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Explanatory notes

The following symbols are used in tables in the *Review*:

… Three dots indicate that data are not available or are not separately reported.

(–) A dash indicates that the amount is nil or negligible.

A blank space in a table means that the item in question is not applicable.

(-) A minus sign indicates a deficit or decrease, unless otherwise specified.

(.) A point is used to indicate decimals.

(/) A slash indicates a crop year or fiscal year; e.g., 2006/2007.

(-) Use of a hyphen between years (e.g., 2006-2007) indicates reference to the complete period considered, including the beginning and end years.

The word "tons" means metric tons and the word "dollars" means United States dollars, unless otherwise stated. References to annual rates of growth or variation signify compound annual rates. Individual figures and percentages in tables do not necessarily add up to the corresponding totals because of rounding.

Capital formation in Latin America: one and a half century of macroeconomic dynamics

Xavier Tafunell

ABSTRACT

Macroeconomic studies indicate that physical capital formation has played a pivotal role in long-term economic growth. These studies have been hampered, however, by a data constraint: in order to pinpoint exactly what the role of capital formation has been, a larger empirical database –larger in terms of both the time span and the geographical area covered– is needed. This study addresses that problem by providing new and very extensive series on capital formation in Latin America. It also describes the different series used to identify long, medium and short-term movements. One of the outstanding features of these investment trends were their marked instability up to 1950. Another salient aspect has been the more robust growth in investment seen in the second half of the nineteenth century, which actually outdistanced the growth spurt that occurred during the "golden age" of 1950-1980.

KEYWORDS

Economic growth, macroeconomics, capital, capital formation, capital movements, investments, measurement, statistics, Latin America

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I
Introduction

Economic historians and specialists in the macroeconomics of development are continually trying to identify the explanatory forces behind long-term growth. Ever since the time of the classical economists, the idea that physical capital formation is one of the determinants of growth has been in the air. Economists who have sought to analyse this question empirically have used one of two approaches: growth regressions or growth accounting. The vast number of studies that have taken the first of these approaches have looked at a wide range of variables, but one of the few variables that is almost never omitted is investment, either as a flow or a stock (Levine and Renelt, 1992). In a study that employed various permutations to combine the variables used in all the different models (Sala-i-Martín, 1997), the author concludes that investment in equipment is the variable that is the most closely correlated with gross domestic product (GDP). More recently, Qi (2007) –as had Temple and Voth (1998) before her– has found that the link between growth and long-term capital formation is stronger in developing economies. In fact, no macroeconomist who has studied this subject has questioned the existence of a close, statistically robust relationship between capital formation and GDP. The issue on which they are not in agreement is the underlying causality; in other words, the role that physical capital formation plays in driving growth (Bosworth and Collins, 2003). This debate cannot, in all likelihood, be resolved until a broader spatio-temporal database can be constructed – one that incorporates very long-term series on investment in developing countries such as the Latin American nations.

A review of the studies done using a growth accounting approach leads to the same conclusion even more clearly. Studies on industrialized economies show that total factor productivity has been the main driver of growth throughout the twentieth century (Kendrik, 1993). Nonetheless, in all regions of the world other than the geographical area covered by the Organisation for Economic Cooperation and Development (OECD), physical capital formation has played a central role in driving growth, even during the second half of the twentieth century (Bosworth and Collins, 2003). The experiences of countries in Africa (Abu-Qarn and Abu-Bader, 2007) and Asia, both in relation to the "tigers" of South-East Asia and the two Asian giants (China and India),[1] are informative. There are thus sound reasons for positing that physical capital formation has been one of the main sources of economic growth in Latin America during the past 150 years. The few growth-accounting studies on the subject for the second half of the twentieth century point in this direction. According to Elías (1992), physical capital formation was the most important determinant of growth in the region's major economies between 1940 and 1985. Hofman (2000), who used a much more sophisticated methodology, also found that capital was the most influential factor of production, although he calculated its contribution as being much smaller. In a study that, unlike any of its predecessors, took in all of the Latin American countries except Cuba for the period from 1960 to 2000, Loayza, Fajnzylber and Calderón (2005) found that capital and labour were more or less on a par in terms of their contribution to growth, whereas multifactor productivity did very little to spur growth.

The aim of this study is to provide the academic community with an extensive body of fresh empirical evidence on Latin American countries' investment flows so that scholars looking at long-term growth trends in these economies will have very long-term data series on this fundamental explanatory factor. As is well known, thanks to the series compiled and reworked by Maddison (2007), we still lack estimated GDP series for the vast majority of Latin American countries for the second half of the nineteenth century and even for the early twentieth century in some cases. As a result, the series on capital formation presented here do not shed

☐ Funding for this study has been provided by the Ministry of Science and Innovation of Spain (Project No. ECO2010-15882). Assistance was provided by Marc Badia, Cristián Ducoing and César Yáñez in locating and reproducing statistics. Sandra Kuntz was kind enough to provide a digital copy of statistics for Mexico which were otherwise unavailable. José Jofré, Frank Notten and Carolina Román helped to build the databases. The author is partially responsible for the data compiled and bears sole responsibility for the way in which they have been processed and for any errors that may be found in these series. The suggestions made by an anonymous *CEPAL Review* referee were also extremely useful.

[1] Regarding the South-East Asian economies, see Krugman (1994), Kim and Landau (1994), Young (1994 and 1995), Collins and Bosworth (1996) and Fukuda and Toya (1998). For China and India, see Bosworth and Collins (2008).

light on the links between capital formation and GDP, but rather on a much simpler and more basic question: the approximate trends in GDP in Latin American economies during the years when the capability of measuring them was not yet in place.

This article is structured very simply. Section II describes the method used to estimate gross fixed capital formation (GFCF) for the "pre-statistics era" (the years before official national accounts were kept). Section III covers the long-term trends in GFCF for 1856-2008. Section IV outlines medium- and short-term movements and then offers a brief concluding review. The study closes with a table showing the series that have been compiled for use by researchers in this field.

II

GFCF estimates for the Latin American countries, 1856-1950

GFCF estimates are usually calculated in the course of the preparation of national accounts, i.e., on the basis of GDP computations. The vast majority of Latin American countries began to keep official national accounts around 1950, and they did so by following the conceptual and methodological guidelines set out by the United Nations. The support provided by the United Nations' regional agency, the Economic Commission for Latin America and the Caribbean (ECLAC), proved to be a crucial factor in the success of this decentralized, collective effort. Thanks to the ongoing technical assistance and advisory services made available by ECLAC, together with its work in compiling and standardizing the data, the region now has a complete, comparable database on the main supply-side and demand-side components of GDP and on total GDP for all the countries of the region from 1950 onward.[2] A number of authors have used these statistics to analyse the way in which capital formation and capital stocks influenced the Latin American economies' growth during the second half of the twentieth century.

The picture is a very different one for the years before 1950. Apart from the individual historical series prepared for some economies of the region, the only fairly broad-coverage homogeneous reconstruction of GFCF series is the one developed by André Hofman (2000) for 1900 and 1994 for Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. The only precedent for an effort of this type was the preliminary evaluations undertaken by, once again, ECLAC in 1951. No study of this sort had been done on the other 14 Latin American countries, however, and, as a result, trends in capital formation for the region as a whole prior to 1950 are simply unknown.

The main objective of this study is simply to determine the annual levels of fixed capital formation in all the countries of the region during a period of time preceding the introduction of official national accounts. How long should this period be? Ideally, the data should go back as far as the early nineteenth century, when these countries were in the process of becoming independent. The early statistical evidence is of such poor quality, however, that the starting point for the series has to be moved up to midway through that century: 1856, to be exact (Tafunell, 2011). The ongoing civil strife and outright chaos experienced by many of these countries up to around that time (or even later) attests to just how difficult it would be to quantify investment levels on any consistent basis during the decades following these countries' political emancipation.[3] After calculating the GFCF up to 1950, the series were merged with the official series compiled by ECLAC.[4] This should by no means be interpreted as implying that the two series are of comparable quality. They have been merged simply in

[2] Historical series on aggregates prepared using a standardized methodology (United Nations System of National Accounts 1993 (SNA,1993)) are contained in the database that can be accessed online through ECLAC Cuadernos estadísticos No. 37 (http://www.eclac.cl/deype/cuaderno37/esp/index.htm). The data for Cuba are limited, and the full annual series therefore usually cover 19 Latin American countries and 13 Caribbean ones. The statistics for the Caribbean nations generally date back only as far as 1970, however. There are some gaps in the series on both Latin American nations and Caribbean countries in the case of the less developed economies. For a discussion of the gaps in capital formation series, see Tafunell (2011).

[3] The overview provided by Dye (2006) is helpful in gaining an understanding of the difficulties involved in establish a stable institutional order. For an opposing interepretation that is highly critical of the conventional wisdom on this subject, see Deas (2010).

[4] This study focuses solely on the series prepared by the author (i.e., the series for 1856-1950), since the series for years since 1950 are well-known and widely available (see footnote 2).

order to obtain a very long-term picture of GFCF trends. This is a legitimate exercise, in the author's view, so long as the results of the quantification are sufficiently reliable.

This statistical reconstruction provides a way of obtaining an overview of the investment activity of all the countries of Latin America, and it has proven to be an almost entirely successful approach. As shown in the tables presented here, measurements of GFCF have been obtained for 17 countries. The only ones that have been omitted are Guatemala, Panama and Paraguay.[5] Since these three small countries account for no more than a tiny fraction of the region's total GFCF, the series presented here for 17 Latin American countries can be viewed as being representative of Latin America as a whole.[6]

GFCF is an economic aggregate that encompasses capital goods of various sorts which are acquired because they serve as inputs for production process, because of the length of their useful life and, above all, because they help to boost productivity in the economy as a whole thanks to their embedded technologies. In calculating the amount of capital stock that they represent, they are usually divided into four categories: machinery and related equipment, transport equipment, residential construction and non-residential construction. Hofman (2000) used this classification for his study on this subject in six of the larger Latin American economies. Unfortunately, it has not been possible –and may never be possible– to apply his methodology to the other economies of the region, especially for the years preceding the twentieth century. The quantifications that I have prepared have yielded investment series for three categories of goods: machinery and related equipment; transport equipment; and construction. Any attempt to break down this last category into residential and non-residential construction is doomed to failure because the types of indicators or information that would be needed in order to differentiate between the two are simply not available.[7] Moreover, the built-in limitations of the official national accounts database maintained by ECLAC are such that the disaggregation of GFCF can be carried only so far. The annual series available in the ECLAC database include just two aggregates: machinery and other equipment, and construction. As a result, the definitive series presented in this article (see the table in the annex) refer only to these two fundamental categories of capital formation.

How have I gone about calculating the levels of these two types of investment? A detailed description of the sources and methods used is provided in Tafunell (2011). A much briefer outline will be provided here owing to space constraints. Official foreign trade statistics are the main –virtually only– source used for this quantification exercise, since the economies of the region presumably purchased their stock of capital goods from more industrialized economies. For the years from 1856 to 1929, trade statistics for Germany, the United States and the United Kingdom have been used; for the period from 1929 to 1950, the calculations are based on official trade statistics for the Latin American countries themselves. The procedure used to arrive at these estimates is based on the compilation of annual series, using indices for investment in equipment and in construction between 1856 and 1950. The series have been converted into dollars at 1950 prices using the level of investment for that year, in current dollars, as a unit of account (*numéraire*), as shown in the ECLAC database. The investment indices that I have ended up with are the result of the chain-linking of separate indices for 1856-1890, 1890-1929 and 1929-1950. The investment series for construction are composed of quantum indices based on imports or the apparent consumption of basic inputs (iron and steel for construction plus –from 1900 on– cement). I also ran a sensitivity test for 1925-1950, comparing the volume (tons) series and the value (constant prices) series for metal inputs in order to verify that using one or the other does not affect the outcome in statistical terms. The series for investment in machinery and other equipment is based on the value of imported goods at 1913 prices for 1856-1929 and at 1950 prices for 1929-1950.[8] For Argentina, Brazil and Mexico, I took domestically produced equipment into account and, for those countries plus Chile, Colombia and Cuba, I took

[5] Panama is not covered because the foreign trade statistics compiled by the more industrialized countries, which were the main source for the estimates up to 1929, attribute merchandise trade flows to that country that were actually directed towards other countries owing to Panama's unique position, thanks to the Panama Canal, as a transit country. The series for Guatemala and Paraguay could not be calculated for 1930-1950 because the data were exceedingly difficult to obtain and/or process.

[6] My calculations (based on official statistics published by ECLAC) indicate that the aggregate level of investment for these three countries in 1950 amounted to just 1.3% of the total for Latin America (20 countries).

[7] An arbitrary estimate of investment in residential construction might be derived from the growth patterns of the urban population. This would be a very tenuous approximation, however, since many countries did not carry out population censuses for many years, and very little is known about their urban population trends.

[8] For the years from 1856 to 1929, I first computed aggregate investment figures in pounds sterling, German marks and United States dollars at current prices and then converted them into a common currency (pounds). I then deflated the resulting aggregate series using a price index for which the base year of 1913 equals 100. For 1929-1950, I also computed series at current and constant prices, with the latter being derived through the application of implicit unit values for 1950 to the quantity data.

domestically produced iron for use in construction into account as well, since, unlike the situation in the other countries of Latin America, national producers were meeting an appreciable share of demand from the 1930s on.[9] One point that remains open for discussion, which could lead to a revision of the calculations, is whether or not investment in equipment in Chile, Cuba and Uruguay, and perhaps in some other countries such as Colombia and Peru, should also include domestic output, since it is quite likely that national producers had ceased to be of negligible importance by 1929 or even a few years before then.[10] The estimates for these countries may also have a slight downward bias because they do not incorporate the output of the railroad companies' machine shops.[11]

The main methodological caveat in terms of the estimates given here has to do with a different aspect, however: investment in construction. Since my measurements are based solely on the apparent consumption of "modern" inputs, such as iron, steel and cement, they are clearly not very representative of activity in housing construction until well into the twentieth century and are actually not sufficiently representative of non-residential construction in the second half of the nineteenth century either. Given the widespread use of traditional materials during those years (stone, wood and clay), my figures on investment in construction surely, at the very least, overstate its long-term growth.[12]

9 For a more detailed discussion, see Tafunell (2011).
10 In his recently submitted doctoral thesis, Ducoing (2012, pp. 69-70) states that, before the Great Depression, Chilean producers accounted for no more than 3% of that country's total available supply of equipment even in their best years. During the Second World War, when it became more and more difficult to import equipment, national producers' share of the market climbed to 16%, but shrank again to less than 7% during the first decade of the post-war period.
11 The studies conducted by Guajardo (1996 and 1998) provide an informative view of the role of railroad machine shops in Chile and Mexico. They indicate that, even in those countries, where it is thought that they became a force to be reckoned with, they actually accounted for no more than a small share of production.
12 This points up what is quite likely an insurmountable constraint, since statistics on the production of traditional construction materials are simply not available for this time period. It must be remembered that the large-scale use of iron and steel in infrastructure works came hand-in-hand with the laying of the railroads. For a discussion of the spread of the use of cement, see Tafunell (2007).

III

The long-term growth of GFCF

The first aspect of the results of this quantification exercise that is of interest is the long-term growth rate of aggregate investment and the way in which it has varied. GFCF in Latin America, according to my calculations, soared by a factor of 95 between 1856 and 1950, which equates to a cumulative annual growth rate of 5.0%. Interestingly enough, this growth rate exceeds, although not by a large margin, the rate registered for the years following 1950, since between 1950 and 2008 it rose at an annual rate of 4.4%. The progress made in terms of capitalization during the first stage of the globalization process (up to 1913) outpaced the advances achieved during the "golden age" of State-led industrialization and during the second stage of the globalization process in recent decades (see tables 1 and 2). This clearly has to do with the "Gerschenkron effect", since the growth potential for investment in the nineteenth century was extraordinary given the extremely low levels it had reached around 1850.

Focusing on the period of 1856-1950 (since much less is known about this period than the one that followed), tables 1 and 2 show the average annual growth rates for GFCF in absolute and per-capita terms for the periods associated with the different growth phases that can be identified according to the literature. These figures show that the years 1873 and 1890 marked the turning points at which sharp, sustained surges in investment triggered serious financial crises (Marichal, 1989). The years 1913 and 1929 are so well known to have been turning points in the business cycle that it is unnecessary to dwell on this point here. The graph of the aggregate investment series for Latin America (see figure 1) leaves little doubt as to the appropriateness of the time-based categories shown in the tables. Clearly, figure 1 depicts major short-term movements (movements encompassing a decade or less) which we will look at again later on (see the following section).

TABLE 1

Cumulative average annual GFCF growth rate
(Percentages)

Period	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Ecuador	El Salvador	Haiti	Honduras	Mexico	Nicaragua	Peru	Dominican Republic	Uruguay	Venezuela	Central America	Latin America
1856-1950	5.7	...	3.8	4.0	6.2	...	4.5[a]	5.6[b]	...	5.1[a]	...	6.9	...	5.2	5.7[a]	4.2[a]	6.8	...	2.6
1856-1913	8.3	...	5.2	5.8	6.0	...	...	...	...	...	...	7.6	...	4.8	...	...	5.1	7.0	4.1
1913-1950	1.8	0.5	1.8	1.3	6.4	2.5	1.3	4.7	4.1	2.7	4.8	5.8	3.0	5.8	3.3	0.9	9.4	...	2.7
1856-1873	9.9	...	4.5	7.6	12.9	...	...	...	...	...	...	8.1	...	12.9	...	...	9.4	6.9	7.1
1873-1890	16.9	...	4.6	9.8	-0.5	...	6.0	6.1	...	5.9	...	18.7	...	-3.6	14.0	8.4	7.1	13.2	8.7
1890-1913	1.2	26.7	6.0	1.5	6.0	7.2	7.7	-0.4	2.1	8.0	15.5	-0.3	-0.9	5.5	3.2	5.8	0.7	2.7	4.1
1913-1929	1.7	2.7	1.0	4.7	11.9	6.2	0.4	8.5	6.8	1.1	2.7	5.8	6.6	7.6	1.9	6.0	14.7	5.5	7.3
1929-1950	1.8	-1.2	2.4	-1.2	2.4	-0.3	2.0	2.0	2.0	4.0	6.4	5.8	0.3	4.4	4.4	-2.9	5.6	...	3.2
1950-1980	4.7	4.9	7.4	3.3	5.3	8.3	...	8.0	...	5.9	8.2	8.3	6.5	5.9	8.5	2.4	5.1	...	6.6
1980-2008	1.9	3.4	1.1	7.0	3.9	4.6	...	1.4	...	2.8	4.3	2.6	2.9	3.3	5.5	0.1	1.3	...	2.2

Source: Prepared by the author on the basis of the annex table and http://www.cepal.org/deype/cuaderno37/esp/index.htm.

[a] 1870-1950.
[b] 1865-1950.
GFCF: Gross fixed capital formation.

TABLE 2

Cumulative average annual rate of GFCF per capita
(Percentages)

Period	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Ecuador	El Salvador	Haiti	Honduras	Mexico	Nicaragua	Peru	Dominican Republic	Uruguay	Venezuela	Central America	Latin America
1856-1950	2.8	...	1.7	2.5	4.4	...	2.6[a]	4.0[b]	...	3.8[a]	...	5.5	...	3.8	2.7[a]	1.8[a]	5.4	...	3.2
1856-1913	4.9	...	3.2	4.3	4.6	...	...	...	...	...	...	6.5	...	3.5	...	...	3.8	5.6	4.8
1913-1950	-0.4	-0.6	-0.4	-0.3	4.2	0.2	-1.0	2.8	2.2	1.4	2.6	4.0	1.2	4.2	0.2	-0.8	7.8	...	0.7
1856-1873	7.1	...	2.9	6.0	11.5	...	...	...	...	...	...	7.1	...	11.6	...	...	8.1	5.6	5.9
1873-1890	13.3	...	2.7	8.3	-1.7	...	5.0	5.0	...	4.9	...	17.3	...	-4.3	11.2	4.7	5.5	11.6	9.1
1890-1913	-2.3	25.9	3.7	0.3	4.3	4.9	5.8	-1.7	1.0	6.7	12.4	-1.3	-2.7	3.8	0.4	3.3	-0.4	1.4	0.9
1913-1929	-0.9	1.2	-1.1	3.3	9.1	4.4	-2.2	7.6	4.6	-0.4	0.5	5.0	5.6	6.1	-1.1	3.7	13.8	3.9	1.6
1929-1950	-0.1	-1.9	0.0	-2.9	0.5	-3.0	-0.1	-0.7	0.5	2.7	4.3	3.2	-2.0	2.7	1.2	-4.1	3.5	...	0.1
1950-1980	3.0	2.6	4.5	1.3	2.4	5.1	...	5.0	...	3.9	5.0	5.1	3.2	3.1	5.3	1.5	1.3	...	3.6
1980-2008	0.6	1.1	-0.6	5.4	2.1	2.2	...	-0.6	...	0.9	1.7	1.0	0.9	1.5	3.6	-0.4	-0.9	...	0.4

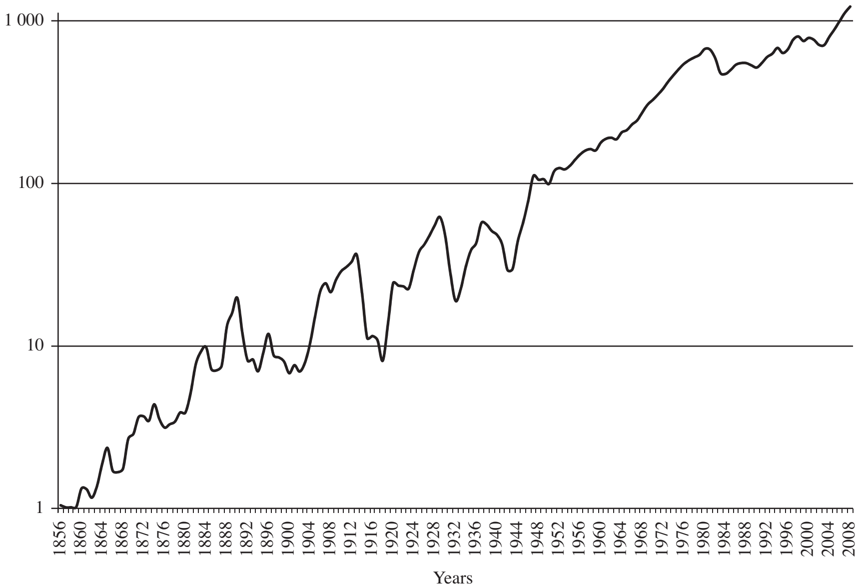
Source: prepared by the author on the basis of the annex table and http://www.cepal.org/deype/cuaderno37/esp/index.htm ; and, for population: C. Yánez and others, "La población de los países latinoamericanos desde el siglo XIX hasta 2008. Ensayo de historia cuantitativa", *Documento de trabajo*, No. 1202, Asociación Española de Historia Económica, 2012.

