan *(millions of pesos at 2009 prices)*	32.70	26.10	21.00	16.80
Loan-to-value ratio (*percentages)*	57.9	66.25	77.19	89.36
Current loan value *(millions of pesos at 2009 prices)*	7.73	8.99	10.50	12.20
Monthly payments (*pesos)*	62 387	80 179	107 080	149 793

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

As the age at origination increases, the expected value of the home at the term of the loan decreases, while the LTV expands. This means that the increase in the latter variable is the dominant effect. In view of the above, the current loan value rises, which is enhanced by the shorter duration of the contract, thus leading to higher monthly payments at increasing rates. This is clearly shown in figure 3: there is a positive relationship between monthly, average and marginal payments and age at origination. A representative individual taking out a reverse mortgage at age 65 would receive periodic monthly payments of 62,387 pesos, which would gradually increase to 149,796 pesos if the mortgage is taken out at age 80. Further details on payments can be found in annex A4.

Figure 3
Case 1: monthly payments



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

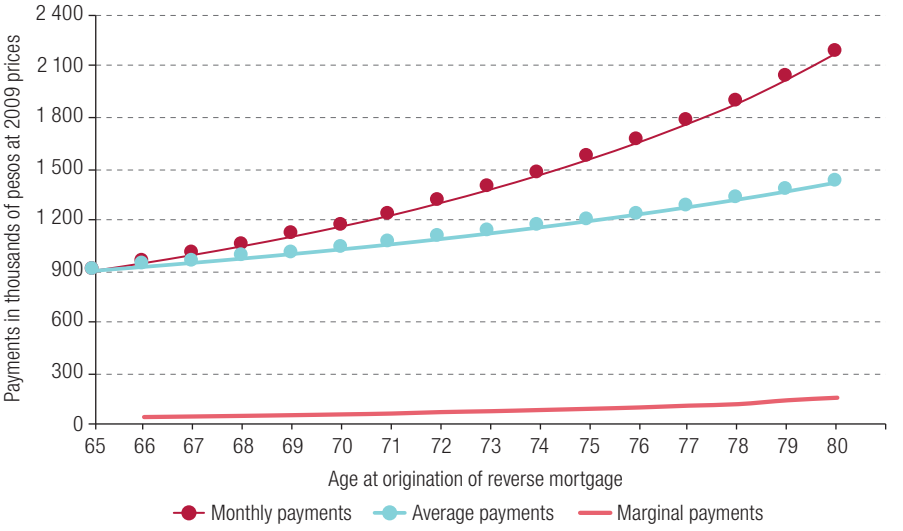
In the second case (see table 9 and annex A1), the same methodology is used but we consider the initial value of the home as the average house price imputed to 2009, i.e. 20.04 million pesos, maintaining the loan-to-value ratio at each age and the rate of increase of monthly payments. Specifically, an individual retiring at 65 would receive an additional 90,907 pesos per month from a reverse mortgage and that figure that would increase to 218,270 pesos if the mortgage is taken out at 80 years (see figure 4 and annex A4). Thus, if this instrument is introduced, there will be dispersion in payments owing to the distribution of the age at which reverse mortgages are taken out. The distribution of house prices, which will depend on future appreciation, will also lead to dispersion.

Table 9
Case 2: analysis of reverse mortgages by age group

Imputed house price of 20.04 million pesos at 2009 prices				
Age when taking out reverse mortgage	65	70	75	80
Imputed house price *(millions of pesos at 2009 prices)*	20.04	20.04	20.04	20.04
Expected house price at term of loan *(millions of pesos at 2009 prices)*	47.60	38.01	30.60	24.50
Loan-to-value ratio *(percentages)*	57.19	66.25	77.19	89.36
Current loan value *(millions of pesos at 2009 prices)*	11.30	13.10	15.3	17.80
Monthly payments *(pesos)*	90 907	116 832	156 031	218 270