[a] 1870-1950.
[b] 1865-1950.
GFCF: gross fixed capital formation.

FIGURE 1

GFCF in Latin America, in constant dollars at 1950 prices

(Index: 1950=100)



Source: prepared by the authors on the basis of the annex table.

GFCF: gross fixed capital formation.

Focusing on the way in which the long-term capitalization process unfolded in Latin America as a whole, figure 1 and tables 1 and 2 shed light on two particularly interesting factors. One is that the peak in investment activity did not occur during the second half of the twentieth century, as is usually thought, but rather in the second half of the nineteenth century. This is especially evident when investment activity is measured in per-capita terms. The growth rate for GFCF from 1856 to 1890 was not equalled at any point in the twentieth century. The second outstanding feature of aggregate investment trends is the marked degree of volatility seen in the 100 years leading up to 1950. Figure 1 shows quite clearly how investment growth cycles and phases have smoothed out since then. In fact, this change in trend is so marked that it may be regarded as signalling the emergence of a different and less unstable investment pattern.[13]

Turning back to the first point: the data indicate that the slowdown in investment actually began before the outbreak of the First World War. The period between 1890 and 1913 was one of slow growth, as capital formation was depressed for the entire decade following the Baring crisis, which set foreign investors back for years. In the following period (1913-1929), a moderate upswing in growth was cut short by the Great Depression. The period 1929-1950 was the least robust stage in the 150 years covered by this analysis, along with 1980-2008; in fact, it was so sluggish that, in per capita terms, total output was completely flat (see table 2). This evidence strongly refutes the traditional historical narrative, in which investment was said to have jumped with the advent of the import-substitution industrialization model which followed the disruption caused by the Great Depression.[14] It would seem that the financial squeeze

[13] The fact that this change in investment trends coincides with the point in time when these estimates begin to be based on official figures would seem to be grounds for a strong suspicion that this changeover in data sources may be the reason why the series for the years before 1950 reflect a much greater degree of volatility than the post-1950 series do. I have been unable to find any corroborating evidence for that suspicion, however.

[14] The traditional view is taken up, from a critical perspective, in the essays of Luis Bértola and Jeffrey Williamson, Stephen Haber and Richard Salvucci that have been published in Bulmer-Thomas, Coatsworth and Cortés Conde (2006). The analysis authored by José A. Ocampo (2004) could be said to set out –for now– the canonical position on this issue, according to which the industrialization process gathered a huge amount of momentum in the 1930s and during the Second World War while not radically changing the development pattern of Latin America that had been in place up to the crisis of 1929.

occasioned by the interruption of external capital inflows and the decline in the purchasing power of exports played a more important part than government action did in galvanizing investment.

Another noteworthy and rather surprising feature of tables 1 and 2 are the differences between countries over a century of GFCF growth. The rates of capital accumulation do not correlate to relative levels of per capita income in 1950, according to data published by Maddison (2007). Mexico, the Dominican Republic (only in absolute terms) and Colombia exhibit the highest rates of capitalization between 1856 and 1950, yet their per capita GDP was below the average for Latin America in 1950. Also surprising is the fact that Ecuador and Haiti —two very laggard economies— built up capital at the same rate as the region overall.[15] Something similar may be supposed to have happened in Central America: although the evolution of investment has not been estimated for 1929-1950, in 1856-1929 it gained more ground than in Latin America overall. Conversely, some of the region's more developed economies, such as Chile, capitalized at below-average rates. The trajectories for other countries coincide with what might be expected in relation to their degree of economic development. It comes as no surprise, then, that investment in Argentina progressed further and investment in Brazil less than the regional average. Incidentally, investment patterns over the century provide the best illustration of the way the major investment opportunities offered by the first wave of globalization contrasted with the limited possibilities available once the international economy began to disintegrate.

What explanation can there be for the fact that national GFCF growth rates in 1856-1950 are so unrelated, in many cases, to relative per capita GDP around 1950? The unexpected figures in tables 1 and 2 seem to cast an ominous doubt on the consistency of the quantification, regardless that previous findings (Tafunell, 2007, 2009a and 2009b) confirm its reliability. The key to the paradox lies, basically, in the starting levels of investment. These were very uneven in the mid-nineteenth century, as we will see below. But first, a look is warranted at how the two basic categories of investment (equipment and construction) evolved. These series are represented in figure 2. Tables 3 and 4 contain the figures for the average annual rates of variation for both categories in the periods under review.

In figure 2 it leaps to the eye that capital formation in machinery and related equipment climbed more vigorously than investment in construction (and more, obviously, than overall investment). This makes sense, since long-term economic growth depends more on the endowment and quality of machinery than on the acquisition and renewal of other capital goods. In Latin America, during the century prior to 1950, the difference between the two annual growth rates was quite considerable: 6.3%, compared with 4.6.[16] Interestingly, the difference between the two rates was greatest in the period 1856-1913 (8.5% and 5.9%, respectively), then it narrowed sharply in 1913-1950 (3.1% and 2.6 %, respectively). What is more, between 1929 and 1950, the relative positions shifted: capital formation in equipment rose very little, whereas investment in construction rose in keeping with its moderate growth since 1890. Figure 2 shows very clearly that capital formation grew faster in equipment than in construction until 1890. Since then, the two series have followed a very similar long-term trajectory. All this backs up the idea mentioned earlier that the capitalization process in the second half of the nineteenth century was materially different to the process in the first half of the twentieth century.

This is, undoubtedly, the most important lesson to be drawn from the comparison between tables 3 and 4. The varied investment profiles of the growth phases between 1856 and 1950 are also interesting to examine. In the upsurge of 1856 to 1873, equipment stock was accumulated at an extraordinarily high —and never repeated— annual rate of 12.2%, almost double the rate for investment in construction. In the following phase (1873-1890) the frenetic pace of railway laying drove growth in construction investment ahead of still-dynamic investment in machinery. The financial crisis of 1890 dealt a harsh blow to the transport sector, with lasting effects, while the equipment endowment rose from then until 1929 at a respectable annual rate of almost 6%. From a general perspective, the data in table 4 are notably similar to those in table 1, owing to the heavy weight of construction investment in GFCF.[17]

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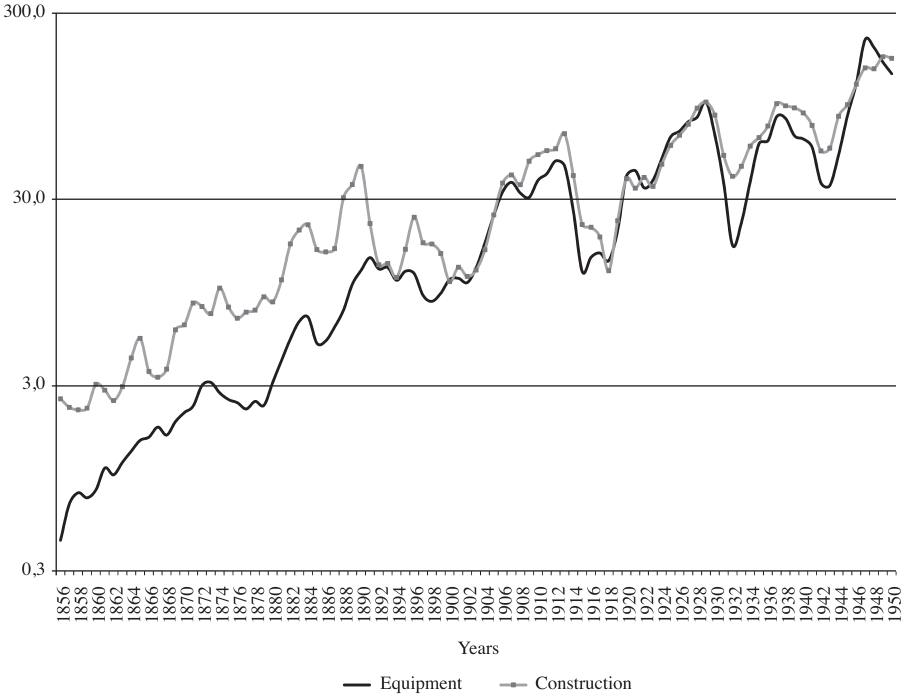
[15] In these two cases, the growth rates do not refer to the total period because information is lacking for the first few years. But it is unlikely that the results would vary significantly if we had those data.

[16] For example, in Spain the rates of increase over this century-long period were, respectively, 3.3% and 2.5%, with an aggregate investment growth rate of 2.6% per year, according to series prepared by Prados de la Escosura (2003).

[17] It will be recalled that the index numbers series for the two categories of GFCF have been transformed by applying the magnitude of GFCF in 1950, at that year's prices. At that date, investment in construction represented 63.8% of overall investment in Latin America (17 countries). It is worth adding that the differences between countries in this respect are not very significant, with a standard deviation of 8.8.

FIGURE 2

GFCF in Latin America, in constant dollars at 1950 prices
(Index: 1929=100)



Source: prepared by the author on the basis of the annex table.

GFCF: gross fixed capital formation.

TABLE 3

Cumulative average annual growth rate of gross investment in equipment
(Percentages)

Period	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Ecuador	El Salvador	Haiti	Honduras	Mexico	Nicaragua	Peru	Dominican Republic	Uruguay	Venezuela	Central America	Latin America (17 countries)
1856-1950	8.4	...	5.8	5.3	5.4	...	4.5[a]	7.3[b]	...	5.0[a]	...	7.8	...	6.6	4.7[a]	4.6[a]	7.7	...	6.3
1856-1913	11.7	...	8.9	7.9	5.9	...	...	...	...	...	...	9.1	...	6.7	...	...	6.0	7.7	8.5
1913-1950	3.4	-0.5	1.1	1.4	4.6	1.7	2.8	4.6	4.2	4.9	7.2	5.8	1.8	6.5	1.4	1.6	10.3	...	3.1
1856-1873	13.2	...	12.0	11.0	13.4	...	...	...	...	...	...	14.1	...	19.0	...	...	3.5	4.1	12.2
1873-1890	19.5	...	7.8	9.5	-1.1	...	6.2	22.3	...	9.1	...	11.1	...	-5.0	20.4	9.5	10.1	15.9	8.5
1890-1913	5.2	33.4	7.5	4.6	6.0	5.2	4.5	7.9	5.6	3.2	8.3	4.0	1.9	7.3	6.0	3.1	4.8	4.6	5.8
1913-1929	6.1	3.8	1.8	6.4	12.6	6.1	0.9	6.1	4.7	7.5	5.8	6.4	5.4	4.8	0.9	5.6	12.8	5.8	5.1
1929-1950	1.5	-3.6	0.6	-2.2	-1.1	-1.5	4.3	3.4	3.8	3.0	8.3	5.3	-0.9	7.7	7.8	-1.3	8.4	...	1.7

Source: prepared by the author on the basis of the annex table.

[a] 1870-1950.
[b] 1865-1950.

TABLE 4

Cumulative average annual growth rate of gross investment in construction
(Percentages)

Period	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Ecuador	El Salvador	Haiti	Honduras	Mexico	Nicaragua	Peru	Dominican Republic	Uruguay	Venezuela	Central America	Latin America (17 countries)
1856-1950	5.3	...	3.4	3.5	6.8	...	4.5[a]	5.1[b]	...	5.2[a]	...	6.4	...	4.7	6.4[a]	5.7	6.5	...	4.6
1856-1913	8.0	...	4.1	4.9	6.1	...	...	...	...	...	...	6.8	...	4.3	...	9.1	4.9	7.0	5.9
1913-1950	1.3	1.2	2.3	1.2	7.9	3.3	0.0	4.9	4.0	2.3	4.2	5.8	5.5	5.4	4.6	0.6	9.0	...	2.6
1856-1873	9.8	...	3.5	6.9	12.1	...	...	...	...	...	...	4.5	...	11.5	...	13.2	10.2	7.7	6.4
1873-1890	16.8	...	3.4	9.9	0.6	...	5.6	5.6	...	5.0	...	23.2	...	-3.1	12.5	7.8	6.8	12.5	11.3
1890-1913	0.8	23.6	5.0	0.0	6.0	12.9	11.3	-3.0	0.8	9.2	18.8	-2.2	-5.5	4.8	1.2	7.1	-0.2	2.5	1.8
1913-1929	5.1	34.3	0.8	2.2	7.5	11.3	16.8	0.6	-1.5	4.1	29.0	-2.9	-3.1	-2.6	1.4	6.1	-0.6	3.1	2.5
1929-1950	1.9	1.3	3.9	0.0	5.7	0.9	-0.1	0.9	1.1	4.3	5.9	6.3	2.0	2.9	6.0	-3.5	4.4	...	2.6

Source: prepared by the author on the basis of the annex table.

[a] 1870-1950.
[b] 1865-1950.

We now return to the questions that remained unanswered from the reading of tables 1 and 2. A working hypothesis may be formed on the basis of table 5. The first few rows of data speak of very uneven levels of investment per capita within the region around 1856. These levels were uneven later, too, in fact throughout the period under study. And it may be tempting to say that there have always been huge inequalities in this respect— as there are, indeed, in other economic aggregates. In colonial times, especially latterly, levels of production activity, and in all probability investment, are known to have differed greatly in the various territories, although these disparities were not necessarily exactly as shown in the first few rows of table 5. All the evidence available points to early development —around the middle third of the nineteenth century— in a few economies such as Cuba, Argentina, Chile and Uruguay (probably in that order), and to lag and stalled or very weak growth in that period in other economies such as Colombia, Ecuador, Bolivia, Mexico, Peru, Venezuela and the small Central American states, except for Costa Rica.[18]

What is really startling in table 5 are the gaping differences in the endowment of new capital per capita by the middle decades of the nineteenth century. Whereas Argentina and Chile were investing around US$ 9 (at 1950 prices) annually per capita, Mexico, the Central American nations, Peru and Colombia were investing US¢ 16, US¢ 45, US¢ 74 and US¢ 89, respectively. We now turn to the data for the 1870s, when economic globalization was beginning to inject vigour into the Latin American economies, and for which my data processing spans a larger and more representative group of nations. Taking the leading economy, Argentina, as a reference, we see that the investment effort in the next most prosperous economies (Chile and Uruguay) was around 50% and 75% of Argentina's, as shown in table 5,[19] and 25% of that figure for Latin America as

[18] Bértola and Ocampo (2010, p. 19) note that economic inequalities were very great in the period 1820-1870. They find that Argentina and Uruguay were the earliest developers, followed by Chile and Cuba.

[19] Cuba should also figure in this group, but the Ten Years' War (1868-1878) depressed investment in the country. With regard to Uruguay, the data in the table and the annex require some clarification. My estimate for investment in construction yields figures too high to be credible until, at least, the final years of the nineteenth century. Fortunately, there is another measurement with which to compare and substitute mine: one prepared by Bértola (1998). This author calculated the gross value added of the construction industry on the basis of data on building permits and public works spending. Comparison of his series and mine shows that the two have a broadly similar profile in terms of cyclical movements, but diverge significantly as to level before 1900. For want of a better explanation, I assume that my figures grossly overstate the level of investment in Uruguay because much of the material imported through the port of Montevideo was in fact destined for the Argentine market. This is mere conjecture, however, and needs to be verified. Meanwhile, I have adopted the series constructed by Bértola and linked it with mine in 1870 and 1936.

TABLE 5

GFCF per capita in dollars at constant 1950 prices
(Ten-year averages)

Period	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Ecuador [a]	El Salvador	Haiti	Honduras	Mexico	Nicaragua	Peru	Dominican Republic	Uruguay	Venezuela	Central America	Latin America (17 countries)
1856-1859	9.3	...	6.1	9.3	0.9	...	...	...	...	...	...	0.2	...	0.7	...	...	2.0	0.5	3.0
1860-1869	22.1	...	6.3	13.6	3.4	...	...	0.3	...	...	...	0.6	...	1.2	...	...	3.1	0.6	4.9
1870-1879	35.5	...	11.8	17.7	5.3	...	7.6	0.9	...	0.7	...	1.0	...	4.4	3.6	27.0	4.1	2.1	8.8
1880-1889	120.0	...	13.6	24.2	8.2	...	8.8	2.6	...	0.8	...	3.4	...	1.1	9.0	56.8	14.4	5.3	18.1
1890-1899	82.0	0.1	16.9	34.6	5.8	20.8	19.8	3.1	5.7	2.6	0.7	6.4	4.3	1.6	10.8	35.0	10.2	9.4	17.9
1900-1909	94.6	0.9	13.9	43.1	4.6	28.4	33.1	3.2	2.2	1.3	1.2	8.8	2.5	2.8	4.0	55.4	4.5	6.2	19.7
1910-1919	90.7	1.3	18.7	50.6	9.5	25.7	56.5	3.4	4.8	3.8	5.6	6.3	4.0	3.2	13.1	91.9	10.9	8.4	24.4
1920-1929	92.6	2.5	21.9	64.5	36.9	42.6	55.2	8.7	12.2	4.0	9.9	11.7	7.4	7.4	19.4	204.4	70.2	17.3	33.9
1930-1939	96.3	2.2	17.1	49.6	27.8	53.7	14.1	6.4	7.0	2.7	8.4	12.1	4.7	6.7	7.1	167.8	100.8	...	31.4
1940-1950	106.4	3.0	25.4	60.3	45.5	57.3	25.4	8.4	10.4	4.7	12.8	24.2	7.5	15.3	12.5	91.8	233.2	...	42.8

Source: X. Tafunell, "Un siglo de formación de capital en América Latina (1856-1950). Ensayo de cuantificación general", paper presented at the X International Congress of the Spanish Association of Economic History (Carmona, Spain, 7-9 September), 2011.

[a] The figure shown for 1860-1869 is the average for 1865-1869.
GFCF: gross fixed capital formation.

a group. The most laggard economies show investment efforts of less than 10% of the figure for Argentina: 8.1% for the Dominican Republic; 6% for the small Central American states; 2.9% for Mexico; 2.6% for Ecuador; and 1.8% for Haiti. Ahead of this group of severely undercapitalized economies was another group, with investment levels that were still very low, comprising Colombia (15.1% of Argentina's level), Peru (12.7%) and Venezuela (11.5%).

What emerges from table 5, then, is that the economies that were the region's richest at the end of the first globalization period (Argentina, Uruguay, Chile and Cuba) made headway in capital formation very early on. In the middle decades of the nineteenth century, if not before, these countries enjoyed an investment boom as a result of which their per capita investment levels were, fluctuations notwithstanding, several times those of poor economies by the starting point of the series (1856-1859). It follows, then, that great divergence must have occurred within the region in the first half of the nineteenth century. This being so, the more laggard economies, whose levels of capitalization per capita were tiny around 1850, would naturally tend to capitalize faster than the advanced economies whenever the opportunity arose, as is apparent in table 2. This, of course, produced a certain amount of convergence within the region, at least in terms of capital formation. In an earlier work (Tafunell, 2009a), I postulated this hypothesis for the period 1914-1930.[20] Now, the data processing over a much longer period seems to bear out that hypothesis for the century and a half since 1856. A more careful analysis of the series, beyond this rapid presentation of the qualitative reconstruction performed, would test this hypothesis and its validity for different historical subperiods.

[20] Bértola and Ocampo (2010, pp. 19-20 and 26) argue that there was a process of economic convergence in the region from 1910 to 1990.

IV

Fluctuations in GFCF: cycles and volatility

Figure 1 shows a markedly cyclical dynamic. Short-term movements (of no more than a decade) prevail over long-term growth trends of the aggregate. The cyclical fluctuations over the course of several historical intervals are large enough and sharp enough to eclipse underlying trends.

The cyclical peaks depicted in figure 1 are compiled in table 6, which shows the cumulative average annual growth rate recorded in each of these cycles —from high to high— and a simple measure of investment volatility, the standard deviation of the year-on-year variation rates.

TABLE 6

GFCF cycles in Latin America

Period	Average annual rate of growth (percentages)	Standard deviation of year-on-year variation rates
1856-1860	5.9	13.7
1860-1865	11.5	16.1
1865-1874	7.9	19.2
1874-1884	7.5	16.4
1884-1890	14.6	27.7
1890-1896	-9.1	29.5
1896-1907	6.6	22.9
1907-1913	6.7	9.8
1913-1920	-5.9	44.6
1920-1929	11.6	23.5
1929-1937	-1.1	28.4
1937-1947	6.9	25.4
1947-1949	-2.8	21.6
1949-1952	5.4	9.6
1952-1958	4.6	3.7
1958-1962	4.1	4.6
1962-1980	7.2	3.5
1980-1987	-2.8	9.0
1987-1994	3.1	4.5
1994-1998	4.1	7.0
1998-2000	-1.0	5.1
2000-2008	5.7	7.0
1856-1950	4.9	25.3
1950-2008	4.4	6.8
1856-2008	4.7	20.4

Source: prepared by the author on the basis of the annex table and http://www.cepal.org/deype/cuaderno37/esp/index.htm.