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

Figure 4
Case 2: monthly payments



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

VI. Conclusions

Our study simulated the social and economic potential of introducing reverse mortgages for pensioners in Chile. We used the methodology proposed by Ma and Deng (2013) and Wang and Kim (2014), with some innovations such as the use of life tables from Chile, as well as data on house prices taken from the 2009 Social Protection Survey, which is highly representative of the population and linked to pension systems. A sample of 1,623,326 pensioners was used, representing approximately 9% of the adult population in Chile (Office of the Superintendent of Pensions, 2009a). The implementation of reverse mortgages will not resolve income poverty among older persons in Chile, but it can help homeowners, who could use it as collateral to enhance their economic independence by recovering some illiquid wealth.

We conclude that the increase in liquidity that comes with taking out a reverse mortgage reduces the percentage of the older population living in poverty. If all qualifying individuals took out a reverse mortgage, the poverty rate would decline by 15%; when we restrict the sample to pensioners contributing to the current fully funded system, the poverty rate is reduced by 7.65%. However, the poverty rate declines by 2% if we consider only the characteristics of the population among which reverse mortgages have been most popular where implemented (Davidoff and others, 2017; Nakajima and Telyukova, 2017), such as being alone, low-income, in poor health and having a property worth more

than the average. These results are in line with the ranges found in the specialized literature, confirming the reliability of our findings —albeit only at a trend level— because random events are incompatible with the predictive capacity we seek.

We find that with the introduction of reverse mortgages at retirement, individuals could use on average 59% of their property as collateral, receiving constant monthly payments of 62,508 pesos, which is equivalent to 60% of the average income of households with retirees. This represents a 57% increase in retirees' per capita income. However, analysis of monthly payments reveals a gender gap, as women receive 42.6% (37,984 pesos) less than men. This difference stems from women's higher life expectancy and lower retirement age, which increases the duration of their mortgages. However, raising their retirement age to 65 narrows the gender gap narrows to 10.9% (9,763 pesos). This indicates that if reverse mortgages were introduced as public policy, it would be necessary to ensure equal financial conditions for both men and women; failing this, although reverse mortgages will improve the well-being of retirees and their households, they could accentuate gender-based wealth gaps.

From another standpoint, our simulations made it possible to analyse how monthly payments would vary according to the age at origination of the reverse mortgage. An individual taking out such a mortgage at age 65 can use 57% of the home's value as collateral; that figure climbs to 89% if the individual takes out a mortgage at 80, which illustrates a positive correlation between the amount received through a reverse mortgage and the age at which it is taken out. Therefore, if this instrument is to be introduced in a public policy context, account must be taken of the dispersion that will result in mortgage payments owing to the distribution in the age of the contract. The distribution of house prices, which will depend on future appreciation, will also lead to dispersion. The diversity that these elements bring to the financial instrument means that more than one type of financial institution may be interested in offering reverse mortgages.

In summary, the findings presented in this study show that reverse mortgages can be useful in increasing liquidity for pensioners. This is important in a context where 70% of Chileans hold that pensions are insufficient to maintain an adequate standard of living in old age. Moreover, we illustrate the significant social potential in terms of poverty reduction, which could lead to undeniable gains in well-being for the target group. What matters most in the use of reverse mortgages is that older persons have access to credit and thus increase their income, without detriment to their current economic situation. However, consideration should be given to the debtor's heirs, as this instrument is a mortgage and does not involve a transfer of ownership. As this could lead to a conflict of interest between the two parties, there is a need for legislation that offers the necessary protection to both heirs and creditors (Fuentes and Moris, 2014).

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Annex A1

Modelling of house prices at different periods

To perform the modelling for this study, we must know the price of houses in periods outside the sampling period. Specifically, we must estimate house prices at the term of the mortgage (period subsequent to the sample) and, the price at the time of retirement (period prior to the sample). To do this, we follow Szymanoski's model (1994), which is detailed below.