GFCF: gross fixed capital formation.

Leaving aside the well-known events since the Second World War, a first point which merits attention is that there were only three episodes of slippage: 1890-1896, 1913-1920 and 1929-1937.

In the first of these cycles the fall was very sharp: almost half (43.7%) measured from high to high. The data show, then, that the Baring crisis had a deeply depressive effect that set it apart from other crises, as several authors have argued (Mitchener and Weidenmier, 2008). The plunge caused by the First World War was not as deep, thanks to the powerful reactivation that ensued in 1919-1920. In the last of the three cycles (1929-1937) the contraction endured during the fateful years of the Great Depression weighed more heavily than the upturn generated by the kick-start of industrialization by import substitution. A final interesting point in this connection is that capitalization slumped more heavily in the two great depressions mentioned than in the "lost decade" of the 1980s.

Turning to cycles dominated by the upswing, the first observations is that these predominate overwhelmingly: high positive average annual rates of variation characterized 9 of the 12 cyclical movements identified. The cycles with the largest overall increases measured from peak to peak were 1884-1890, 1860-1865 and 1920-1929. The first stands out significantly from the others. The other two were similar, but given that the last doubled the first in length, it may be said that the two largest cyclical investment drives in pre-1950 Latin America occurred in the 1880s and the 1920s. This is consistent with the fact that the contractions that ended these booms were the severest in the century between 1856 and 1950, except for the downturn during the First World War. Obviously, the latter was exceptional inasmuch as its cause was wholly exogenous, unlike other investment crises. What is more, all the cycles —except those indicated— were characterized by a relatively high and stable rate of investment growth: between 6% and 8% per year. This was, according to the data, the cruising speed at which Latin America managed to capitalize until the Second World War. The region departed from this investment pattern —with either positive or negative variations— only during a few periods of turbulence in extraordinary circumstances. Since the Second World War, the stationary rate of investment has been lower, from 4% to 5% per year. The most obvious deviation from this cyclical pattern occurred towards the end of the "golden age" (1962-1980), during which Latin America exhibited the most sustained, though not the most intensive, investment effort in its history.

For reasons of space, it is outside the scope of this work to analyse the nature of the movements in the series in greater depth. Yet there is one highly idiosyncratic component of the macromagnitude examined which should not be overlooked: its great variability. The data in table 6 show clearly that investment has fluctuated strongly. The measure of volatility far exceeded the annual growth rate in all the cycles. The only two exceptions to this pattern occurred at the time of the largest boom, during the shield of State intervention (from 1952 to 1958 and from 1962 to 1980). But the prime focus of attention must be the fact that in the century prior to 1950, standard deviation was five times the rate of annual variation, which speaks of an extremely volatile variable. By contrast, since 1950 the investment cycle has become much less extreme (standard deviation is only 50% more than the growth rate). The most severe cycle by far was during the First World War, when there was an extreme swing between the most violent contractionary and expansionary phases in the last century and a half. The cycles of 1884-1890, 1890-1896 and 1929-1937 were also turbulent, with large expansions and reactivations before and after major slumps. Conversely, the expansionary cycle at the end of the *belle époque* (1907-1913) was characterized by a very stable rate of growth. No doubt the mythical aura surrounding this period has much to do with that regularity. Interestingly, the same cannot be said of the other period often thought to be the most prosperous before the "golden age": the 1920s.

V
Concluding remarks

Empirical studies on the theory of economic growth are limited by a lack of statistical data on the basic macromagnitudes of developing economies in the period before 1950. In the case of the Latin American countries, data on capital formation were particularly lacking. This work has to a great extent covered that deficit by providing a quantification of GFCF and its two main components —investment in equipment and in construction— for all the countries of the region, except Guatemala, Panama and Paraguay. The annual and continuous series provided span the period from 1856 to 1950. Linking these series with those generated by the official national accounts systematized and standardized by ECLAC provides a reliable quantification of GFCF in the Latin American economies from 1856 to the present.

Several important facts emerge from the examination of very long-term GFCF patterns. First, the greatest investment growth occurred in the second half of the nineteenth century, during the first wave of globalization; more specifically, between 1856 (possibly earlier) and 1890. Second, it was over this period, not later, that equipment endowment grew faster than endowments of other capital goods, which means that the region's economies boosted their long-term growth potential more in the nineteenth century than they did later, or at least during the first half of the twentieth century. Third, GFCF was highly volatile during the century leading up to 1950, becoming much less so thereafter. The explanation for the contrast probably lies in the key impact of primary goods exports and foreign capital on GFCF before the Second World War. Insofar as investment instability is bad for economic growth, the possibilities for Latin American economies have brightened since the Second World War. Fourth and last, the data show that the most laggard economies have tended to make a greater investment effort per capita than more advanced economies. This has produced only very partial convergence, however: the disparities in per capita investment levels, which were extreme in the mid-nineteenth century, have remained very sharp.

ANNEX

Table A-1
Gross fixed capital formation (GFCF) at constant prices
(Index: 1929=100)

Year	Argentina			Bolivia (Plurinational State of)			Brazil			Chile			Colombia			Costa Rica			Cuba			Ecuador		
	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF
1856	0.1	1.1	0.8				0.6	10.0	4.9	0.5	4.1	2.0	0.6	0.6	0.6									
1857	0.1	1.0	0.7				1.3	8.3	4.5	0.7	4.7	2.4	0.2	0.6	0.3									
1858	0.0	0.7	0.5				1.5	8.0	4.5	0.9	6.8	3.4	0.4	0.5	0.4									
1859	0.1	1.0	0.7				1.5	7.8	4.4	0.6	6.1	2.9	0.6	0.4	0.5									
1860	0.1	1.0	0.7				1.7	12.2	6.5	0.7	7.8	3.7	0.4	0.5	0.5									
1861	0.1	0.9	0.7				1.7	10.3	5.6	1.0	9.4	4.5	1.7	0.6	1.3									
1862	0.1	1.0	0.8				2.1	8.9	5.2	0.3	6.3	2.8	1.2	0.9	1.1									
1863	0.2	2.7	2.0				1.9	7.3	4.4	0.9	5.2	2.7	1.6	1.8	1.7									
1864	0.2	3.8	2.7				1.1	10.4	5.4	1.9	5.9	3.6	2.1	2.8	2.4									
1865	0.5	5.1	3.7				1.9	8.8	5.0	1.3	11.2	5.4	1.5	1.6	1.5							0.9	1.8	1.5
1866	0.4	3.7	2.7				1.7	6.7	4.0	1.4	5.4	3.0	2.8	2.3	2.6							1.1	0.6	0.7
1867	0.3	2.0	1.5				1.5	8.7	4.8	2.7	8.0	4.9	3.6	3.0	3.4							0.3	1.7	1.2
1868	0.3	2.5	1.8				2.0	9.1	5.2	2.6	8.8	5.2	2.4	3.2	2.7							0.0	1.6	1.0
1869	0.4	5.1	3.7				2.6	11.1	6.5	2.6	15.9	8.2	2.5	2.2	2.4							1.1	1.9	1.6
1870	0.6	5.2	3.8				3.0	10.4	6.4	2.0	20.9	9.9	2.8	3.6	3.0				7.2	2.8	4.5	0.7	1.8	1.5
1871	0.3	7.5	5.4				2.9	20.1	10.7	1.8	14.4	7.1	3.9	2.6	3.4				9.8	1.5	4.6	6.1	4.1	4.8
1872	0.7	5.2	3.8				3.2	20.6	11.2	2.2	12.6	6.5	5.4	5.7	5.5				12.6	2.3	6.2	2.6	4.1	3.5
1873	0.6	5.5	4.1				3.9	18.0	10.4	2.8	12.6	6.9	4.7	4.5	4.7				11.4	3.2	6.3	0.2	16.8	11.0
1874	0.9	10.6	7.7				3.9	19.1	10.9	2.5	21.5	10.4	3.6	2.2	3.1				8.1	3.8	5.4	1.0	5.6	4.0
1875	0.6	7.7	5.6				4.0	15.9	9.4	2.5	18.1	9.0	2.7	1.4	2.2				7.6	3.3	4.9	0.2	1.8	1.2
1876	0.3	4.3	3.1				3.7	19.5	10.9	2.3	9.1	5.2	3.0	1.1	2.3				7.4	2.9	4.6	2.0	3.4	2.9
1877	0.2	2.8	2.0				3.1	30.8	15.8	1.1	6.5	3.3	3.6	1.3	2.8				8.6	12.2	10.8	7.8	2.6	4.4
1878	0.4	3.1	2.3				3.7	28.3	15.0	0.9	8.3	4.0	3.8	2.1	3.2				10.4	18.8	15.6	2.0	2.2	2.1
1879	0.4	4.9	3.6				3.5	32.7	16.8	0.8	6.4	3.1	3.8	4.8	4.2				10.4	10.9	10.7	1.1	3.0	2.3
1880	0.4	5.2	3.8				5.3	22.7	13.2	0.8	12.0	5.5	4.6	3.7	4.3				9.0	4.6	6.2	3.2	6.7	5.4
1881	0.8	7.3	5.4				6.0	31.4	17.6	1.5	12.7	6.2	4.7	2.6	3.9				11.2	4.3	6.9	4.6	8.4	7.1
1882	1.6	19.1	13.9				7.1	35.1	19.9	2.2	18.4	8.9	6.8	5.7	6.4				17.2	4.1	9.0	3.8	8.9	7.1
1883	2.6	29.1	21.3				8.9	30.2	18.6	3.7	19.7	10.4	8.7	8.4	8.6				21.0	6.7	12.1	1.7	2.5	2.2
1884	4.9	32.8	24.6				9.4	29.3	18.5	4.5	25.5	13.2	6.6	14.2	9.4				14.5	7.0	9.8	3.7	10.7	8.2
1885	3.9	21.8	16.5				7.8	21.2	13.9	1.8	16.3	7.9	4.7	9.6	6.5				10.7	5.8	7.6	4.8	4.5	4.6
1886	3.5	19.8	15.0				8.0	20.8	13.9	1.9	19.0	9.0	5.8	5.2	5.6				14.4	6.1	9.2	10.1	12.4	11.6
1887	4.7	22.1	17.0				8.3	16.3	11.9	2.8	23.0	11.2	5.2	7.9	6.2				13.3	5.4	8.4	14.9	24.0	20.8
1888	8.1	54.6	40.9				9.6	22.0	15.3	3.6	24.9	12.5	4.2	4.7	4.4				16.9	6.0	10.1	13.7	50.0	37.2
1889	11.4	60.4	46.0				10.1	28.5	18.5	10.5	36.6	21.4	3.9	7.2	5.1				25.8	8.3	14.9	8.6	24.8	19.1
1890	12.0	76.9	57.8	0.1	0.6	0.3	14.2	31.7	22.2	13.3	63.2	34.1	3.9	5.0	4.3	11.9	2.3	7.7	31.5	8.2	17.0	6.7	42.6	30.0
1891	5.3	25.8	19.8	0.4	0.3	0.4	32.1	37.6	34.6	7.4	31.8	17.6	4.0	5.6	4.6	13.2	4.6	9.4	40.3	7.3	19.7	9.1	20.4	16.4
1892	3.8	8.2	6.9	2.2	0.6	1.6	24.7	25.7	25.2	11.9	32.7	20.6	3.8	4.4	4.0	11.8	7.0	9.7	49.2	27.2	35.4	7.5	10.4	9.4
1893	6.1	10.1	8.9	0.4	1.2	0.7	25.9	22.9	24.5	9.4	24.3	15.6	4.0	6.5	4.9	8.5	9.1	8.7	42.8	48.6	46.4	8.7	9.7	9.3
1894	5.2	8.8	7.7	0.9	1.2	1.0	19.3	16.5	18.0	10.2	36.3	21.1	3.2	4.9	3.8	8.2	16.5	11.9	33.7	30.3	31.6	10.2	10.4	10.4
1895	4.5	13.4	10.8	0.3	0.5	0.4	24.8	37.4	30.6	10.9	35.6	21.2	3.4	4.9	4.0	10.4	6.4	8.6	17.9	6.1	10.5	7.9	17.9	14.4
1896	4.4	30.2	22.6	0.4	0.5	0.4	24.8	43.0	33.1	7.9	25.0	15.0	4.8	6.6	5.4	12.4	16.8	14.3	6.4	5.1	5.6	10.5	27.4	21.4
1897	4.3	19.6	15.1	1.2	0.3	0.8	16.7	28.0	21.9	4.7	8.3	6.2	5.4	9.0	6.7	11.6	23.5	16.9	3.8	7.4	6.0	11.8	17.8	15.7

Year	Argentina			Bolivia (Plurinational State of)			Brazil			Chile			Colombia			Costa Rica			Cuba			Ecuador		
1898	6.3	20.5	16.3	1.0	0.1	0.7	12.0	27.1	18.9	4.4	8.6	6.2	4.7	9.3	6.4	13.3	14.2	13.7	5.9	22.4	16.2	15.1	15.5	15.3
1899	7.1	12.9	11.2	24.3	0.7	15.4	11.2	21.1	15.7	6.9	18.4	11.7	2.6	5.4	3.6	14.2	26.6	19.7	15.8	48.6	36.3	16.3	17.7	17.2
1900	7.8	13.6	11.9	10.4	0.3	6.6	14.0	13.9	13.9	9.8	10.8	10.2	1.5	0.9	1.3	17.7	11.6	15.0	22.2	22.1	22.1	24.2	13.4	17.2
1901	8.9	18.1	15.4	32.0	0.6	20.2	8.6	10.3	9.4	16.6	15.4	16.1	2.8	1.9	2.5	15.9	14.7	15.4	34.3	31.6	32.6	30.5	21.4	24.6
1902	8.1	13.0	11.5	38.0	0.3	23.9	11.0	14.1	12.4	8.9	11.4	9.9	4.0	1.2	3.0	16.6	17.7	17.1	24.5	30.8	28.4	17.9	4.6	9.3
1903	11.0	15.7	14.3	12.7	0.3	8.1	12.5	13.7	13.0	10.8	12.3	11.5	6.7	1.3	4.7	22.6	9.5	16.8	26.2	24.6	25.2	17.7	5.3	9.7
1904	19.0	22.1	21.2	13.3	2.8	9.4	16.4	18.0	17.1	19.3	16.8	18.3	5.4	2.2	4.3	21.1	12.6	17.4	42.0	31.4	35.4	23.1	12.9	16.4
1905	28.4	34.7	32.9	19.6	2.2	13.1	23.0	26.6	24.7	28.7	27.2	28.0	5.5	3.1	4.7	20.9	13.9	17.8	77.3	53.6	62.5	31.2	26.3	28.0
1906	40.8	53.8	50.0	13.1	8.9	11.5	30.5	44.2	36.8	43.4	32.2	38.7	4.6	4.4	4.5	30.6	22.9	27.2	70.4	57.3	62.2	28.8	21.5	24.1
1907	38.4	59.7	53.4	29.1	11.6	22.5	41.2	45.7	43.3	47.3	44.4	46.1	6.6	4.1	5.7	36.2	19.7	28.9	62.3	63.4	63.0	26.6	13.3	18.0
1908	32.1	50.6	45.2	23.8	15.1	20.5	41.3	47.4	44.1	42.2	29.1	36.7	7.4	4.5	6.3	31.2	20.2	26.3	45.2	62.5	56.0	25.5	15.7	19.2
1909	38.6	73.8	63.4	19.0	11.6	16.2	42.8	53.2	47.6	18.7	42.6	28.6	7.4	8.2	7.7	27.1	31.2	28.9	50.8	64.2	59.2	27.9	23.1	24.8
1910	46.1	76.0	67.2	18.4	19.8	18.9	52.9	60.5	56.4	21.3	45.3	31.3	9.5	8.7	9.2	28.1	34.1	30.8	77.2	75.0	75.8	27.6	20.4	23.0
1911	39.0	77.5	66.2	22.7	26.5	24.1	61.8	63.6	62.6	33.5	60.7	44.9	11.1	10.3	10.8	35.2	41.6	38.0	85.8	84.8	85.2	33.9	20.2	25.0
1912	40.1	69.7	61.0	32.2	23.7	29.0	84.4	86.8	85.5	38.2	68.1	50.7	11.9	13.1	12.4	36.8	36.0	36.5	84.9	90.6	88.4	33.5	22.9	26.6
1913	38.8	91.7	76.1	54.9	83.1	65.4	74.8	98.2	85.5	37.2	63.8	48.2	15.0	19.0	16.4	38.6	37.0	37.9	86.9	96.8	93.1	39.0	20.9	27.3
1914	24.4	57.4	47.7	26.7	33.0	29.0	33.9	42.7	37.9	25.1	44.7	33.2	13.9	17.7	15.3	25.7	25.4	25.5	68.5	87.6	80.4	35.5	22.4	27.0
1915	11.5	27.2	22.6	10.1	12.4	11.0	11.1	21.1	15.7	6.8	23.0	13.6	9.4	11.3	10.1	15.2	12.8	14.1	90.6	92.6	91.9	21.6	24.9	23.7
1916	8.7	19.6	16.4	10.8	8.4	9.9	13.5	19.6	16.3	12.6	33.3	21.2	7.6	13.6	9.8	13.3	11.9	12.7	145.7	128.9	135.2	18.6	20.3	19.7
1917	7.1	13.8	11.8	14.4	11.5	13.3	14.2	13.5	13.9	14.4	37.7	24.1	7.7	12.8	9.6	7.9	8.2	8.0	155.3	129.3	139.1	22.9	13.6	16.9
1918	6.8	6.4	6.5	21.9	16.6	19.9	11.1	7.8	9.6	19.4	30.5	24.1	5.6	6.2	5.8	6.5	1.0	4.0	117.9	85.9	97.9	18.5	12.6	14.7
1919	11.8	16.9	15.4	25.9	15.2	21.9	23.5	30.0	26.5	17.0	30.7	22.7	8.5	15.3	10.9	9.0	6.1	7.7	139.8	111.9	122.4	33.3	16.2	22.2
1920	23.5	32.6	30.0	26.8	27.2	27.0	44.3	46.1	45.1	19.9	30.2	24.2	27.0	30.6	28.3	26.4	14.4	21.1	335.3	185.0	241.5	48.2	26.0	33.8
1921	31.3	33.4	32.8	48.9	20.1	38.1	40.6	31.5	36.4	26.7	33.1	29.4	29.4	22.8	27.0	37.8	10.5	25.7	230.6	92.7	144.5	41.1	25.2	30.8
1922	35.1	41.9	39.9	32.1	17.9	26.8	38.1	48.1	42.7	33.5	30.6	32.3	21.5	27.3	23.6	21.5	16.2	19.1	72.2	83.0	79.0	59.4	31.3	41.2
1923	34.9	27.8	29.9	49.4	29.0	41.8	34.9	30.2	32.8	36.1	31.5	34.2	31.1	30.2	30.8	30.4	20.0	25.8	138.9	125.3	130.4	61.9	52.3	55.7
1924	41.2	40.8	40.9	54.0	38.8	48.3	54.9	43.3	49.6	38.1	41.2	39.4	36.5	38.3	37.1	46.2	28.5	38.4	185.1	132.8	152.5	72.1	65.7	68.0
1925	52.4	61.0	58.5	63.2	67.9	64.9	79.5	59.1	70.2	44.4	41.9	43.4	54.3	45.4	51.1	49.9	30.4	41.3	189.2	91.8	128.4	61.9	75.6	70.7
1926	53.7	63.6	60.7	62.7	61.5	62.3	68.8	73.6	71.0	66.1	46.4	57.9	85.9	63.7	77.9	43.4	32.9	38.8	123.2	77.1	94.4	57.6	54.8	55.8
1927	65.7	76.4	73.3	64.1	79.5	69.9	83.5	80.4	82.1	47.9	55.1	50.9	111.6	64.3	94.5	54.9	54.2	54.6	143.6	87.8	108.8	72.1	100.7	90.7
1928	87.9	94.8	92.8	74.8	98.0	83.5	89.1	90.1	89.5	42.8	64.6	51.9	112.3	106.3	110.2	73.9	74.2	74.1	93.1	89.6	90.9	91.4	97.1	95.1
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1930	88.0	93.6	91.9	71.9	70.1	71.3	37.8	61.5	48.6	80.7	112.6	94.0	41.4	55.2	46.4	38.8	50.2	43.8	67.7	61.0	63.5	67.3	83.0	77.5
1931	53.9	59.5	57.9	30.4	33.6	31.6	20.8	30.6	25.3	38.7	39.6	39.1	17.9	30.9	22.6	25.4	52.9	37.5	38.7	17.0	25.2	32.7	60.5	50.7
1932	22.6	41.6	36.0	25.6	30.4	27.4	12.8	36.4	23.6	4.8	17.2	10.0	11.6	33.8	19.6	10.8	35.6	21.7	24.3	10.7	15.8	17.6	29.4	25.2
1933	26.2	44.8	39.4	31.7	27.2	30.0	22.1	51.1	35.3	4.2	24.2	12.6	16.0	53.1	29.4	33.0	45.1	38.3	21.2	11.0	14.9	26.8	36.9	33.3
1934	47.1	58.0	54.8	39.1	36.4	38.1	39.7	68.9	53.0	12.0	36.2	22.1	21.0	75.1	40.5	24.4	69.8	44.4	50.6	14.7	28.2	38.3	36.8	37.3
1935	65.0	65.2	65.1	35.2	44.6	38.7	88.4	74.8	82.2	29.4	62.6	43.2	25.9	75.6	43.9	26.9	78.1	49.6	72.2	23.6	41.9	62.7	51.5	55.4
1936	83.9	73.9	76.8	47.5	82.1	60.5	63.5	84.9	73.2	33.3	56.6	43.0	25.3	114.4	57.5	40.4	133.4	81.5	89.4	34.7	55.2	83.5	48.7	61.0
1937	117.6	105.2	108.8	65.3	128.0	88.8	82.0	105.2	92.6	31.5	66.0	45.8	35.6	142.8	74.4	54.1	94.6	72.0	114.7	39.1	67.5	90.0	66.7	74.9
1938	128.1	94.9	104.7	75.9	119.2	92.1	74.1	93.6	83.0	39.3	72.4	53.1	34.4	193.0	91.7	104.5	92.9	99.4	79.2	32.1	49.8	75.2	68.4	70.8
1939	82.3	87.3	85.9	68.9	105.7	82.7	55.1	103.6	77.2	31.3	64.2	45.0	38.9	170.0	86.3	187.2	185.0	186.2	69.7	36.9	49.2	77.2	58.0	64.8
1940	73.2	79.1	77.4	72.4	97.3	81.7	58.7	106.2	80.4	36.6	74.1	52.2	30.6	151.1	74.2	148.7	158.6	153.1	57.4	38.5	45.6	75.0	69.9	71.7
1941	58.9	62.7	61.6	65.1	113.4	83.2	50.8	103.9	75.1	35.4	66.3	48.3	27.5	135.3	66.5	85.8	134.1	107.2	72.4	40.5	52.5	69.3	48.7	56.0
1942	53.4	47.2	49.0	61.4	109.7	79.5	25.7	93.5	56.7	22.4	61.3	38.6	10.7	60.4	28.7	27.0	53.1	38.5	45.0	20.6	29.8	74.3	49.3	58.1
1943	48.6	38.9	41.7	71.6	112.3	86.8	29.3	97.8	60.6	17.3	64.1	36.8	10.7	109.5	46.4	52.7	55.9	54.1	48.6	29.7	36.8	45.6	43.7	44.4
1944	49.3	52.7	51.7	59.8	112.4	79.5	35.6	126.2	77.0	24.1	69.7	43.1	16.2	211.2	86.7	45.6	48.9	47.1	67.1	42.9	52.0	68.5	72.2	70.9
1945	53.4	55.7	55.0	47.3	102.1	67.8	79.7	132.1	103.6	25.0	81.1	48.4	42.5	211.6	103.7	65.5	88.3	75.6	92.3	62.2	73.6	86.6	66.5	73.6
1946	108.3	85.0	91.8	65.3	102.5	79.2	127.2	167.8	145.7	46.6	96.9	67.6	45.8	275.2	128.8	96.2	129.2	110.8	147.8	71.7	100.3	166.6	82.4	112.1
1947	295.2	112.4	166.2	69.6	107.4	83.8	175.3	179.4	177.2	73.7	101.8	85.4	100.0	341.2	187.2	137.4	147.8	142.0	288.3	91.3	165.4	181.6	94.4	125.1
1948	303.1	123.0	176.0	84.3	111.9	94.6	106.7	163.2	132.5	61.9	95.0	75.7	80.1	232.5	135.2	74.3	76.3	75.2	262.6	81.3	149.5	192.7	96.6	130.5
1949	168.2	140.0	148.3	89.0	182.6	124.0	113.5	199.7	152.8	88.1	106.0	95.5	64.2	289.2	145.5	69.7	91.5	79.3	216.9	97.6	142.5	215.1	123.6	155.8
1950	138.1	148.9	145.7	46.3	130.6	77.9	112.8	223.9	163.5	62.4	99.0	77.7	79.5	318.2	165.8	72.4	121.1	93.9	244.0	96.9	152.2	203.2	121.9	150.5

TABLE A-1 (CONTINUED)

Gross fixed capital formation (GFCF) at constant prices
(Index: 1929=100)

Year	El Salvador			Haiti			Honduras			Mexico			Nicaragua			Peru			Dominican Republic			Uruguay		
	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF
1856										0.3	1.0	0.6				1.1	2.5	2.2					0.3	
1857										0.6	1.0	0.8				1.5	5.3	4.5					0.2	
1858										0.3	0.5	0.4				3.0	2.2	2.4					0.2	
1859										0.1	0.2	0.2				3.9	2.0	2.4					0.4	
1860										0.2	0.7	0.4				2.6	1.8	2.0					0.3	
1861										0.2	0.6	0.4				3.5	1.5	2.0					0.3	
1862										0.4	0.6	0.5				3.5	2.9	3.1					0.5	
1863										0.6	3.2	1.8				3.1	2.7	2.8					0.4	
1864										1.6	2.8	2.2				3.9	4.3	4.2					0.4	
1865										2.6	12.4	7.3				11.5	4.2	5.8					0.4	
1866										2.6	7.9	5.1				4.3	3.8	3.9					0.9	
1867										2.4	0.5	1.5				5.3	2.9	3.5					1.4	
1868										0.7	0.9	0.8				3.6	7.8	6.8					1.3	
1869										1.3	3.0	2.1				4.6	20.7	17.1					2.5	
1870				3.9	4.4	4.3				1.3	2.7	1.9				13.0	17.2	16.3	3.8	2.3	3.0	2.1	2.0	2.1
1871				1.9	4.7	4.0				1.5	7.8	4.5				23.2	34.2	31.7	2.4	6.9	4.7	2.6	1.7	1.9
1872				3.0	5.3	4.7				2.3	8.5	5.2				29.4	45.9	42.2	1.9	14.2	8.4	4.3	2.3	2.7
1873				3.4	6.1	5.4				2.5	2.2	2.3				22.0	15.6	17.0	1.0	6.6	3.9	4.4	2.2	2.7
1874				3.2	8.0	6.7				2.9	4.5	3.6				15.4	18.4	17.8	1.4	7.5	4.6	2.0	1.7	1.8
1875				4.9	8.6	7.6				1.4	2.7	2.0				12.3	14.3	13.8	2.9	15.0	9.2	1.7	2.0	1.9
1876				4.9	9.4	8.2				1.4	2.9	2.1				6.5	63.4	50.7	2.8	7.0	5.0	3.0	1.8	2.1
1877				5.7	14.7	12.2				2.1	5.1	3.5				4.4	5.1	4.9	3.7	9.7	6.9	2.4	1.5	1.7
1878				5.3	9.2	8.1				2.2	8.4	5.2				7.6	7.8	7.7	5.7	9.4	7.6	2.6	1.5	1.8
1879				4.5	3.1	3.5				2.4	9.4	5.7				5.2	6.1	5.9	15.6	6.9	11.0	2.0	1.7	1.7
1880				5.7	10.3	9.0				4.4	23.8	13.6				1.6	2.5	2.3	18.2	12.1	15.0	3.0	2.0	2.2
1881				4.8	10.8	9.1				8.4	36.3	21.6				2.6	2.8	2.8	13.9	11.0	12.4	8.2	2.0	3.4
1882				7.8	5.9	6.4				12.6	37.6	24.4				6.8	5.8	6.1	27.5	19.3	23.2	4.9	1.9	2.6
1883				8.5	4.0	5.3				10.7	31.9	20.7				7.7	5.4	5.9	45.9	17.1	30.8	5.6	3.1	3.6
1884				6.8	6.8	6.8				5.5	7.8	6.6				6.9	8.2	7.9	32.7	25.0	28.7	12.1	4.2	5.9
1885				9.2	11.0	10.5				3.4	3.5	3.4				5.8	3.8	4.2	11.4	31.3	21.8	6.5	9.4	8.8
1886				9.7	10.0	9.9				4.1	6.3	5.1				4.3	4.9	4.8	10.9	27.8	19.7	4.3	8.8	7.8
1887				9.4	9.6	9.6				5.9	11.2	8.4				6.1	5.5	5.6	10.6	26.6	19.0	10.0	6.5	7.3
1888				9.9	8.8	9.1				8.0	22.6	14.9				8.3	7.2	7.5	9.2	19.1	14.3	11.7	10.0	
1889				12.1	9.8	10.5				9.5	40.9	24.3				12.4	7.5	8.6	13.7	22.0	18.1	23.1	9.4	12.5
1890	13.9	24.5	21.5	15.1	14.0	14.3	6.6	1.4	2.4	15.1	75.0	43.4	28.1	77.2	44.5	9.3	9.1	9.1	22.5	48.8	36.3	20.7	8.0	10.9
1891	16.7	23.2	21.3	14.1	13.5	13.7	6.9	1.7	2.7	15.7	36.3	25.4	22.6	30.3	25.2	13.1	30.0	26.2	26.7	37.2	32.2	8.9	4.7	5.6
1892	19.0	8.9	11.8	19.7	29.9	27.0	4.8	0.8	1.6	12.0	35.7	23.2	37.5	32.8	35.9	8.5	7.3	7.6	28.1	24.7	26.3	4.5	3.7	3.8
1893	14.9	18.2	17.2	27.7	31.1	30.1	3.4	0.9	1.4	10.5	15.4	12.8	10.7	24.8	15.4	7.3	8.1	7.9	33.2	52.8	43.4	6.0	3.0	3.7
1894	16.1	8.3	10.5	23.9	24.3	24.2	4.2	1.2	1.8	11.1	17.8	14.3	11.4	16.4	13.1	5.7	5.4	5.5	41.3	62.3	52.3	10.4	2.6	4.4
1895	25.0	23.2	23.7	21.5	78.5	62.6	4.2	1.3	1.9	15.5	21.4	18.3	28.4	33.6	30.1	7.7	6.1	6.5	33.7	33.9	33.8	8.9	3.8	4.9
1896	33.0	38.3	36.8	24.8	106.3	83.6	4.7	2.9	3.3	17.9	47.5	31.9	23.7	27.4	25.0	11.6	4.6	6.1	26.5	20.9	23.6	10.2	3.9	5.3
1897	24.9	43.8	38.5	13.9	43.2	35.0	6.6	8.5	8.1	20.5	77.2	47.2	19.6	24.2	21.2	10.1	6.0	6.9	19.0	21.2	20.1	5.6	3.4	3.9
1898	10.9	2.7	5.0	7.0	17.9	14.8	4.6	10.0	8.9	24.3	65.6	43.8	13.5	35.5	20.9	10.8	6.3	7.3	20.1	24.6	22.5	6.6	4.0	4.6

Year	El Salvador			Haiti			Honduras			Mexico			Nicaragua			Peru			Dominican Republic			Uruguay		
1899	7.3	9.7	9.0	7.8	18.8	15.7	4.2	6.7	6.2	30.9	80.0	54.1	15.6	33.3	21.6	11.5	5.8	7.1	23.0	13.9	18.2	8.6	4.4	5.3
1900	11.3	2.7	5.2	11.6	10.7	10.9	5.7	3.7	4.1	36.0	29.3	32.8	21.5	10.0	17.6	18.9	5.7	8.6	26.1	4.3	14.7	8.0	4.1	5.0
1901	11.2	3.8	5.9	12.5	14.3	13.8	7.3	3.0	3.9	33.0	31.5	32.2	14.4	11.5	13.4	17.7	5.0	7.8	22.0	4.5	12.8	8.2	5.2	5.8
1902	9.9	2.2	4.4	11.7	10.4	10.7	4.4	1.6	2.2	35.1	41.7	38.2	14.2	10.2	12.9	17.9	9.5	11.4	10.3	2.9	6.4	12.3	5.5	7.0
1903	12.4	2.2	5.1	13.2	8.5	9.8	6.3	3.3	3.9	40.8	35.7	38.4	18.5	11.5	16.2	25.2	12.4	15.3	9.8	2.6	6.1	10.5	7.9	8.5
1904	18.7	3.5	7.8	20.2	15.7	16.9	8.9	10.0	9.8	41.6	36.0	38.9	21.5	14.6	19.2	29.5	12.0	16.0	14.2	3.3	8.5	12.0	4.9	6.5
1905	23.1	5.7	10.6	15.8	20.4	19.1	8.6	13.6	12.6	45.3	49.2	47.1	27.5	11.9	22.3	32.0	23.5	25.4	23.5	4.1	13.4	22.4	7.0	10.4
1906	22.2	5.9	10.6	17.6	26.1	23.8	9.3	14.3	13.3	58.6	79.8	68.6	26.2	9.0	20.4	37.9	30.1	31.9	26.8	5.3	15.5	33.3	7.5	13.2
1907	28.0	5.0	11.5	15.1	20.2	18.8	10.4	13.4	12.8	61.7	81.0	70.8	24.4	6.8	18.5	38.6	32.7	34.0	30.1	14.2	21.8	50.7	10.1	19.1
1908	24.0	6.9	11.8	21.2	15.6	17.2	13.2	11.7	12.0	47.4	71.9	59.0	22.3	7.7	17.4	26.5	25.2	25.5	27.8	26.3	27.0	29.7	12.3	16.2
1909	24.3	5.7	11.0	34.1	46.6	43.1	12.8	13.1	13.0	44.0	96.7	68.9	23.4	16.3	21.0	22.2	14.9	16.5	40.6	23.5	31.6	29.4	12.9	16.6
1910	39.1	6.4	15.7	41.9	53.1	50.0	16.0	16.3	16.2	53.6	106.6	78.6	32.4	16.2	27.0	28.4	17.9	20.2	54.9	25.2	39.4	40.9	20.7	25.2
1911	43.4	11.3	20.4	54.9	83.7	75.7	20.2	28.9	27.2	50.4	81.7	65.2	51.3	34.2	45.6	33.4	28.7	29.8	73.3	32.9	52.1	43.2	24.8	28.9
1912	43.7	23.6	29.3	42.3	138.1	111.3	21.9	44.8	40.2	45.0	59.1	51.7	49.1	29.9	42.7	33.8	25.6	27.5	98.6	51.5	73.9	46.6	28.2	32.3
1913	48.3	29.4	34.8	31.4	105.0	84.5	40.6	71.4	65.3	37.3	44.7	40.8	43.2	21.1	35.8	47.1	26.5	31.1	86.2	63.7	74.4	41.7	38.6	39.3
1914	34.8	18.3	23.0	13.8	25.8	22.4	45.8	99.7	89.1	16.5	22.8	19.4	31.5	18.4	27.1	35.0	19.8	23.2	52.8	46.2	49.3	25.4	18.8	20.3
1915	23.6	15.8	18.0	10.0	23.9	20.0	56.4	80.0	75.4	9.0	12.8	10.8	25.2	19.6	23.3	18.4	14.1	15.0	50.6	42.5	46.3	10.3	12.2	11.8
1916	20.7	25.6	24.2	18.9	52.2	42.9	40.9	56.1	53.1	13.2	17.8	15.4	40.5	43.9	41.6	26.9	21.4	22.7	75.5	71.2	73.2	10.3	11.9	11.5
1917	19.7	30.0	27.0	90.2	111.5	105.6	18.2	43.6	38.6	18.6	27.6	22.9	35.4	42.0	37.6	28.9	21.1	22.8	108.8	109.1	109.0	10.8	11.8	11.6
1918	10.9	7.2	8.3	72.5	49.0	55.5	12.3	24.3	21.9	22.4	27.6	24.9	25.5	20.5	23.8	38.3	15.3	20.4	101.8	61.1	80.5	8.8	14.4	13.2
1919	22.1	19.9	20.5	43.0	31.8	34.9	24.3	65.9	57.7	31.8	46.6	38.8	33.0	21.8	29.2	48.9	33.1	36.6	78.8	55.4	66.5	18.3	19.2	19.0
1920	55.6	34.4	40.4	67.0	69.4	68.7	69.2	145.2	130.2	58.2	70.9	64.2	69.8	34.8	58.0	92.4	37.7	50.0	219.4	130.3	172.7	24.6	37.3	34.5
1921	61.7	22.5	33.6	33.0	23.5	26.1	132.0	134.6	134.1	100.2	75.4	88.5	75.6	13.7	54.8	93.4	31.3	45.2	306.1	108.0	202.3	28.0	42.3	39.1
1922	35.8	13.9	20.1	30.8	24.2	26.0	72.1	135.7	123.1	50.0	52.4	51.1	22.8	15.8	20.4	47.4	38.9	40.8	97.0	46.6	70.6	26.7	44.1	40.2
1923	43.5	22.5	28.5	77.8	50.3	58.0	93.5	179.7	162.6	50.6	58.9	54.5	47.9	42.6	46.1	71.0	44.9	50.7	117.7	87.1	101.7	31.4	53.7	48.8
1924	105.1	35.9	55.6	62.1	78.1	73.6	72.0	81.3	79.4	70.0	65.7	68.0	78.6	79.7	78.9	95.8	54.8	64.0	182.2	96.1	137.1	35.4	61.8	55.9
1925	135.4	127.8	130.0	101.1	60.9	72.1	53.7	75.0	70.8	76.6	71.0	73.9	97.4	70.8	88.5	111.0	60.9	72.1	165.8	89.0	125.6	54.0	64.5	62.2
1926	171.1	131.0	142.4	90.3	89.4	89.6	53.3	76.8	72.1	72.7	71.8	72.3	72.8	100.0	81.9	106.1	76.6	83.2	129.5	81.1	104.1	49.9	55.4	54.1
1927	102.1	88.0	92.0	102.5	128.1	120.9	60.4	81.5	77.4	68.4	68.5	68.4	71.9	71.1	71.6	106.8	89.5	93.4	167.8	121.9	143.7	69.5	97.3	91.1
1928	104.0	53.5	67.8	113.6	124.4	121.3	68.2	89.1	85.0	74.8	80.5	77.5	99.7	97.6	99.0	88.8	70.6	74.7	141.1	103.7	121.5	67.5	99.3	92.2
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1930	59.6	77.7	72.6	82.1	74.3	76.5	95.6	108.9	106.3	90.3	90.5	90.4	85.3	58.2	76.2	78.2	38.1	47.1	58.3	59.5	58.9	103.9	96.5	98.1
1931	26.8	48.9	42.6	63.7	41.9	48.0	99.2	142.9	134.2	52.7	63.2	57.7	20.2	79.2	40.0	50.7	33.0	36.9	31.5	53.9	43.2	61.9	75.4	72.4
1932	18.2	20.1	19.6	49.9	31.8	36.9	126.7	98.9	104.4	37.2	47.2	41.9	11.9	22.4	15.4	35.3	20.3	23.6	24.9	35.8	30.6	20.3	54.1	46.6
1933	21.1	32.9	29.6	60.2	44.4	48.8	122.9	89.6	96.2	50.6	64.1	57.0	17.1	37.7	24.0	60.8	24.7	32.8	53.3	84.2	69.5	18.1	39.8	35.0
1934	36.3	46.8	43.8	87.3	55.5	64.4	92.0	85.8	87.0	71.5	106.6	88.1	22.5	56.5	33.9	90.4	37.7	49.5	50.9	81.2	66.8	33.1	45.8	43.0
1935	40.6	65.8	58.6	64.7	59.4	60.9	97.6	95.3	95.8	84.4	115.8	99.2	21.1	70.3	37.6	138.8	54.2	73.2	34.7	100.7	69.2	32.2	39.6	37.9
1936	33.2	51.8	46.5	59.8	46.2	50.0	66.9	135.3	121.8	102.4	119.9	110.7	23.1	104.2	50.3	146.7	67.6	85.3	45.0	121.3	85.0	57.2	47.5	49.7
1937	55.5	71.5	67.0	70.8	67.1	68.2	107.6	124.9	121.4	139.9	166.3	152.4	43.4	91.5	59.5	169.2	103.0	117.8	60.4	143.1	103.7	92.4	67.8	73.3
1938	36.1	38.8	38.0	65.4	39.1	46.4	90.9	132.2	124.0	64.3	109.9	85.8	37.3	64.9	46.6	206.0	99.7	123.5	48.8	84.1	67.2	108.2	71.9	80.0
1939	38.7	58.3	52.7	72.0	77.4	75.9	86.4	132.3	123.2	76.5	124.6	99.2	109.9	97.7	105.8	176.7	118.2	131.3	54.3	112.3	84.7	65.8	64.4	64.7
1940	49.2	66.8	61.8	63.0	96.5	87.2	111.3	129.7	126.1	80.0	138.1	107.4	99.9	102.2	100.7	217.9	122.5	143.9	40.0	100.2	71.5	64.4	57.3	58.9
1941	34.6	62.0	54.2	44.5	65.7	59.8	155.7	156.1	156.0	119.5	150.0	133.9	95.4	145.2	112.1	234.0	130.0	153.3	36.0	90.6	64.6	49.3	53.2	52.3
1942	27.6	62.8	52.8	33.5	33.6	33.6	130.0	166.6	159.3	76.3	142.3	107.5	62.7	49.7	58.3	159.6	95.3	109.7	25.8	33.2	29.7	21.6	12.2	14.3
1943	20.6	63.5	51.3	37.0	64.9	57.1	150.0	104.5	113.5	105.1	156.0	129.1	87.9	170.8	115.7	180.3	128.1	139.8	35.7	71.7	54.5	7.7	16.7	14.7
1944	43.9	65.1	59.1	105.7	83.4	89.6	124.1	139.8	136.7	150.9	209.1	178.4	97.6	113.3	102.9	220.3	164.2	176.8	44.9	147.0	98.4	7.1	21.4	18.2
1945	48.2	38.6	41.3	84.5	88.3	87.2	150.5	162.4	160.1	247.2	266.0	256.0	73.7	93.2	80.3	276.9	170.1	194.0	54.7	148.7	103.9	12.7	31.2	27.1
1946	85.2	58.8	66.3	114.7	108.6	110.3	354.3	207.5	236.6	359.3	315.6	338.7	66.9	123.5	85.9	410.8	207.4	253.0	88.1	252.1	174.0	31.9	51.7	47.3
1947	179.7	84.6	111.7	117.0	98.1	103.4	431.2	239.9	277.8	382.0	345.0	364.5	95.7	125.5	105.7	427.6	190.2	243.4	204.8	463.8	340.5	48.1	42.1	43.4
1948	181.5	96.3	120.5	167.7	158.1	160.8	468.0	244.1	288.4	313.9	270.1	293.2	83.7	118.5	95.3	430.4	165.6	225.0	248.6	422.9	339.9	61.2	36.7	42.2
1949	173.8	109.5	127.8	231.7	241.2	238.6	596.4	268.8	333.7	280.2	310.7	294.6	112.4	151.8	125.6	493.6	163.7	237.7	187.7	308.3	250.9	40.4	37.9	38.4
1950	218.0	126.4	152.5	187.8	244.3	228.5	532.5	330.4	370.4	296.5	361.8	327.3	83.2	152.4	106.4	476.1	183.4	249.0	145.9	340.7	247.9	76.0	47.7	54.0