We define the following variables:

$$H_t: \textit{House price in year } t$$

$$H_0: \textit{House price in year } t=0 \textit{ initial}$$

Let us assume the percentage H_t with respect to H_0 is X_t:

$$X_t = \frac{H_t}{H_0}$$

Then:

$$x: \textit{Random variable of the set of observations } X_t$$

Applying the natural logarithm to X_t we obtain the percentage change in the house price between the initial period and random period "t":

$$Y_t = ln(X_t) \rightarrow X_t = exp(Y_t)$$

Where:

$$y: \textit{Random variable of the set of observations } Y_t$$

Using the exponential function $g(a)=exp(a)$ we have:

$$g(y)=exp(y) \rightarrow E(x)=E(exp(y))=E(g(Y))$$

Here, Szymanoski (1994) argues that long-term house price trends can be modelled by a geometric Brownian motion (GBM) process. Consequently, we assume that Y_t is a GBM, which implies that in the period "t", Y_t has a mean of $\mu \cdot t$ and a standard deviation of $\sigma\sqrt{t}$, which depicts normal distribution. At the same time, the above means that X_t is defined as a GBM with a log-normal distribution.

Consequently, we know that since $F(y)$ is the probability function of "y" and $f(y)$ is the density function of "y", then:

$$E\big(g(y)\big) = \int_{-\infty}^{+\infty} g(y)dF(y) = \int_{-\infty}^{+\infty} g(y)f(y)dy \qquad \text{(I)}$$

As stated, variable "y" follows a normal distribution, which means that $f(y)$ is a normally distributed density distribution with a mean of μ and standard deviation of σ.

$$f(y) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2\right] \qquad \text{(II)}$$

Replacing (II) in (I):

$$E\left(g(y)\right) = E\left(exp(y)\right) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} exp(y) \cdot exp\left[-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2\right] dy \quad \text{(III)}$$

We standardize the above and replace *"y"* with $(y-\mu)/\sigma$, obtaining the following:

$$E\left(exp(y)\right) = exp\left(\mu + 0,5\sigma^2\right) \cdot \left(\frac{1}{\sqrt{2\pi}}\right) \int_{-\infty}^{+\infty} exp\left[-\frac{1}{2}\left(y-\sigma\right)^2\right] dy = exp\left(\mu + 0,5\sigma^2\right) \cdot \beta \quad \text{(IV)}$$

Where the value of β is 1:

$$\beta = \left(\frac{1}{\sqrt{2\pi}}\right) \int_{-\infty}^{+\infty} exp\left[-\frac{1}{2}\left(y-\sigma\right)^2\right] dy \; = 1 \quad \text{(V)}$$

Through equations (IV) and (V) we have:

$$E(X) = E\left(exp(y)\right) = exp\left(\mu + 0,5\sigma^2\right) \quad \text{(VI)}$$

Thus, assuming that x is a stochastic variable, with μ and σ as constants and time as a function, equation (VI) is calculated as:

$$E\left(x(t)\right) = exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right) \quad \text{(VII)}$$

We then have:

$$E\left(H(t)\right) = H_0 \cdot exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right) \quad \forall t \geq 0 \quad \text{(VIII)}$$

$$E\left(H(t)\right) = \frac{H_0}{exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right)} \quad \forall t \leq 0 \quad \text{(IX)}$$

Annex A2

Life tables

Table A2.1
Life tables for 2009[a]
(Ages and percentages)