TABLE A-1 (CONCLUDED)

Gross fixed capital formation (GFCF) at constant prices
(Index: 1929=100)

Year	Venezuela			Central America (5 countries)			Latin America (17 countries)		
	Equipment	Construction	GFCF	Equipment	Construction	GFCF	Equipment	Construction	GFCF
1856	0.5	0.7	0.6	0.6	1.1	0.9	0.4	2.7	1.8
1857	0.6	0.7	0.7	0.3	0.6	0.5	0.7	2.4	1.7
1858	0.2	0.6	0.5	0.7	0.9	0.8	0.8	2.3	1.7
1859	0.2	0.8	0.6	0.4	0.5	0.5	0.7	2.5	1.8
1860	0.3	0.2	0.2	0.4	0.8	0.7	0.8	3.2	2.2
1861	0.4	0.3	0.3	0.3	0.5	0.4	1.1	3.0	2.2
1862	0.5	0.3	0.4	0.1	0.9	0.6	1.0	2.8	2.1
1863	0.5	0.4	0.4	0.1	1.7	1.1	1.2	3.2	2.3
1864	2.5	2.5	2.5	0.1	0.9	0.6	1.3	4.4	3.2
1865	1.1	4.5	3.8	0.1	0.5	0.3	1.5	5.6	3.9
1866	0.3	0.6	0.5	0.4	0.9	0.7	1.6	4.1	3.1
1867	0.1	0.8	0.6	0.5	3.7	2.4	1.8	4.2	3.2
1868	0.1	0.9	0.7	0.6	2.0	1.4	1.6	4.4	3.3
1869	0.5	1.3	1.1	0.4	3.5	2.2	1.9	7.5	5.2
1870	1.1	1.0	1.0	0.7	10.9	6.8	2.1	7.6	5.4
1871	0.4	0.2	0.3	0.9	4.4	3.0	2.3	8.9	6.3
1872	0.6	1.2	1.0	1.6	4.8	3.5	3.0	9.4	6.8
1873	0.9	3.5	2.9	1.2	3.9	2.8	3.1	9.7	7.0
1874	0.9	4.4	3.6	0.6	1.7	1.2	2.7	11.3	7.8
1875	1.4	3.0	2.7	2.3	4.5	3.6	2.5	8.4	6.0
1876	1.8	1.1	1.3	2.1	3.2	2.7	2.4	7.5	5.4
1877	2.1	0.9	1.2	2.6	4.7	3.8	2.2	8.1	5.8
1878	1.7	0.6	0.8	1.7	3.9	3.0	2.5	8.2	5.9
1879	1.1	0.7	0.8	2.6	12.0	8.1	2.3	10.0	6.9
1880	1.6	2.8	2.5	2.2	7.7	5.4	3.1	9.9	7.2
1881	2.0	3.1	2.8	2.3	7.1	5.2	4.1	13.1	9.5
1882	2.3	6.5	5.6	4.6	11.0	8.4	5.3	18.8	13.4
1883	2.5	3.1	2.9	5.7	26.0	17.7	6.6	21.9	15.7
1884	2.2	5.1	4.5	8.0	17.4	13.6	7.0	23.2	16.6
1885	2.2	9.4	7.8	5.5	7.1	6.4	5.0	18.4	13.0
1886	2.5	12.0	9.9	5.8	7.8	7.0	5.2	16.3	11.8
1887	3.3	9.6	8.2	9.9	21.5	16.8	6.2	18.2	13.4
1888	3.6	10.7	9.1	10.1	18.3	15.0	7.6	34.1	23.4
1889	3.8	16.1	13.3	11.5	19.8	16.4	10.5	41.4	28.9
1890	4.9	10.8	9.4	14.6	28.6	22.9	12.5	54.6	37.6
1891	5.4	9.2	8.4	16.2	26.6	22.4	14.6	25.3	21.0
1892	5.7	6.2	6.1	17.1	12.2	14.2	12.7	14.1	13.5
1893	5.6	11.1	9.8	13.8	16.0	15.1	12.9	13.9	13.5
1894	5.0	2.6	3.1	16.1	28.7	23.6	11.0	11.9	11.5
1895	5.6	3.1	3.7	23.4	37.4	31.7	12.3	17.0	15.1
1896	4.4	4.1	4.2	28.1	52.5	42.6	12.0	25.0	19.8
1897	4.1	3.1	3.3	20.2	27.1	24.3	9.1	18.4	14.7
1898	3.1	1.3	1.7	12.6	10.4	11.3	8.5	17.7	14.0

Year	Venezuela			Central America (5 countries)			Latin America (17 countries)		
1899	2.7	1.1	1.4	11.0	16.0	14.0	9.4	15.9	13.3
1900	2.5	1.4	1.6	14.1	6.1	9.3	11.1	11.3	11.2
1901	2.8	1.4	1.7	13.4	9.8	11.3	11.3	13.3	12.5
1902	1.8	0.8	1.0	13.0	12.5	12.7	10.7	11.6	11.2
1903	2.6	1.2	1.5	15.4	6.4	10.0	12.9	12.0	12.4
1904	4.4	2.4	2.8	17.5	14.1	15.5	17.5	16.1	16.7
1905	4.7	3.1	3.5	21.5	23.3	22.6	24.6	24.7	24.7
1906	4.7	3.5	3.8	25.4	24.6	24.9	32.9	36.8	35.2
1907	4.6	3.7	3.9	27.9	17.6	21.8	37.0	41.0	39.4
1908	4.5	2.5	3.0	24.0	13.8	18.0	32.4	35.3	34.2
1909	4.8	3.4	3.8	23.9	19.4	21.2	30.8	48.0	41.0
1910	6.3	5.0	5.3	27.8	23.7	25.3	38.0	52.7	46.7
1911	8.3	6.6	7.0	33.2	30.4	31.6	41.2	56.1	50.1
1912	10.4	7.5	8.1	35.5	40.3	38.3	48.3	58.9	54.6
1913	14.6	10.2	11.2	39.7	44.2	42.4	45.4	68.3	59.0
1914	9.8	8.4	8.7	28.2	31.0	29.9	25.9	40.3	34.5
1915	7.1	5.9	6.1	17.1	23.2	20.7	12.3	22.0	18.1
1916	7.3	7.0	7.0	16.7	23.1	20.5	14.6	22.1	19.1
1917	6.6	6.3	6.4	12.7	21.5	17.9	15.4	19.5	17.9
1918	4.3	2.8	3.1	9.5	14.3	12.3	14.1	11.5	12.5
1919	6.3	5.3	5.5	14.9	20.9	18.5	20.4	22.1	21.4
1920	15.0	10.5	11.5	35.2	37.4	36.5	39.9	37.2	38.3
1921	16.5	11.1	12.3	48.6	30.3	37.7	42.8	31.1	35.8
1922	16.8	11.0	12.3	28.7	31.2	30.2	34.6	35.6	35.2
1923	21.0	15.9	17.0	40.8	46.5	44.1	38.0	31.0	33.8
1924	33.4	28.2	29.4	65.3	65.6	65.5	49.7	43.0	45.7
1925	55.3	42.8	45.6	80.5	73.1	76.1	65.0	55.3	59.2
1926	103.2	84.7	88.8	80.6	89.2	85.7	69.8	64.7	66.8
1927	98.9	58.3	67.5	73.8	72.9	73.3	78.4	69.9	73.4
1928	84.3	103.8	99.4	90.9	90.7	90.8	83.0	86.9	85.3
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1930	79.3	84.8	83.6	53.1	70.7	63.5	66.5	86.5	78.4
1931	40.1	50.1	47.9				36.7	54.1	47.1
1932	28.1	48.9	44.2				17.0	38.5	29.8
1933	36.8	58.3	53.5				22.4	45.6	36.2
1934	48.0	59.3	56.8				37.3	57.0	49.0
1935	58.1	64.4	63.0				59.8	64.0	62.3
1936	75.6	76.6	76.4				62.0	73.4	68.8
1937	126.3	90.1	98.3				83.6	96.9	91.5
1938	145.0	111.4	119.0				81.7	94.3	89.2
1939	172.1	110.7	124.6				65.9	91.9	81.4
1940	156.1	90.1	105.0				63.3	86.4	77.1
1941	126.2	50.6	67.6				57.2	74.0	67.2
1942	78.1	38.8	47.6				36.8	54.0	47.0
1943	39.2	36.4	37.1				35.6	55.8	47.6
1944	237.8	111.2	139.7				52.2	82.9	70.5
1945	421.8	164.3	222.4				84.6	95.6	91.2
1946	449.5	169.7	232.8				126.1	123.1	124.3
1947	795.1	268.0	387.0				217.0	150.8	177.5
1948	895.2	334.3	460.9				196.3	149.2	168.3
1949	883.8	387.4	499.4				164.2	173.1	169.5
1950	541.2	248.5	314.5				142.2	169.7	158.6

Source: prepared by the author.

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Economic growth and the environment

Adolfo Figueroa

ABSTRACT

The relationship between economic growth and the environment is one of the most significant problems in modern economics. Empirical data are increasingly available, but the theories behind those data remain a matter of debate. This paper presents an elementary theoretical model of the interactions between the economic process and the environment, drawing on a theory developed by Georgescu-Roegen, in which the laws of thermodynamics are applied to the economic process. The model assumes that the growth and distribution process is currently operating amid conditions of environmental distress. The model is able to predict and explain the observed relationship between economic growth and the environment, identifying new public policy implications. The paper thus aims to contribute to the debate on the choices that society must make about the future of humanity.

KEYWORDS Economic growth, environment, consumption, non-renewable resources, pollution, thermodynamics, economic aspects, environmental aspects

JEL CLASSIFICATION B52, E24, O13, O15, O33, Q32

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I
Introduction

The relationship between economic growth and the environment has been studied from both an empirical and a theoretical perspective. The key data show that total output per person grew at an average rate of 1.4% per year in the period 1870-2000, with the highest rate (4%) recorded during the past century (Maddison, 2003). This process has been accompanied by an equally rapid degradation of the environment, including the depletion of non-renewable resources and pollution. Some studies show that certain non-renewable resources are approaching exhaustion (Clugston, 2012). The standard measure of pollution is the concentration of carbon dioxide (CO_2) in the atmosphere, measured in parts per million (ppm). According to physicist Richard Muller, "The amount of carbon dioxide was pretty constant from A.D. 800 until the late 1800s, at a level of 280 ppm. In the last century it has shot up to 380 ppm —an increase of 36%. If we continue to burn fossil fuels, we expect the carbon dioxide to keep rising […] The carbon dioxide comes from human activity, including the burning of fossil fuels and the destruction of enormous regions of forest" (Muller, 2008, pp. 265-266).

The planet's average temperature has been on the rise since the beginning of the industrial revolution, around 1850 (IPCC, 2007). Whether this global warming, and the climate change associated with it, is endogenous or exogenous to the economic process is still a matter of scientific debate. The factors affecting climate change can be summarized in three affirmations: first, human fossil-fuel burning causes CO_2 concentrations in the air to rise; second, CO_2 is a greenhouse gas; and third, the greenhouse effect increases the average global temperature. The first two are accepted by scientists, but the third is under debate.

According to some scientists, the emission of greenhouse gases leads to global warming, which results in climate change; that is, production generates waste and pollution, which triggers climate change (Aeschbach-Hertig, 2007). From their point of view, climate change is endogenous to the production process. For others, climate change is exogenous: it is caused mainly by natural variations in solar activity (Chilingar, Sorokhtin and Khilyuk, 2008, p. 1572). A third group concludes that, although climate change is a complex problem and hard to decipher with any certainty, it is likely to be endogenous to some extent (IPCC 2007, cited in Muller 2008, p. 254).

In the particular case of Latin America, some empirical evidence exists of environmental degradation in the long period of economic growth since the 1940s (Sunkel and Gligo, 1980; Gligo 1993). The negative impact of climate change upon average output and output variability has also been reported as a set of stylized facts (Galindo and Samaniego, 2010).

These are the facts, but how can they be explained? In standard economics, the paper by Robert Solow (1974) is still the classical reference; however, as will be shown below, this paper has shortcomings, which the new literature has not been able to resolve (Barro and Sala-i-Martin, 2004; Grimaud and Rouge, 2005; Lafforgue 2008). A different approach was adopted by Nicholas Georgescu-Rogen (1971), who applied the laws of thermodynamics to the economic process.

This paper presents a theoretical model using Georgescu-Rogen's framework. This model seeks to show the interactions between the economic process and the environment and thus establish the relationship between economic growth and the environment. The model attempts to explain the facts set forth above and to answer the following questions: Can economic growth go on forever? Can consumption be distributed equally between generations? What is the role of technological progress in the interactions between growth and environmental degradation?

The paper is divided into seven sections. Section II presents model A, which is based on an economic process using non-renewable natural resources. Section III examines the intergenerational consumption frontier. Section IV sets out model B, which applies the laws of thermodynamics to the economic process. Section V looks at model C, which considers the substitutability of capital, labour and natural resources. Section VI discusses the factors that could lead to changes in the intergenerational consumption frontier. Lastly, the conclusions of the study can be found in section VII.

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II

Model A: The economic process using non-renewable natural resources

This theoretical model will assume an abstract human society with given resource endowments and production technology. This society produces a single good, referred to as "good B".

With regard to the production process, the model uses the flow-fund framework of Georgescu-Roegen (1971). By definition, production is a continuous, self-perpetuating process in which two categories of production factors can be distinguished: *funds*, which act as agents, and *flows*, which are the materials being transformed into goods. In other words, funds can take the form of either inputs or outputs of the production process, whereas flows go in only one direction, either inwards or outwards.

The algorithm that will be applied in the construction of the most appropriate model begins with model A, which is based on a specific process for the production of good B. It is represented in the form of a production system as follows:

$$Q_j^* = F(K, L) \qquad (1)$$

$$Q_j^* = (1/z)\, N_j, \text{ such that } z > 0 \text{ and } \Sigma N_j \leq S_0,\ j=1,2,\ldots,T \qquad (2)$$

The production system (1)-(2) assumes that the flow of gross output Q^* is produced in period j using quantities of two types of production factors: the fund of services contained in the stocks of capital K and labour L —equation (1)— and the flow of material inputs N sourced from the stock of non-renewable natural resources S_0, which in this case will refer to mineral resources in the Earth's crust and will be considered the only input —equation (2). Capital stock K is composed of good B. Renewable natural resources will be ignored for the time being.

The production system (1)-(2) represents a particular notion of a production process in which Q_j^* is the output flow produced in period j, and N_j is the flow of mineral resources used in the same period. Production can continue period after period for as long as the stocks of K and L remain constant and the flow of mineral inputs is assured, until the stock S_0 is depleted.

The production system (1)-(2) assumes the use of limitational technology; that is, the first and second types of factor cannot be substituted for each other. Mineral resources cannot be substituted for capital or labour; however, K and L are substitutable factors, as indicated by equation (1). The proportion of mineral resources to gross output in the production process, represented by the coefficient z, is fixed and determined by technology.

Finally, the production system (1)-(2) also assumes given values for the length of the working period and the work intensity of production units in businesses that produce good B. The model assumes the full employment of the labour force and machinery. In a long-run analysis, such as that provided by this paper, a lengthy unit of time is used —in this case, a decade.

Some of these assumptions will be modified in the construction of two alternative models that will be presented in subsequent section of this paper. The laws of thermodynamics (on the relationship between matter and energy) will be introduced in model B; while model C will consider substitution between funds and flows. Model B will turn out to be the most appropriate of the three models.

In model A, if mineral resources are considered as redundant factors, the relevant equation in the production process is equation (1). Net output is by definition equal to gross output minus the quantity of goods allocated to the reposition of the stock K. The term "reposition" in this case refers to the quantity of good B needed to keep stock K constant; this implies securing the same stock and thus the same quantity of service funds period after period.

The coefficient of reposition of K can be represented by b, which indicates the quantity of good B needed per unit of K for the value of K to remain constant. Multiplying b by the quantity of K will give the total quantity of good B needed directly to repair the wear and tear on machinery and thus keep the stock of capital K constant period after period.

The reposition equation for any period j can be written as:

$$\begin{aligned} R_j &= b\,K \\ &= r\,Q_j^*, 0 < r < 1 \end{aligned} \tag{3}$$

In equation (3) R indicates total reposition, that is, the total quantity of good B that is needed to maintain constant the stock of K. From equation (1), it follows that given K and L, the quantity of gross output Q^* is known. Hence, the flow of reposition R can be represented as a fixed proportion of Q^*: the coefficient r. In a truly productive process, the coefficient r must be less than one.

The flow of net output Q can be written as:

$$\begin{aligned} Q_j &= Q_j^* - R_j \\ &= Q_j^* - r\,Q_j^* \\ &= (1 - r)\,Q_j^* \end{aligned} \tag{4}$$

Equation (4) shows that the flow of net output Q is a fixed proportion of the flow of gross output Q^*. Because there is reposition, stock K is a *renewable* factor and net output is sustainable over time; that is, net output can be repeated period after period, as long as the mineral resources are a redundant factor. Net output may be allocated to capital accumulation or to consumption; however, the model assumes that all net output is allocated to consumption.

If society is endowed with machinery and labour in quantities K_1 and L_1, which are now the redundant factors of production, the relevant equation that applies to the production process is equation (2). The initial stock of mineral resources S_0 will decrease continuously in the production process, even if the same quantity of gross output is produced period after period. Therefore, the quantity remaining of the stock of mineral resources at the end of the period T, referred to as term S(T), can be written as:

$$\begin{aligned} S(T) &= S_0 - \Sigma\,N_j, j=1, 2, ..., T \\ &= S_0 - \Sigma\,z\,Q_j^* = S_0 - z\,\Sigma\,Q_j^* \\ &= S_0 - z\,Q^*\;T \end{aligned} \tag{5}$$

Equation (5) shows that if the quantity of gross output is constant, the initial stock of mineral resources declines steadily over time at the rate of N= z Q^* per unit of time. The new stock at period T becomes S(T) according to the number of periods for which the production process was repeated.

III

The intergenerational consumption frontier

This section takes into consideration both equations of the production system (1)-(2). K_1 and L_1 shall represent the factor endowments of machinery and labour needed to produce gross output Q_1^* and render redundant the initial stock of mineral resources. The mineral resources required for the production of net output Q, as defined in equation (4), can then be included in equation (5) as follows:

$$\begin{aligned} S(T) &= S_0 - z\,F\left(K_1, L_1\right)T \\ &= S_0 - z\,Q_1^* T \\ &= S_0 - \left[z/\left(1-r\right)\right]Q_1 T \\ &= S_0 - \mu\,Q_1 T, \text{ where } \mu = z/\left(1-r\right) \end{aligned} \tag{6}$$

In equation (6) the depletion rate of the initial stock of mineral resources is now presented in terms of the net output Q_1. The stock of mineral resources declines steadily over time at the rate of N= μQ_1 per unit of time, where μ represents the technological requirement of mineral resources per unit of net output.

The period at which the stock of mineral resources is eventually depleted can be found by setting the value of equation (6) to zero, that is, $S_0 = \mu\,Q_1\,T$. This equality shows that a given initial stock and a given technological coefficient imply a fixed total output, whether that output is produced in the current period or in the future. If the net output for a given period is doubled, the number of periods over which that output can be sustained will be reduced by half. The higher the net output, the fewer the periods over which it can be repeated. A given net output level cannot be produced indefinitely.

By dividing equation (6) by μ, we obtain:

$$\begin{aligned} S(T)/\mu &= S_0/\mu - Q_1\,T \\ Q(T) &= Q_0 - Q_1\,T \end{aligned} \tag{7}$$

The term Q(T) shows the time path of net output, whereas Q_0 shows the quantity of net output that could be produced during the initial period. The productive capacity of mineral resources declines over time at the rate given by Q_1. This production capacity is given by the linear equation (7), in which the flow of net output Q_1, determined by the stock of machinery and labour, constitutes the (negative) slope.

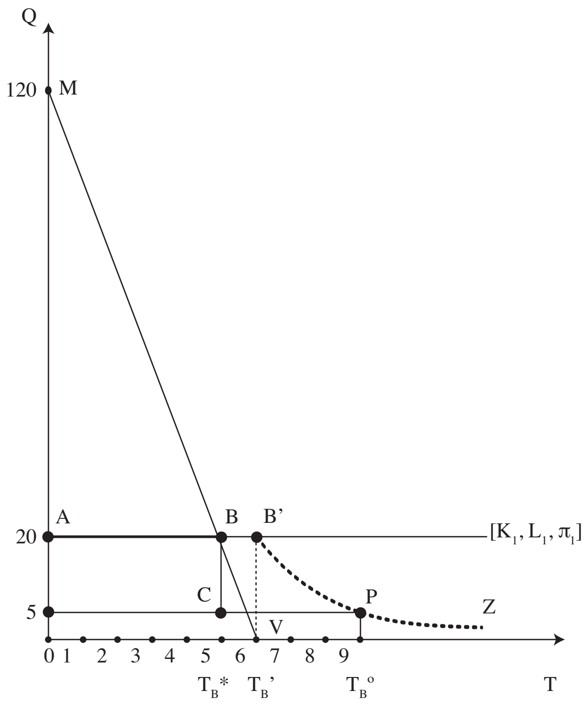
Equation (7) represents the constraints of both funds and flows in the production of net output Q_1, such that the stock of mineral resources is initially the redundant factor ($Q_0>Q_1$). As the net output Q_1 is repeated period after period, the stock of mineral resources will decrease continuously and irrevocably, until it is ultimately depleted. By setting Q(T)=0, we can determine the period in which depletion will occur, let us call it T', at which point net output will become zero. T' implies the extinction of human society. The period in which mineral resources stop being redundant —let us call this T^*— can also be easily determined by setting $Q(T)=Q_1$. It is therefore clear that $T^*=T'-1$.

Another assumption will now be introduced into the model. Society would not readily allow nature to determine the end of its existence and would take action if confronted by the risk of extinction. We assume, therefore, that society will decide at period T^* (that is, when mineral resources are no longer redundant) to extend the duration of the remaining stock of mineral resources for more than one period by lowering the level of consumption. In that scenario, the remaining stock of mineral resources could be extended over several periods and used at the rate given by the new consumption level until these resources were depleted. We will refer to this end period, to be determined by society, as T°, such that $T^*<T'<T°$.

Equation (7) is represented in figure 1. The horizontal axis measures time and the vertical axis net output. Given the stocks of K_1 and L_1, and also given the level of technology Π_1, the corresponding flow of net output is represented by the segment OA, that is, $Q_1=$ OA. The mineral resources constraint is represented by the line MV. OM units of net output could then initially be produced with the given stock of mineral resources; hence, mineral resources are initially redundant. But as OA units of net output are repeated period after period, the stock of mineral resources will decrease until the stock is depleted, which occurs at period T_B' (period 6 in figure 1). This is the basic nature of the flow-fund production process, as initially represented by the production system (1)-(2).

FIGURE 1

The intergenerational consumption frontier



Source: Prepared by the author.

Note: vertical axis measures consumption levels, assuming OM=120 units and OA=20 units; horizontal axis measures generations as time intervals.

Figure 1 also shows that net output is equal to consumption. At period T_B^*(period 5), when mineral resources are no longer redundant, society will decide to intervene and extend the duration of mineral resources by reducing consumption to a fraction of the current consumption level OA. Those mineral resources that have not been used at the end of that period could then last for several further periods until they are eventually depleted. This would depend, however, on the choices made by society with respect to the fraction of consumption. If consumption is reduced by half, the extension will be for two periods; if consumption is reduced to one third of current levels, the extension will be for three periods, and so on. The set of consumption possibilities is thus shown by the curve B'Z, which is an equilateral hyperbola.

The time path of the consumption possibilities may be called the *intergenerational consumption frontier*. In figure 1, it is represented by the segment AB and a particular point in the segment B'Z. The segment AB is constrained by the stocks of K_1 and L_1 and the segment B'Z by the remaining stock of mineral resources.

Let us suppose that society decides to choose point P in the segment B'Z. Beyond period T_B^*(period 5), the consumption level is given by the segment CP (the level C is one fourth of OA in figure 1) and will last for four additional periods, until mineral resources are depleted in period T_B° (period 9). The initial stocks of labour and machinery now become redundant, and the quantity of net output is limited by the available mineral resources. To simplify, we assume that the number of workers remains unchanged, even though only a proportion of them are needed in production. Some institutional changes will have to be introduced into society to accommodate the separation between workers' participation in production and in distribution. With no reposition needed, the stock of machines will be allowed to decline.

The distribution of consumption between generations can also be seen in figure 1. The consumption level of the present generation (OA for period 1) will be higher than the average consumption level of future generations (OA for four generations and OC for four generations). Consequently, there is consumption inequality between generations. The reason lies in the finite stock of mineral resources, which will not allow consumption level OA to be prolonged indefinitely.

In conclusion, when non-renewable natural resources are used in the production process, the current generation's consumption level cannot be sustained indefinitely. This is simply the result of the inevitable depletion of a given stock of exhaustible resources. Moreover, there will be a degree of inequality in the level of consumption between generations: the average consumption level of future generations will necessarily be lower than that of the current generation.

IV

Model B: Applying the laws of thermodynamics to the economic process

Environmental economics textbooks usually recognize two schools of thought in this new discipline (Hanley, Shogren and White 2001). The standard economic theory on the environment is based on neoclassical theory and the first law of thermodynamics. The other school, known as bioeconomics, was developed by Georgescu-Roegen (1971), who applied the second law of thermodynamics —the entropy law— to the economic process. Both laws of thermodynamics will now be introduced into the analysis of the production process, as well as the production system (1)-(2) and its derived relations.

So far, the effect of consumption on the environment has operated through a continuous decrease in the stock of mineral resources until its ultimate depletion. This process may be referred to as the *pure depletion effect* of a given non-renewable resource.

The laws of thermodynamics that are of interest in the economic process were put simply by Georgescu-Roegen (1971, pp. 5-6), as follows:

"Let us take the case of an old-fashioned railway engine in which heat of the burning coal flows into the boiler and, through the escaping steam, from the boiler into the atmosphere. One obvious result of this process is some mechanical work: the train has moved from one station to another. To wit, the coal has been transformed into ashes. Yet one thing is certain: the total quantity of matter and energy has not been altered. That is the dictate of the Law of the Conservation of Matter and Energy—which is the First Law of Thermodynamics … At the beginning the chemical energy of the coal is *free*, in the sense that it is available to us for producing some mechanical work. In the process, however, the free energy loses its quality, bit by bit. Ultimately, it always dissipates completely into the whole system where it becomes *bound* energy, that is, energy which we can no longer use for the same purpose. […] In other words, high entropy means a structure in which most or all energy is bound and low entropy, a structure in which the opposite is true. […This is] the Entropy Law, which is the Second Law of Thermodynamics. All it says is that the entropy of the universe (or of an isolated structure) increases constantly … and irrevocably. We may say that in the universe there is a *continuous* and *irrevocable* qualitative degradation of free into bound energy."

The outcome of the production process includes not only goods, but also "bads" because waste is an inevitable outcome of the production process. This constraint is set in the first law of thermodynamics: matter and energy can only be rearranged, not destroyed or created.

The first law has another implication for the production process. The production of material goods involves the transformation of inputs (the flow elements of production) by agents (the fund elements). Therefore, mineral resources are essential elements in the economic process in the sense that N=0 implies $Q^*=Q_1=0$. This property was already introduced as an assumption of the production system (1)-(2). According to the second law, waste is transformed into pollution of the biophysical environment. Depletion of resources and pollution are the two ways in which the economic process contributes to the degradation of the environment.

The production of goods is dependent upon the environment in two ways: (i) as a source of mineral resources (low entropy); and (ii) as a sink for waste (high entropy), which together degrade the environment (Daly 1996, p. 33). The Earth's size imposes limits on both components, as the given stock of mineral resources and finite capacity to absorb waste restrict our ecosystem's capacity to continue supporting human life as we know it. For the production process, the given stock of mineral resources would not be a problem if everything could be recycled, but the entropy law prevents full recycling; similarly, waste would not be a problem if our ecosystem's absorptive capacity were infinite.

Consequently, any production process, even those with a constant net output flow, implies a continuous and irrevocable depletion of mineral resources. Therefore, the economic process is a human activity that can also be seen as the transformation of low entropy (mineral resources) into high entropy (waste and pollution). Available matter and energy can be used only once in the production process. The production process thus implies degradation of free into bound energy.

Both laws of thermodynamics are very much interrelated. As economist Kenneth Boulding (1976, p.5) stated:

"In a closed system, the first law says that all that can happen is rearrangement; the second law says that if rearrangement happens, it is because there is some kind of potential for rearrangement, and as rearrangement goes on, potential is gradually reduced to zero and we get to the point where nothing further can happen."

The economic process only rearranges matter and energy, but in doing so the production capacity is qualitatively degraded. Therefore, as production is repeated period after period, the potential of the production system is continuously and irrevocably degraded. The economic process is not mechanical, but entropic.

How do the laws of thermodynamics affect the intergenerational consumption frontier? First, the effect of waste on the qualitative degradation of the biophysical environment must be taken into account. Waste will lead to environmental pollution, of water, air and soil. We may assume that pollution leads to an increase in the average global temperature and that climate change will affect the production process by making it more risky.

Second, pollution is an outcome of the production process; however, it will have a feedback effect upon the production process as it will increase the cost of replacing machinery. Owing to the direct damage inflicted by pollution upon the physical capital and the higher risk of destruction from climate change, a higher depreciation rate will now be required to keep machines both productive and durable.

As a result, more mineral resources will be required to maintain the same level of net output. Because the flow of pollution *accumulates* in the environment, as the same net output is produced period after period, the feedback effect will compound over time, and thus the technological coefficient of mineral resources required per unit of net output will increase over time; that is, the value of the coefficient μ will rise continuously over time.

The initial assumption on the production process indicated by the system (1)-(2) will now be modified. Given the values $K=K_1$, $L=L_1$ and $\pi = \pi_1$, the flow of gross output $Q^*=Q_1^*$ will be determined, provided that mineral resources flow in the quantity of N, which now includes the requirements of both direct material inputs and the indirect inputs induced by the level of pollution (P). The level in period T can be written as:

$$P(T) = \Sigma P_j = \Sigma\beta N_j = \beta z \Sigma Q_j^*, j = 1, 2, \ldots, T \qquad (8)$$

The coefficient β indicates the pollution rate from burning minerals in the production process or the rate of greenhouse gas emissions from using energy from mineral resources.

We can determine the total coefficient of mineral resources required per unit of net output as follows. First, the costs associated with the reposition of machinery R are now:

$$\begin{aligned} R(T) &= r\,Q_1^* + r'\,P(T) = r\,Q_1^* + r'\,\beta\, z\, \Sigma\, Q_j^* \\ &= r\,Q_1^* + r'\,\beta\, z\, Q_1^*\, T = (r + r'\beta\, z\, T)\, Q_1^* \\ &= \lambda(T)\, Q_1^* \end{aligned} \quad (9)$$

$$\begin{aligned} Q(T) &= Q_1^* - R(T) \\ &= Q_1^*\, [1 - \lambda\,(T)], \end{aligned} \quad (10)$$

where $[1 - \lambda]>0$, and $\lambda'(T)>0$

In equation (9), the first term shows the usual reposition cost, which is equal to the proportion r of total gross output, plus the costs of reposition due to the pollution effect on the machinery, which is equal to the proportion (r') of the level of pollution. Therefore, the coefficient of total reposition per unit of gross output is represented by λ, which increases over time, and, as a function of time T, is represented by $\lambda(T)$. Equation (10) shows the new relationship between net output and gross output.

The quantity of mineral resources required per unit of net output is then obtained from equation (10) as follows:

$$\begin{aligned} N(T) &= z\,Q_1^* \\ &= (z/[1 - \lambda\,(T)])\, Q_1 \\ &= \varepsilon\,(T)\, Q_1, \end{aligned} \quad (11)$$

where $\varepsilon(T)= z/[1 - \lambda(T)]$, $\varepsilon'(T)>0$, and $\varepsilon(0)=z/(1 - r)= \mu$.

The coefficient ε represents the quantity of mineral resources required per unit of net output, the value of which includes the feedback effect of pollution on the production process; moreover, the value of this coefficient increases over time owing to the cumulative effect that production has on pollution.

In order to derive the time path of the consumption possibilities frontier, equation (6) has to be rewritten to take into account the new relations that have become apparent:

$$\begin{aligned} S\,(T) &= S_0 - \Sigma\, N_j = S_0 - z\,\Sigma\, Q_j^* = S_0 - z\,Q_1^* T \\ &= S_0 - (z\,/[1 - \lambda\,(T)])\, Q_1 T \\ &= S_0 - \varepsilon\,(T)\, Q_1 T \end{aligned} \quad (12)$$

$$Q\,(T) = [S_0\ /\ \varepsilon\,(T)] - Q_1\ T \quad (13)$$

Equation (12) shows the time path of the stock of mineral resources, which at the point in time T is equal to the initial stock S_0 minus the quantity used up to that period. Equation (13) is the result of dividing equation (12) by the coefficient ε, which increases over time.

Equation (13) shows the entropic production process. It integrates flows and funds, as well as the interactions between the economic process and the biophysical environment. The quantity of net output Q_1, determined by the funds, the stock of machinery and labour, takes into account the constraint imposed by the stock of mineral resources. As T increases the requirement of mineral resources per unit of net output (the coefficient ε) also increases, which implies a continuous downward shift of the intercept of the frontier curve. The production time path, determined by the mineral resources constraint, is now non-linear, a convex curve. Thus, the same net output will lead to a more rapid depletion of mineral resources than in the previous case, which ignored the pollution feedback in the production process.

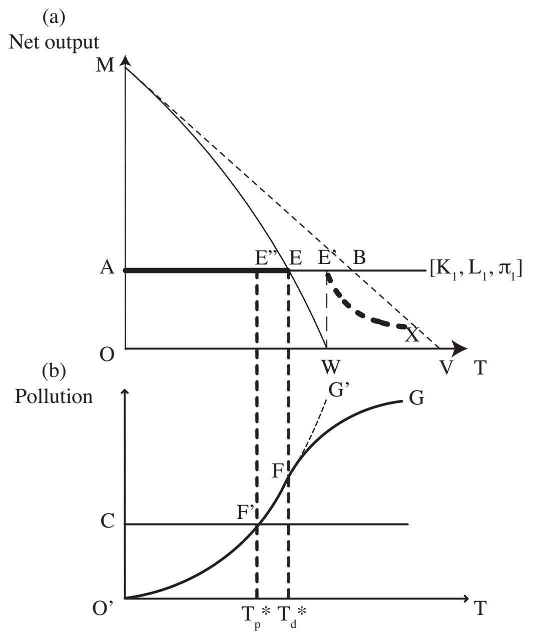
The entropic production process is represented in figure 2, with the depletion effect shown in panel (a). The straight line MV assumes a constant technological coefficient of mineral resources required per unit of net output (as in figure 1). This line represents the initial period. Since the coefficient ε increases over time, the line MV will shift continuously inwards and the new production frontier will be represented by the convex curve MW, which will transect the segment AB at point E. The entropic production process implies a more rapid depletion rate of mineral resources, as shown by the curve MW.

The point at which social intervention takes place occurs when the curve MW transects horizontal line AB at point E, referred to as period T_d^*. Beyond this period, the consumption possibilities for the remaining mineral resources will be given by the curve E'X. Then, social choice will determine a particular point along this curve. The intergenerational consumption frontier is more limited than the comparable curve shown in figure 1 because of the effect of the entropy law.

Panel b of figure 2 depicts the pollution effect. As the same quantity of net output is repeated over time, waste and pollution accumulate in the environment, as represented by the curve O'G. The curve rises sharply up to the period T_d^* when mineral resources become scarce. Beyond that point, at which society intervenes, the level of pollution continues to rise but at a slower rate, following the path FG rather than FG'; that is, as consumption levels fall, the rate of increase of pollution also falls, but the level of pollution increases continuously and irrevocably, in line with the law of entropy. Society can modify the rate of degradation, but cannot prevent degradation altogether.

FIGURE 2

Natural-resource depletion and pollution in the production process



Source: Prepared by the author.

Figure 2 thus shows the two laws of thermodynamics in action. These laws impose constraints on the production process through depletion and pollution and, as suggested in the figure, these effects are interrelated. The effect of the depletion of mineral resources sets a time limit on the production of a given net output: output OA can be repeated until period T_d^*. Pollution will have the same property. Our ecosystem has a limited capacity to absorb waste if it is to maintain its capacity to support human life. That limited capacity can be represented as a threshold, given by the level O'C, which occurs in period T_p^*. If atmospheric pollution exceeds this threshold, the preservation of human life, as we know it, cannot be guaranteed. The segment F'G of the rising pollution curve O'G will result in a steady decline in people's quality of life owing to food source pollution and on the deterioration of human health. At that stage humans will have to make qualitative changes and adopt adaptation measures since, for example, low oxygen levels in the air could result in a kind of anaerobic human existence.

The effects of resource depletion and pollution will impose different threshold periods on the human species, depending on which of the two effects occurs first. In figure 2, for instance, our model assumes that the pollution threshold (T_p^*) will be reached before depletion (T_d^*). The relevant constraint of the environment is, in this case, the capacity of the ecological system to support human society, not the depletion of mineral resources. This ecological capacity is the ultimate element of scarcity in the economic process. Everything can be produced or substituted, except ecological capacity. We humans cannot generate another ecological environment with which to sustain our existence. In this case, the intergenerational consumption frontier will trace the path of AE" only. The model assumes that human society will be motivated to take action when confronted with the risk of extinction. In such a situation, humans will need to achieve technological and institutional innovations to move to another age. Just as humans evolved out of the stone age despite the continuing existence of stones, the use of mineral resources will be abandoned before they become exhausted.

Figure 2 clearly indicates that the ecological challenges faced by humanity will persist even if consumption levels remain steady, that is, even if we had a zero-growth society, in terms of output and population. Certainly, the problem will be more acute if society embarks on a process of economic growth, as will be shown below.

The role of renewable natural resources in the economic process has been disregarded in the entropic model. The implicit assumption that these resources were abundant will now be revised. For this purpose, two sources of energy must now be distinguished in the production process: (i) the finite and therefore exhaustible mineral resources in the Earth's crust; (ii) the sun's energy, in the form of solar radiation, which provides the Earth with a source of energy for renewable natural resources, such as forests and fish stocks.

The Earth is a closed thermodynamic system, inasmuch as it obtains energy from the sun but does not exchange matter with outer space (Baumgärtner 2004, p. 320). The scarcity of renewable natural resources comes from the Earth's limited size as a trap for solar energy. As agricultural soil is limited and subject to erosion, it belongs in the category of non-renewable resources.

Fish stocks, forests and other biological resources may, however, be subject to depletion if the rate of biological reposition is slower than the rate at which they are exploited by humans. When renewable natural resources are not renewed, they become depleted in the same way as mineral resources. In this case, renewable natural resources can also be included in the coefficients that determine the model's intergenerational consumption frontier. Those renewable natural resources that are in fact renewed may be considered as redundant factors in the model and may thus be ignored in the analysis.

In panel (a) of figure 2, the production frontier as constrained by solar energy, considered an absolute redundant factor of production, can be introduced as a horizontal line starting from above point M. Under this assumption, the segment AE and the social choice of one, and only one, point in the segment E'X can still represent the intergenerational consumption frontier, which is now determined by non-renewable resources and by those renewable resources that human production activity has made non-renewable.

V

Model C: Substitutability between funds and flows

Another set of assumptions about the production process, according to standard economics, are covered by the concept of *production function*, which can be represented as follows:

$$Q = F(K, L, N) \tag{14}$$

Standard economics thus assumes that the quantity of output produced depends upon the stocks of machinery, labour and natural resources, and that all of these factors of production can be substituted for one another (Solow 1974, p.34). This simple equation implicitly suggests that the three factors play the same role in the production process. In such a scenario, net output could be produced with machinery and workers alone, thereby making it possible to sustain the level of net output indefinitely. Note the difference with the flow-fund approach, which was represented as a *production system* in equations (1)-(2), rather than as a production function.

A consequence of the standard economics assumption about the production process is that the production of a given net output can go on forever. Therefore, output growth can also go on forever. There are no limits to the production of goods. This view was established by Solow in his seminal paper of 1974 and updated by Lafforgue (2008, p. 541) as follows:

> "It is now generally accepted that the limited supply of non-renewable resources does not necessarily imply a limit to growth. In particular, the neoclassical theory gives rise to three main possibilities: (i) substitution of the resource by other inputs, such as capital; (ii) improvement of resource efficiency; and (iii) development of backstop technologies. However, without any technical change, none of these outcomes will balance the resource exhaustion and continue to sustain some positive growth in the long run."

According to this view, a way to introduce substitution between machinery and mineral resources would be to assume that the technological coefficient of mineral resources per unit of net output will fall as machinery stocks increase. This substitution would be induced by changes in the relative prices of minerals, that is, as mineral resources become more expensive.

Even accepting the possibility of substitution, the question remains: Where would the new machines come from? They would have to be produced and that would require more mineral resources. The net effect of substitution and the savings of mineral resources would be smaller than if a pure substitution effect were to take place; for example, windmills can substitute oil in generating energy, but building windmills requires minerals and other inputs. In addition, the net output is a material good, which cannot be totally dematerialized, according to the first law of thermodynamics, thus setting a limit on the possibilities of substitution.

In figure 1, if a quantity of capital can substitute mineral resources, then the line MV could shift outwards, to another line that could be referred to as M"V" (not drawn). But producing that quantity of capital would require mineral resources and would also imply reposition costs in terms of mineral resources. So, the net effect of substituting minerals would be smaller than the initial effect (a change from line MV to, say, line M'V', which would be drawn below line M"V"). If we assume that the net effect is positive, the curve representing the intergenerational consumption frontier would shift outwards. That would extend period T^*, though it would remain finite. More substitution could proceed, until the limit was reached. If the line MV represents the limit of substitution possibilities, the model will have captured the substitution effect.