Age (t)	Men		Women		
				retiring at 60	retiring at 65
	Q_t	p_t	Q_t	p_t	p_t
60			0.31	1	
61			0.33	99.69	
62			0.37	99.36	
63			0.40	98.99	
64			0.44	98.60	
65	1.24	1	0.48	98.16	1
66	1.36	98.76	0.53	97.69	99.52
67	1.49	97.42	0.57	97.17	98.99
68	1.64	95.97	0.63	96.62	98.43
69	1.81	94.39	0.69	96.01	97.81
70	1.99	92.68	0.76	95.35	97.13
71	2.20	90.84	0.85	94.62	96.40
72	2.42	88.84	0.95	93.82	95.58
73	2.66	86.69	1.08	92.93	94.67
74	2.92	84.38	1.23	91.93	93.65
75	3.23	81.92	1.40	90.79	92.49
76	3.36	79.27	1.59	89.52	91.20
77	3.91	76.61	1.82	88.10	89.75
78	4.31	73.62	2.08	86.50	88.12
79	4.75	70.45	2.38	84.70	86.28
80	5.26	67.10	2.73	82.68	84.23
81	5.87	63.57	3.14	80.42	81.93
82	6.56	59.84	3.60	77.90	79.36
83	7.31	55.91	4.13	75.10	76.50
84	8.16	51.83	4.73	71.99	73.34
85	9.08	47.60	5.41	68.59	69.87
86	10.07	43.28	6.17	64.88	66.09
87	11.13	38.92	7.03	60.87	62.01
88	12.27	34.59	7.97	56.60	57.65
89	13.46	30.34	9.01	52.08	53.06
90	14.17	26.26	10.14	47.39	48.28
91	16.02	22.54	11.37	42.59	43.38
92	17.37	18.93	12.70	37.74	38.45
93	18.75	15.64	14.12	32.95	33.57
94	20.22	12.71	15.64	28.30	28.83
95	21.74	10.14	17.24	23.87	24.32
96	23.32	7.93	18.93	19.76	20.13

Table A2.1 (concluded)

Age (t)	Men		Women		
				retiring at 60	retiring at 65
	Q_t	p_t	Q_t	p_t	p_t
97	24.93	6.08	20.72	16.02	16.32
98	26.59	4.57	22.60	12.70	12.94
99	28.36	3.35	24.62	9.83	10.01
100	30.26	2.40	26.30	7.41	7.55
101	32.26	1.68	27.71	5.46	5.56
102	34.42	1.13	29.61	3.95	4.02
103	36.71	0.74	31.65	2.78	2.83
104	39.15	0.47	33.82	1.90	1.93
105	41.76	0.29	36.15	1.26	1.28
106	44.53	0.17	38.36	0.80	0.82
107	47.50	0.09	41.29	0.49	0.50
108	50.66	0.05	44.12	0.29	0.30
109	54.02	0.02	47.16	0.16	0.17
110	100.00	0.01	100.00	0.09	0.09

Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w 3-propertyvalue-4350.html.

[a] For the purposes of this table, as in the rest of the document, it is assumed that individuals take out a reverse mortgage at the time of their retirement.

Where:

Q_t = Probability that individual is not alive in year t+1,but alive in t.

p_t = Survival probability or probability that the individual is alive in year t, and was alive when the reverse mortgage was taken out.

For women, two values are presented for P_t. The first value is given for the current situation, with women retiring at 60. The second corresponds to the hypothetical scenario of women retiring at the same age as men, i.e. at 65 years.

Lastly, table A2.2 shows the probability of a representative individual being alive at a random age, represented in each row of the table, and the age at origination of a reverse mortgage, between 65 and 80 years, in the columns. The values in this table correspond to the geometric average of the survival probabilities by sex, weighted by the percentage of each gender in the sample.

Table A2.2

Survival probabilities, by age at which a representative individual takes out a reverse mortgage

(Ages and percentages)