In sum, in the entropic production process, substitution between fund and flow factors is possible —but only to a certain extent. This is in line with the assumption that mineral resources are essential factors of production, which is consistent with the laws of thermodynamics. However, these substitution effects will not eliminate the intergenerational consumption frontier. Even with substitution, if a given net output is repeated period after period, mineral resources will eventually become scarce and depleted and pollution will increase. Therefore, as long as mineral resources are essential factors in the production process, this conclusion will hold true. In short, the conclusions reached so far using the entropic model B retain their validity.

By comparison, standard economics has developed a large body of literature on growth theory. The models presented in popular textbooks predict that economic growth can proceed indefinitely and that the role of non-renewable natural resources can be ignored (Barro and Sala-i-Martin 2004). Given the rates of savings, population growth and technological progress, and assuming that K grows by 5%, L by 2% and π by 3%, in a dynamic equilibrium total output will grow by 5%, and so the output per person will increase by 3% (the difference between 5% and 2%). This could be repeated period after period, indefinitely. In these models, there are no constraints on growth.

Some neoclassical models do deal with non-renewable natural resources and an even smaller number with the problem of pollution, which is treated as simply a problem of externalities, and thus amenable to solution via Pigouvian taxes (Grimaud and Rouge, 2005). The neoclassical models that include natural resources in the economic process are still mechanical, and the qualitative consequences of economic growth for the environment (via the entropy law) are ignored. In this regard, Baumgärtner (2004, p. 308) affirmed that, "[neoclassical theory assumes that] on the whole thermodynamic constraints are simply irrelevant for economics".

VI
Changes in the intergenerational consumption frontier

The concept of the intergenerational consumption frontier has been constructed on the basis of a series of givens. The exogenous variables of model B include technology and the endowments of machinery, labour and mineral resources. It is time to analyse the effect of changes in these exogenous variables on the intergenerational consumption frontier.

An exogenous increase in the stocks of machinery and labour, together with any technological changes incorporated in new physical and human capital investments, will boost the current flow of gross output and net output; hence, the consumption level of the current generation will also increase. But that will lead to a concomitant rise in the rate of depletion of mineral resources, which will in turn increase the rate of pollution. In figure 2, higher stocks of K and L, and a higher level of π, will modify the intergenerational consumption frontier as follows: the level of consumption OA will shift upwards, leading to an inward shift of the curve MW representing the depletion of mineral resources and also an upward shift of the pollution curve O'G. Thus, the critical periods T' and T^* will occur sooner.

Another consequence is that the degree of intergenerational inequality will be higher: the consumption level of the present generation will increase, but the average consumption level of future generations will fall. In other words, economic growth implies greater intergenerational inequality. Therefore, the only choice society has is how to distribute the consumption level and the corresponding non-renewable resources between generations. A higher consumption level allocated to the current generation will mean that less mineral resources will be left for future generations, whose total consumption level will therefore be lower.

Consider now an exogenous technological change that leads to a decrease in the initial coefficient of mineral resources per unit of net output, the coefficient ε, which is determined by the initial coefficients z and

λ, as shown in equation (11). A reduction in the value of this technological coefficient is equivalent to an increase in the initial stock of mineral resources. This is a mineral-resource-saving technological change. Therefore, the intergenerational consumption frontier will shift outwards and the pollution curve will shift downwards.

These effects can be visualized using figure 2. With new technologies that save mineral resources per unit of net output, the intercept of the mineral resources constraint curve will move upwards, above point M; the curve MEW will shift outwards and so, consequently, will the intergenerational consumption frontier. The pollution curve O'G will shift downwards. From equations (8) and (10), we can see that the reason for this shift is that the curve O'G is determined by the flow of net output (Q_1=OA), which remains unchanged, and also by the technological coefficients, which will be lower. As a result, the critical periods T' and T^* will occur later.

It is still true, however, that the current level of consumption cannot be repeated period after period indefinitely; consequently, technological progress cannot eliminate the intergenerational consumption frontier—it can only move it to another level. At each new level of technology, there will be a new intergenerational consumption frontier; moreover, this new frontier will reduce the degree of inequality between generations. This is assuming that technological change is cost-free. Taking into account the cost of mineral resources in research and development (R&D), the net effect would be smaller.

Could technological change be efficient enough in saving mineral resources to make a given consumption level sustainable indefinitely? If we assume that technological change is endogenous and cost-free, it is possible to imagine a scenario in which, following the depletion by half of mineral resources in a given period of production, technological change could occur immediately and reduce the technological coefficient of minerals per unit of net output by half, which would be equivalent to doubling the remaining mineral resources. As a consequence, the stock of mineral resources would remain constant over time, that is, the mineral resources would have become *renewable* natural resources. If that were the case, the consumption level OA in figure 2 could be repeated forever. Along this horizontal line, machines and minerals would become renewable resources thanks to technological change.

However, the lower panel of figure 2 must also be considered: pollution will inevitably continue to have an impact. Mineral resources will be used up to produce Q_1 in the first period; and even if the stock of mineral resources were recovered economically through technological change, the mineral resources used up will have generated pollution. In the next period, net output will be repeated and new mineral resources will be used up; and even if the stock of mineral resources were recovered economically, the pollution caused will inevitably have had an impact and will now have accumulated for two periods, and so it would continue. The curve O'G will then become linear. In this case, pollution, not depletion, would be the limiting factor in the economic process. Technological change would now have to eliminate the build-up of pollution to achieve a non-entropic production process and would therefore have to solve two problems: depletion of natural resources and pollution. In the most favourable scenario, it is unlikely that technological change can subvert the laws of thermodynamics.

Economic growth combined with mineral-resource-saving technological change seem to have an ambiguous effect on the threshold periods, T' and T^*. The growth effect reduces the length of those threshold periods, whereas the technology effect extends them. However, given the argument set forth above about the limits of technological change, the economic growth effect will prevail and the time thresholds will be shorter. In sum, this suggests that economic growth will curtail the survival of human society, as we know it.

VII
Conclusions

Of the three theoretical models presented in this paper, model B, the entropic model, applies the laws of thermodynamics to the economic process and focuses on the interactions between the economic process and the biophysical environment. The outcomes of these interactions include consumption patterns, the depletion of natural resources and pollution of the environment. This examination of consumption patterns allows us to trace an intergenerational consumption frontier: any consumption level can be maintained for only a finite number of periods.

The exogenous variables of the entropic model include the initial stocks of capital, labour and mineral resources together with technology. Increases in the stocks of capital and labour, as well as new labour-saving technology, reduce the finite number of periods of the intergenerational consumption frontier, whereas technological progress that leads to savings in non-renewable natural resources increases this number.

The entropic model is able to predict the observed relationship between economic growth and environmental degradation. Thus, the empirical observation that increased world CO_2 concentrations in the air have coincided with a period of rapid economic growth, as described in the introduction, has a scientific explanation.

The entropic model has several implications for public policies. First, since any given consumption level can be sustained for a finite number of periods only, a higher consumption level will go on for fewer periods; that is, economic growth cannot go on indefinitely. Second, economic growth exacerbates the inequality in the intergenerational distribution of consumption. Third, technological progress can only reduce the rate at which environmental degradation takes place, since that degradation itself is continuous and irrevocable. Fourth, the conflict in relation to growth exists not only between generations, but also within the current generation: less developed countries will have more limited ecological space to grow if the most developed countries and a few emerging economies keep growing. In this regard, Edward Wilson, a Harvard biologist, concluded that, "To raise the whole world to the US [present living standard] level with existing technology would require two more planet Earths" (Wilson 1998, p. 282).

These relationships cannot be ignored in the debate on public policy alternatives, at both the national and international levels. These are the fundamental economic problems of our time and can be attributed to the fact that the economic processes of growth and distribution are currently taking place amid conditions of environmental distress, as explained by the entropic model presented in this paper.

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Internationalization and technology in MERCOSUR

Isabel Álvarez, Bruno B. Fischer and José Miguel Natera

ABSTRACT

The Southern Common Market (MERCOSUR), widely recognized as one of the most advanced regional integration schemes worldwide, is increasingly attractive to multinational enterprises and also very active in outward investments, despite persistent innovation and competitiveness gaps. In this paper we analyse internationalization and technology trends in MERCOSUR in relation to trade, the activities of multinational enterprises (MNEs) and the features of national systems of innovation. Our empirical findings, based on traditional gravity models, show the impact of foreign direct investment (FDI) (inward and outward) on exports, classified according to their technological content. Income distribution, which shapes the institutional characteristics of MERCOSUR countries, is specifically addressed as a proxy for the structural aspects of MERCOSUR countries. The findings confirm that technological and internationalization capacities —both as host and home countries of FDI— influence trade within the bloc.

KEYWORDS

MERCOSUR, globalization, competitiveness, trade, foreign direct investment, technology transfer, multinational enterprises

JEL CLASSIFICATION

F1, F4, O3

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I
Introduction

Structural changes introduced in the countries of the Southern Common Market (MERCOSUR) have helped to attract more multinational enterprises (MNES) to the region than during the import-substitution industrialization (ISI) period, but problems associated with weak specialization and innovation still persist in these economies.[1] In this paper we examine the relationship between internationalization trends and the technology content of exports using an empirical framework based on gravity models that can provide new insight into integration processes involving developing countries.[2]

Production in the MERCOSUR countries is characterized by a high proportion of activities in low-growth industries and limited innovation efforts —a characteristic shared by other Latin American countries. Although the manufacturing sector has increased its share in the exports of these economies, commodities continue to predominate, which can be an obstacle to international competitiveness (Cassiolato and Lastres, 1999). This production structure prevents these countries from fully benefiting from the advantages associated with advanced technological specialization, which would lead to greater integration in dynamic international markets. Such specialization ultimately depends on each country's industrial structure, as well as on the characteristics of a complex set of elements referred to as national systems of innovation (Narula and Wakelin, 1995).

Although openness does not necessarily lead to growth and development (Rodrik, 1999; Fagerberg and Srholec, 2008), some national capabilities can be built —or improved— through trade, and a higher degree of openness may enhance competitiveness gains. By carrying out their production activities and generating value added, large, internationalized corporations may help their host countries to enter more technologically sophisticated segments of the global value chain, which could boost national innovation capacity. Those enterprises can then contribute not only to expanding investment flows between countries, but also to promoting the competitiveness of both home and host economies. This last aspect can be seen most clearly in regional contexts (Rugman and Doh, 2008).

In recent years, developing economies have experienced a surge in FDI inflows and the emergence of outward FDI (Chudnovsky, 2001; UNCTAD, 2005 and 2007). In particular, the FDI boom in Latin American countries in the 1990s strengthened the position of MERCOSUR economies as host and home countries that were increasingly used by multinationals as platforms to expand their operations in the region. Some MERCOSUR countries have taken advantage of their potential as active players in terms of outward FDI. These new trends justify an analysis of bilateral flows between MERCOSUR countries to examine the opportunities that international companies may have opened up for the technological integration of the bloc, taking into account some of the structural features of its member countries.

This paper analyses the relationship between trade, FDI and technology in MERCOSUR, based on the assumption that the competitiveness of Latin American countries is conditioned by their technological capabilities and access to knowledge (Rosales, 2009). Data from several recognized international sources will be used to build gravity models in order to identify the factors determining trade flows, while controlling for innovation patterns. To that end, we will test the influence of FDI flows on export performance, disaggregated by the technological level of products. We expand the traditional gravity model to take into account some specific characteristics of the MERCOSUR countries' internationalization and institutional frameworks, including, for example, income distribution as measured by the Gini index.[3] We propose an alternative empirical framework for studying trade that looks at internationalization, level of technological development and the influence of the national institutional features of these Latin American countries.

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[1] Latin American countries on the whole continue to make extremely limited investments in research and development (R&D) at the domestic level (see Gonçalves, Lemos and De Negri (2008); and Yoguel, Borello and Erbes (2009)).

[2] Several search requests using the ISI Web of Knowledge online platform have shown that scientific articles on the relationship between FDI and innovation in MERCOSUR are scarce (our search yielded only one hit containing the three keywords). This further justifies the analysis of this relationship conducted in this paper.

[3] Alonso and Garcimartín (2011) found that the Gini index is a robust indicator of overall institutional quality.

The paper is organized into five sections. Following this introduction, the second section contains a review of the main background literature. The third section describes some of the features of firms' internationalization in the MERCOSUR countries and the region's innovation performance, as well as the trade and FDI flows within the region. Section four presents the theoretical foundation of our empirical analysis and a discussion of the findings. The last section draws some conclusions from our findings and highlights their policy implications, as well as possible avenues for future research.

II

Background literature

According to the eclectic paradigm, FDI flows can be explained by a combination of ownership, location and internalization advantages (OLI theory) that large companies are able to harness and which justify their internationalization through investments abroad (Dunning, 1977 and 1981). Some economists argue that the effect of regional integration on FDI depends on the attractiveness of the locations and the scope of countries' trade liberalization and investment policies (Blomstrom and Kokko, 1997). The evidence available suggests that the impact of integration among the MERCOSUR countries has been smaller than that of other regional integration processes, such as the European Union (Worth, 1997), while there is only limited information on the location advantages for attracting FDI in different regional blocs. Studies have revealed that the macroeconomic impact of FDI in MERCOSUR countries is not significant, with neither a positive nor a negative effect on growth in the region; however, the microeconomic impact of FDI appears to be much stronger (Chudnovsky and López, 2007) as MNEs have expanded their presence in the region and MERCOSUR countries are more competitive now than during the ISI period. The main motivations for FDI, such as market seeking, efficiency seeking and knowledge seeking, vary depending on the country's stage of economic development (Dunning, 2006; Narula and Dunning, 2000; Dunning and Narula, 1996). In the MERCOSUR countries, MNEs in the services and manufacturing sectors have adopted a predominantly market-seeking strategy and have increased exports flows significantly, especially to neighbouring countries (Chudnovsky, 2001). Nonetheless, there are some differences between countries, with firms in Brazil adopting asset-seeking strategies and those in Uruguay predominantly motivated by resource seeking with a focus on exports, which more closely resembles the traditional strategies of MNEs in the region. Efficiency seeking is becoming an increasingly important motivation: during the ISI period, MNE subsidiaries operated on the basis of a high degree of national integration, but since the 1990s strategies have focused on fostering international trade integration (Chudvnosky, 2001; Chudnovsky and Lopez, 2007).

In the discussion on developing countries' approach to innovation, one interesting argument is that developing economies should focus on the adaptation and efficient use of existing technology, at least in the first stages of development, also known as the industrialization phase (Lall, 1996 and 2000). Countries must first develop their technological capabilities in order to adopt the technical changes and innovations developed elsewhere (Dahlman, Ross-Larson and Westphal, 1987; Lall, 1992). The decision to absorb and adapt existing technologies or create new technologies through the expansion of research and development (R&D) and innovation is unique to each nation and dependent on its level of development (Gerschenkron, 1962) and degree of modernization. These differences in approach are dictated by the industrial structure of many developing economies, which combine traditional labour-intensive industries and technologically complex industrial activities (Uchida and Cook, 2005). Although most of the data are from the Asian economies, other economies have been able to carve out their own technological niches (for example, Brazil in aircraft, electronics and computers) as a result of a combination of government efforts and domestic and foreign capital.

It is generally accepted that the acquisition of technological expertise is a cumulative process, one that necessarily requires the development of absorptive capacities, involvement in a variety of networks, interaction with customers and suppliers, and the acknowledgement of other factors specific to the local environment (Cantwell, 1989; Lundvall and others, 2002; Fagerberg and Srholec, 2008a; Álvarez, Marín and Fonfría, 2009; Álvarez and Cantwell, 2011). The upgrading process can therefore be viewed as the culmination of efforts to build new capabilities in developing countries, which entails two levels of action: investments at the national level in science and technology, information flows, infrastructure and supporting institutions; and micro-level efforts by firms to develop new organizational and technological skills so that they can tap into new information and select the most advantageous specialization vis-à-vis other firms (Lall, 1997). There is a certain overlap between innovation and diffusion activities and, therefore, they do not take place sequentially in all cases (López and Lugones, 1997). Indeed, technology diffusion often involves continuous (generally incremental) technical change to adapt to specific contexts; nonetheless, the increasing internationalization of productive activities has allowed some countries to fast-track the process of technological upgrading thanks to the technology transfer possibilities inherent to global value chains —a strategy that has been applied systematically in East Asia and North and Central America. Costa Rica, for example, has specialized in high-technology export-oriented production in a short period of time, moving swiftly from agriculture in the 1980s to a high-tech specialization in electronics in the 1990s, then to medical instruments and aeronautics in the 2000s.

Although the technological activities carried out by MNEs in host countries are diverse (Archibugi and Michie, 1995; Cassiolato and Lastres, 1999; Patel and Pavitt, 2000; Cantwell and Janne, 1999), there is a broad consensus regarding the active role that MNEs can play in the generation and diffusion of knowledge at the international level. These companies may be seen as a channel of access to international markets through trade and, in turn, that access may lead to the extension of the productive systems in which MNEs operate. Nevertheless, greater intra-firm interaction in relation to technological change and the increased mobility of MNEs does not detract from the importance of building local capabilities in developing economies. In fact, a study on the effects of technological transfer from United States multinationals confirmed the existence of local factors that have significant positive effects for developed countries, but not for developing countries, with human capital playing a crucial role (Xu, 2000). An analysis of two countries in Latin America by Mortimore and Vegara (2004) showed that the nature of FDI and its effect depends on technological capacities, human capital thresholds and supplier capabilities in the host country, and established that a minimum capability level is required to benefit from technology diffusion from MNEs. These findings support the role of national innovation systems in attracting FDI.

In the case of MERCOSUR, MNE subsidiaries are more involved than domestic companies in international trade (imports and exports) (Chudnovsky and Lopez, 2007). However, the technology content of subsidiaries' exports is lower than that of their imports —particularly those from their countries of origin— and the bulk of these exports are destined for developing countries, especially in Latin America. The specialization patterns of subsidiaries in MERCOSUR have two notable features: they export high added value and technologically sophisticated goods to MERCOSUR and the rest of Latin America, while they import capital goods, inputs and components from developed countries (Chudnovsky, 2001). Moreover, as the results of some case studies have shown, in the sequential internationalization strategies of MNEs from the Latin American economies —the so-called *multilatinas*— production facilities have taken precedence over marketing in the activities of their subsidiaries abroad in order to benefit from location advantages (Cuervo-Cazurra, 2007).

In recent decades, MERCOSUR countries have introduced policies to attract foreign investment and to enhance the quality and productivity of local firms in order to make their economies more competitive, while also giving impetus to the *multilatinas*. Meanwhile, the increasing role of technology flows and the activity of MNEs in the regional integration process has been explored to a lesser degree in the literature, opening a new window of opportunity for research.

III
A short description of the data

Inward FDI trends have been positive for all the MERCOSUR countries in recent decades (see figure 1). Nonetheless, in the period 1980-2008, Argentina and Brazil attracted more FDI in relative terms than Paraguay and Uruguay, as shown by the figures for inward FDI stock as a percentage of gross domestic product (GDP). Inward FDI stock began to falter in the early 1990s in all of the countries except Argentina, and declined sharply at the beginning of the 2000s for all of the countries, including Argentina, owing not only to the world economic cycle, but also to the domestic economic and political crises affecting these countries. In 2000, Uruguay overtook Brazil and Argentina to take the leading position in this indicator in MERCOSUR (UNCTAD, 2005 and 2007). Overall, FDI has grown as a proportion of GDP in the last decades, though it plateaued and dipped to some extent in the 2000s, except in Uruguay.

Regarding outward FDI stocks as a proportion of GDP, Brazil and Argentina are the countries in the region with the highest capacity for investing abroad as they have the comparative advantages inherent to their size to fuel the capitalization process needed to set up MNEs. The values for this indicator for the smallest countries (Paraguay and Uruguay) pale in comparison with those for Brazil and Argentina (see figure 1). In the period under consideration, MNEs from the two larger economies performed very positively. Argentina saw a remarkable jump in its outward FDI stock in 2002 and for several years posted higher levels than Brazil. The Argentine capital outflows varied substantially over the period as a whole, although the overall tendency was positive; more moderate fluctuations were observed for Brazil. In any case, the differences between the countries are less prominent than those for inward FDI. Brazilian outward FDI stock has been growing steadily since the late 1990s, while Argentine stock was also following that path until it declined sharply in 2002; the data for Paraguay and Uruguay show outward FDI from these two countries has been rather stagnant.

Figure 2 illustrates spending on R&D as a percentage of GDP. This indicator can shed light on innovation in MERCOSUR countries and is a proxy for investment in building technological capabilities, which can be defined as the "ability to search for, create, and use knowledge commercially" (Fagerberg and Shrolec, 2009). Each country's capacity to be more productive in the learning economy is dependent on the scale of its efforts to achieve the higher knowledge levels that lead to greater economic benefits (Lundvall and Johnson, 1994). Although R&D expenditure paints only a partial picture of the efforts that countries are taking to build their technological capabilities, it shows that Brazil is leading the way in creating new opportunities in the region in both absolute (owing to the size of the Brazilian economy) and relative terms (see figure 2). Spending on R&D as a percentage of GDP in the region has remained relatively unchanged over the last 15 years, with Brazil spending the most, followed by Argentina and Uruguay, while Paraguay lags far behind.