	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
65	100															
66	99.2	100														
67	98.3	99.1	100													
68	97.4	98.2	99.1	100												
69	96.4	97.2	98.0	99.0	100											
70	95.3	96.1	96.9	97.8	98.9	100										
71	94.1	94.8	95.7	96.6	97.6	98.7	100									
72	92.8	93.5	94.3	95.2	96.2	97.4	98.6	100								
73	91.3	92.1	92.9	93.8	94.7	95.8	97.1	98.4	100							
74	89.8	90.5	91.3	92.1	93.1	94.2	95.4	96.7	98.3	100						
75	88.0	88.7	89.5	90.4	91.3	92.4	93.6	94.9	96.4	98.1	100					
76	86.1	86.8	87.6	88.4	89.4	90.4	91.5	92.9	94.3	96.0	97.9	100				
77	84.1	84.8	85.6	86.4	87.3	88.3	89.4	90.7	92.1	93.8	95.6	97.7	100			
78	81.9	82.5	83.3	84.1	85.0	85.9	87.0	88.3	89.7	91.2	93.0	95.1	97.3	100		
79	79.4	80.1	80.8	81.6	82.4	83.4	84.4	85.6	87.0	88.5	90.2	92.2	94.4	97.0	100	
80	76.8	77.4	78.1	78.8	79.7	80.6	81.6	82.8	84.1	85.6	87.2	89.1	91.3	93.8	96.7	100
81	73.9	74.5	75.1	75.9	76.7	77.5	78.5	79.7	80.9	82.3	83.9	85.8	87.8	90.2	93.0	96.2
82	70.7	71.3	71.9	72.6	73.4	74.2	75.2	76.3	77.5	78.8	80.4	82.1	84.1	86.4	89.1	92.1
83	67.3	67.9	68.5	69.1	69.9	70.7	71.6	72.6	73.7	75.0	76.5	78.2	80.0	82.2	84.8	87.7
84	63.7	64.2	64.8	65.4	66.1	66.8	67.7	68.7	69.7	71.0	72.3	73.9	75.7	77.8	80.2	82.9
85	59.8	60.3	60.8	61.4	62.0	62.7	63.5	64.4	65.5	66.6	67.9	69.4	71.0	73.0	75.2	77.9
86	55.7	56.1	56.6	57.1	57.7	58.4	59.1	60.0	60.9	62.0	63.2	64.6	66.1	68.0	70.0	72.5
87	51.3	51.7	52.2	52.7	53.2	53.9	54.6	55.3	56.2	57.2	58.3	59.6	61.0	62.7	64.6	66.8
88	46.9	47.2	47.6	48.1	48.6	49.2	49.8	50.5	51.3	52.2	53.2	54.4	55.7	57.2	59.0	61.0
89	42.3	42.6	43.0	43.4	43.9	44.4	45.0	45.6	46.3	47.1	48.1	49.1	50.3	51.7	53.2	55.1
90	37.7	38.0	38.4	38.7	39.1	39.6	40.1	40.7	41.3	42.0	42.8	43.8	44.8	46.1	47.5	49.1
91	33.3	33.5	33.8	34.2	34.5	34.9	35.4	35.9	36.4	37.1	37.8	38.6	39.5	40.6	41.9	43.3
92	28.9	29.1	29.3	29.6	29.9	30.3	30.7	31.1	31.6	32.2	32.8	33.5	34.3	35.2	36.3	37.6
93	24.6	24.8	25.1	25.3	25.6	25.9	26.2	26.6	27.0	27.5	28.0	28.6	29.3	30.1	31.0	32.1
94	20.7	20.9	21.0	21.2	21.5	21.7	22.0	22.3	22.7	23.1	23.5	24.0	24.6	25.3	26.0	27.0
95	17.1	17.2	17.4	17.5	17.7	17.9	18.1	18.4	18.7	19.0	19.4	19.8	20.3	20.8	21.5	22.2
96	13.8	13.9	14.0	14.2	14.3	14.5	14.7	14.9	15.1	15.4	15.7	16.0	16.4	16.9	17.4	18.0
97	11.0	11.0	11.1	11.2	11.4	11.5	11.6	11.8	12.0	12.2	12.4	12.7	13.0	13.4	13.8	14.3
98	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.5	9.6	9.9	10.1	10.4	10.7	11.1
99	6.4	6.5	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.2	7.3	7.5	7.6	7.9	8.1	8.4
100	4.8	4.8	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.4	5.5	5.6	5.8	6.0	6.2
101	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.3	4.5
102	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1
103	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1
104	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4
105	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
106	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
107	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
108	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
109	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w 3-propertyvalue-4350.html.

Annex A3

Descriptive statistics of the sample

Table A3.1
Descriptive statistics of the sample

Variable	Mean	Standard deviation	Minimum	Maximum
Sex (Men=1) *(percentages)*	40.92	45.76	0	1
Age	71.22	7.96	60	96
Head of household (head of household=1) *(percentages)*	65.09	47.68	0	1
Household income *(pesos at 2009 prices)*	103.75	136.58	0	2 000.00
Per capita income *(pesos at 2009 prices)*	34.72	49.53	0	450.00
Poverty rate *(percentages)*	86.25	34.44	0	1
Imputed house price *(millions of pesos at 2009 prices)*	20.40	4.11	2.50	50.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Annex A4

Reverse mortgage payments by age at origination

Table A4.1
Reverse mortgage payments by age at origination
(Chilean pesos)

House price at retirement	14.00 millions of pesos at 2009 prices	20.04 millions of pesos at 2009 prices
Age at origination	Monthly payments - case 1	Monthly payments - case 2
65	62 387	90 907
66	65 453	95 375
67	68 741	100 166
68	72 273	105 312
69	76 074	110 850
70	80 179	116 832
71	84 616	123 297
72	89 619	130 588
73	94 972	138 387
74	100 786	146 860
75	107 080	156 031
76	113 898	165 965
77	121 423	176 930
78	129 535	188 751
79	139 169	202 790
80	149 793	218 270

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

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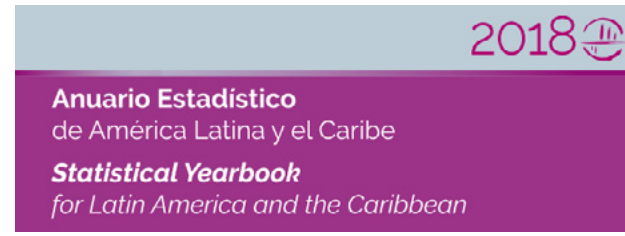

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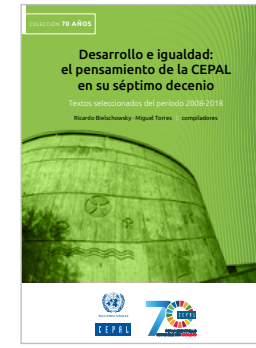

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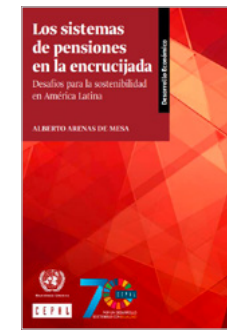

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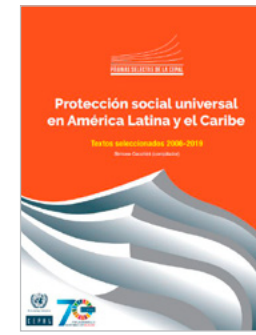

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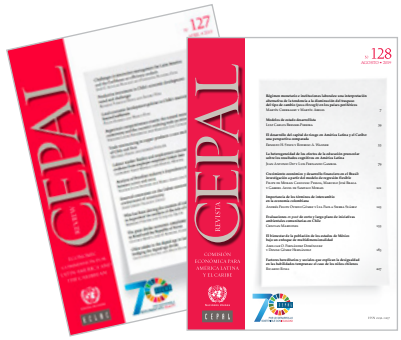

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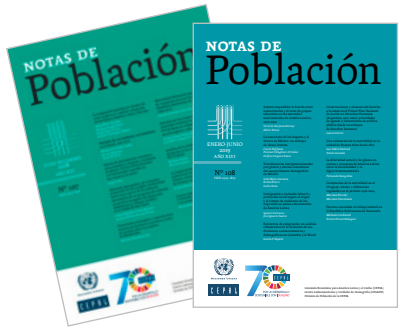

Observatorio Demográfico
Demographic Observatory

Documentos de Proyectos
Project Documents

Metodologías de la CEPAL
ECLAC Methodologies

Coediciones/*Co-editions*

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