FIGURE 1

MERCOSUR: inward and outward FDI stock by country, 1990-2008
(Percentages of GDP)

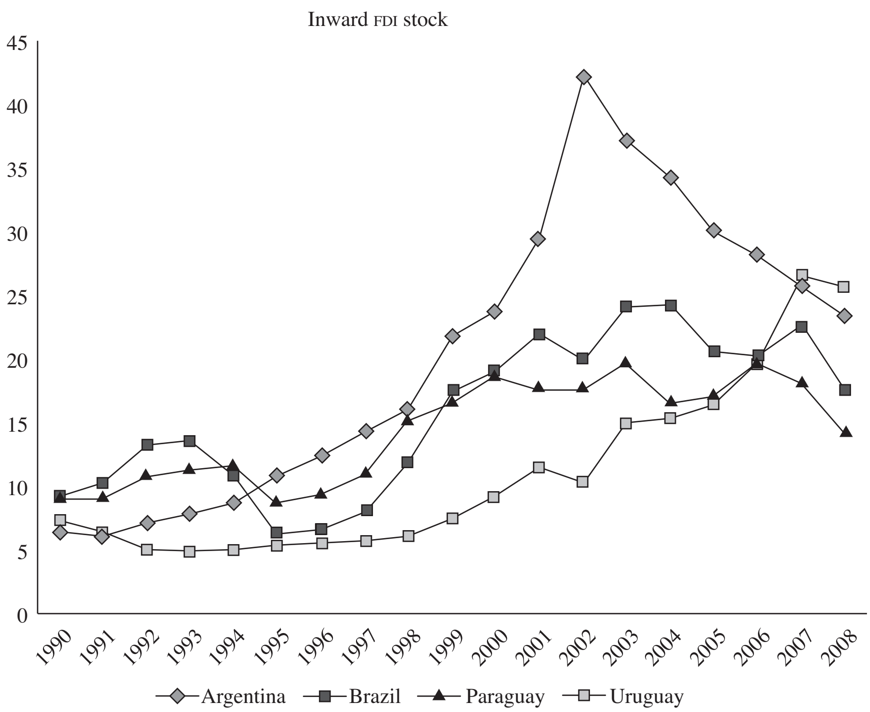
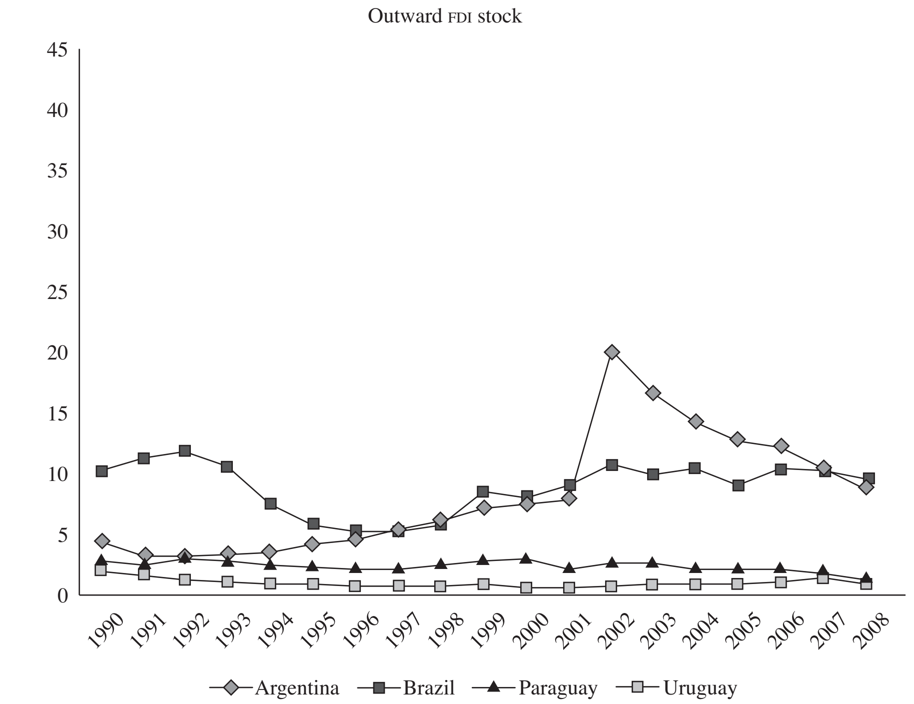


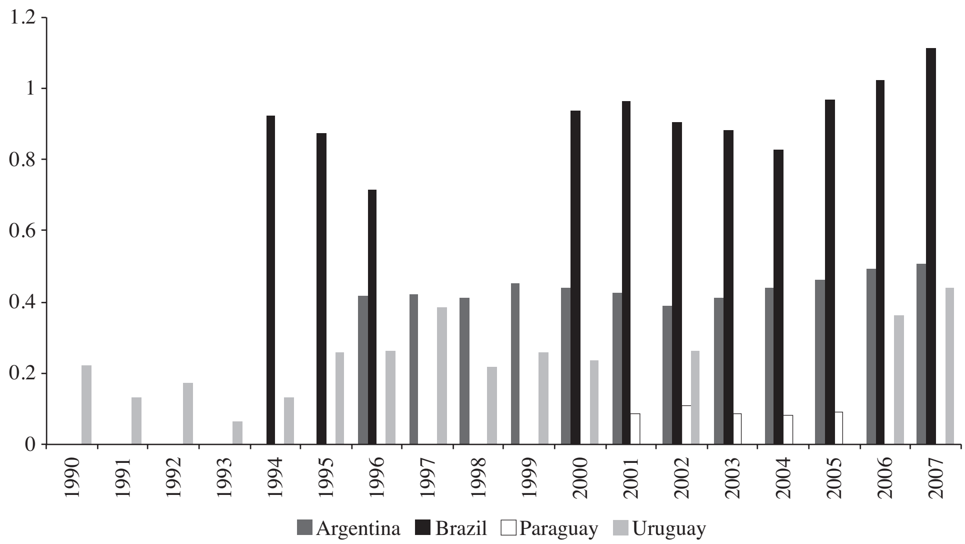
Figure 1 (concluded)



Source: United Nations Conference on Trade and Development (UNCTAD), UNCTADSTAT [online] http://unctadstat.unctad.org/.

FIGURE 2

R&D expenditure as a percentage of GDP



Source: Ibero American Network of Science and Technology Indicators (RICYT).

Tables 1 and 2 show the distribution of the largest MNEs from MERCOSUR countries and from outside the region.[4] As shown in table 1, nearly 70% of the largest Argentine MNEs have affiliates in Brazil or Uruguay, which reveals how attractive the regional bloc is to Argentine companies. Similarly, Uruguayan firms tend to focus on other countries in the region, with more than 90% of the largest Uruguayan MNEs located in Argentina, Brazil or Paraguay. However, the pattern for Brazilian multinationals is rather different since the MERCOSUR countries are not among their main FDI targets (with the exception of Argentina which hosts 21.2% of Brazil's largest MNEs). Data for Paraguay were not available.

Table 2 shows that the share of MERCOSUR economies playing host to the largest foreign MNEs is quite small. In fact, none of the largest foreign-owned firms operating in Brazil and Argentina are originally from the MERCOSUR economies. Although Brazilian and especially Argentine companies account for a proportion of the largest foreign-owned firms operating in Paraguay and Uruguay, MNEs from other countries still predominate, accounting for roughly 75% in both cases. These two tables thus illustrate that MERCOSUR is an important destination for FDI from MNEs within the bloc (outward FDI from MERCOSUR countries), while inward FDI is mostly dominated by companies from countries outside the region.

Finally, information on trade flows between MERCOSUR countries adds further detail to the picture of internationalization trends. Figure 3 presents the export profiles of the MERCOSUR countries (only intra-MERCOSUR trade flows are considered) according to the technological classification of exports suggested by Hatzichronoglou (1997).[5] The vast majority of Paraguay's exports are low technology, with other types of products accounting for a

[4] Data are from the United Nations Conference on Trade and Development (UNCTAD) investment country profiles, which list the largest foreign multinational enterprises in the host economy and the largest foreign affiliates of home-based transnational corporations.

[5] Data are not available for 1994 for Brazil and for 1992 for Uruguay.

TABLE 1

Location of largest foreign affiliates of home-based MNEs in MERCOSUR
(Percentages)

Host country / Home country	Argentina	Brazil	Paraguay	Uruguay	Other
Argentina	-	34.3	0.0	34.3	31.4
Brazil	21.2	-	0.0	3.0	75.8
Paraguay	-	-	-	-	-
Uruguay	58.1	29.0	3.2	-	9.7

Source: United Nations Conference on Trade and Development (UNCTAD) foreign direct investment country profiles.

TABLE 2

Host position of the largest affiliates of foreign MNEs in MERCOSUR
(Percentages)

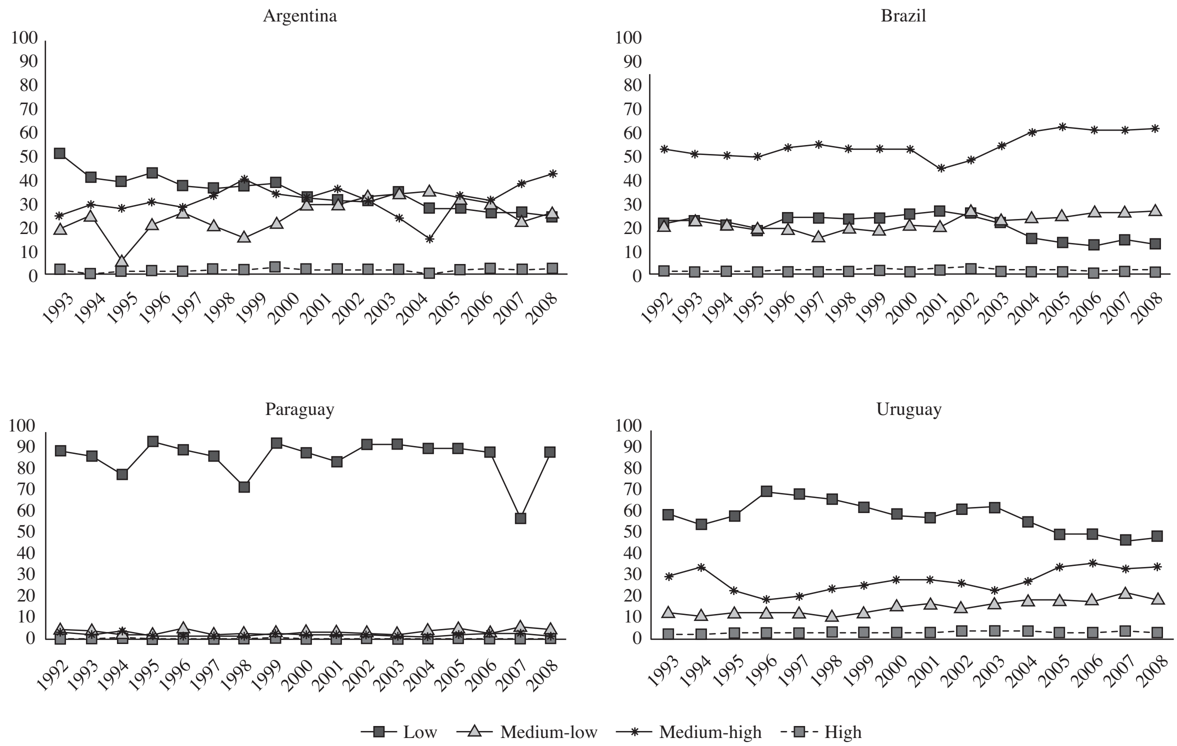
Host country / Home country	Argentina	Brazil	Paraguay	Uruguay	Other
Argentina	-	0.0	0.0	0.0	100.0
Brazil	0.0	-	0.0	0.0	100.0
Paraguay	11.5	7.7	-	3.8	76.9
Uruguay	22.7	2.3	0.0	-	75.0

Source: United Nations Conference on Trade and Development (UNCTAD) foreign direct investment country profiles.

negligible proportion of its export structure. Overall, the export breakdown of Argentina, Brazil and Uruguay is more technologically advanced. The share of low-tech products has decreased in Argentina and Brazil, but remains significant in Argentina and is high in Uruguay. It is worthy of note that the medium-high technology category has expanded in the most recent years of the period under consideration. The proportion of high-tech products exported by Brazil and Argentina to their MERCOSUR partners is very small and has not increased over time, which denotes an important weakness that may have interesting implications for intra-MERCOSUR trade, perhaps ultimately fostering greater specialization in higher value added activities, especially in Brazil and Argentina, in relation to neighbouring markets.

FIGURE 3

Country export profiles according to the technological classification of products, 1992-2008
(Percentages)



Source: Based on data from the Inter-American Development Bank (IDB), *DATAINTAL: Sistema de estadísticas de comercio de América*, Washington, D.C., 2010.

IV

Empirical model and findings

The estimation of international trade models has a long tradition in economics and the use of gravity equations in relation to bilateral trade, in particular, has dominated empirical research on international trade. Thus, the volume of trade between two countries is proportional to the size of their economies, and the factor of proportionality depends on measures of trade resistance between them (Anderson, 1979; Helpman and Krugman, 1985; Helpman, 1984; Feenstra, 2002; Anderson and Van Wincoop, 2003). This approach has been supplemented with theoretical underpinnings and better estimation techniques since most of the studies have estimated the gravity equation using samples of countries that have only positive trade flows between them, disregarding countries that do not trade with each other. Standard specifications of the gravity equation impose symmetry that is inconsistent with the data and this leads to biased estimates. This problem was corrected in Helpman, Melitz and Rubinstein (2008) where a simple model of international trade with heterogeneous firms predicted positive as well as zero trade across pairs of countries, allowing the number of exporting firms to vary across destination countries.[6]

Some methodological issues should be considered in the analysis of bilateral trade flows using the gravity model. One crucial issue is the econometric specification of the gravity equation, as well as the validity and reliability of the estimation (Greenaway and Milner, 2002; Gil and others, 2005). Very often, gravity equations that have been estimated using cross-section or pooled data on total trade have been challenged because, among other reasons, conventional ordinary least squares (OLS) estimations are unable to deal with the heterogeneity that is inherent to bilateral trade flows. Using panel data is accepted as an appropriate solution to this problem because they allow for individual country-pair characteristics. However, it was not possible to apply this solution here owing to limited data availability and a lack of panel data for the empirical analysis of internal trade within MERCOSUR since bilateral flows in the given period provide few observations. To address this limitation, we applied a pooled regression model for the period 1992-2008,[7] which justifies the use of simple OLS estimations.

The objective of this empirical analysis is to study trade flows between the MERCOSUR countries and how the internationalization processes of these countries are conditioned by both FDI patterns and institutional contexts. We use the framework provided by gravity models, which we extend in the following two directions: first, we assume that technology transfer processes help to define a country's innovation system, which justifies the consideration of the absorption of technologies from abroad (inward FDI) and the development of a country's own capabilities (outward FDI), introducing a control for trading disembodied knowledge (using royalty receipts as a proxy[8]); second, we include certain indicators in the model to reflect the structural characteristics of the institutional set-up of these economies.

One of our contributions to the literature on this topic is a modified version of the gravity model that takes account of the structural aspects of trading economies. Income distribution, which can be measured for most Latin American economies, is used as a proxy indicator of countries' institutional set-up (Alonso and Garcimartín, 2011). Although the precise theoretical foundations have not yet been established for the inclusion of these determinant factors in trade or FDI models, greater specialization in high-tech activities is expected to be positively related to a more unequal economy (Freeman, 2011). In fact, countries with higher levels of technological internationalization are expected to score higher Gini values and thus score a positive sign in relation to this variable. In addition, to analyse the different levels of technology in the goods traded between the MERCOSUR countries, we use the classification of trade flows defined by the Organisation for Economic Cooperation and Development (OECD), distinguishing between low, medium-low, medium-high and high technological content. Since this taxonomy was constructed for developed countries, we combine medium-high and high technological content into a single category for the countries included in our study.

Accordingly, equation (1) is the estimation of the basic model of trade including international flows of capital and technology, while equation (2) also includes the institutional variable described above (for a description of variables see table 3):

$$lnTRD_{ijt} = lnGDPPC_{jt} + lnPOP_{jt} + lnDIST_{ij} + lnFDI_{it} + lnROYALTYRCPT_{it} + \varepsilon_{ijt} \quad (1)$$

$$lnTRD_{ijt} = lnGDPPC_{jt} + lnGINI_{jt} + lnPOP_{jt} + lnDIST_{ij} + lnFDI_{it} + lnROYALTYRCPT_{it} + \varepsilon_{ijt} \quad (2)$$

where:
TRD_{ijt}: Trade flows from country "i" (exporter) to country "j" (importer) in period "t".
$GDPPC_{jt}$: GDP per capita of importing country "j" in period "t".
POP_{jt}: Population of importing country "j" in period "t".

6 This involves a two-stage estimation procedure that uses an equation for selecting trade partners in the first stage and a trade flow equation in the second.

7 Anderson (1979) suggests that pooled data models are a functional form of operating gravity equations in his seminal article "A Theoretical Foundation for the Gravity Equation". The ordinary least squares (OLS) estimation method is used.

8 We chose not to use royalty payments after testing this variable in the models and discovering that it introduces collinearity effects into the model, meaning that no additional information could be obtained from it.

$DIST_{ij}$: Distance measured in kilometres between the capitals of country "i" and country "j".
FDI_{it}: Inward FDI stocks for exporting country "i" in period "t" used to verify foreign multinationals' impact on the country's exporting capacity; and outward FDI stocks in period "t" as a representation of the country's level of internationalization. This variable takes into account total FDI flows and does not reflect only internal FDI stocks in the MERCOSUR countries.
$ROYALTYRCPT_i$: Royalty receipts by exporting country "i" in period "t".
$GINI_{jt}$: Gini index for country "j" (importer) in period "t".
ε_{ijt}: Error term for trade flows between country "i" and country "j" in period "t".

We expect GDP per capita and the population size of the importing country to have a positive impact on trade flows, with larger markets attracting more trade. A greater distance between capitals is expected to have a negative impact, as we assume that markets located near to each other are more likely to trade. Although GDP is usually one of the variables applied in gravity models (see, for example, Brenton, Di Mauro and Lücke, 1999; Bloningen and others, 2007; Feenstra, Markusen and Rose, 2001; Anderson and Van Wincoop, 2003; Frankel, Stein and Wei, 1995; Feenstra, 2002; Anderson, 1979), in our analysis we use GDP per capita because it gives a measure of purchasing power that reflects development levels within the MERCOSUR markets. By including GDP per capita and population size, we can control for market size in a basic decomposition of GDP.

Highlighting some relevant social and economic characteristics can help to frame the countries under analysis. First, Brazil is the clear leader in terms of GDP and population size, but it ranks third among MERCOSUR countries in terms of GDP per capita. Second, with regard to income distribution, Brazil and Paraguay have the highest Gini index coefficients in MERCOSUR. These characteristics pose a clear challenge for the application of the gravity models since the outcomes might be conditioned by expectations stemming from the institutional features of Brazil —the most influential economy in the bloc. Thus, it is relevant to include the institutional features that foster development to avoid biased results, especially considering the institutional complexity of Latin American countries.

TABLE 3

Codes, description and sources of operational variables

Variable	Description	Source
TRD	Bilateral trade flows, 1992-2008, classified into three groups by technological content, as defined by Hatzichronoglou (1997): low; medium-low; and medium-high and high	DATAINTAL, Inter-American Development Bank
GDPPC	Gross domestic product per capita, 1992-2008	World Development Indicators, World Bank
POP	Population, 1992-2008	World Development Indicators, World Bank
DIST	Distance between countries' capitals (for Brazil the economic centre, São Paulo, was used instead of Brasilia)	-
FDIIN	Total inward FDI stock, 1992-2008	UNCTADSTAT
FDIOUT	Total outward FDI stock, 1992-2008	UNCTADSTAT
ROYALTYRCPT	Total royalties receipts, 1992-2008	World Development Indicators, World Bank
GINI	Gini index, 1992-2008	CANA Database

Source: Prepared by the authors.

The results of the estimations calculated using equations (1) and (2) justify our interest in national innovation systems. The estimations have been conducted both on aggregate trade data (total trade flows) and on data disaggregated by the technological content of exports (low technology, medium-low technology, and medium-high/high technology products). In addition, separate estimations were replicated for bilateral flows with the Latin American region as a whole, as well as with the United States and Europe, including MERCOSUR as a control variable. The estimations confirm that this regional trade agreement has an effect on trade and FDI flows.

Table 4 contains the results for a typical gravity model examining the effect that foreign capital plays on the export capacity of a host country by looking at the inward FDI stock and the usual gravity variables for the importing markets, without regard to the amount of royalties received by the exporting economy. As expected, the DIST variable (measured in kilometres) has a consistently negative impact on trade.[9] The coefficients corresponding to population size (the POP variable) are all significant and positive, though it is worth taking into account that the Brazilian population is significantly larger than those of the other South American countries. The variable for GDP per capita is only statistically significant in relation to the trade of medium-low and medium-high/high technology products and the negative sign of the estimated coefficient —contrary to what is normally expected from gravity models— reveals the least sophisticated patterns of consumption in these economies. This could be explained by the notable influence in the bloc of Brazil, which has a lower GDP per capita than Uruguay and Argentina, despite being the market leader in the region. For the period under consideration, the ROYALTYRCPT indicator is not significant in relation to the trade flows with the highest technological content. Meanwhile, the impact of inward FDI on trade between MERCOSUR countries is significant and positive, and its influence (coefficients) increases in line with the technological content of the exports. This suggests that foreign capital and intra-firm trade resulting from the integration of global value chains may boost the export capacity of MERCOSUR countries, promoting the generation of capabilities and higher value added commerce within the bloc. However, one intriguing implication of this is that countries' export capacity could become dependent on multinational firms from third countries.

Next, we estimate a similar model, this time using outward FDI to assess the influence of the internationalization capacity of MERCOSUR nations on their intra-bloc trade structure (see table 5). GDP per capita again performs poorly as a gravity variable, while the population size coefficients remain robust and significant, similar to the finding for the set of

9 Although we would expect a less significant coefficient for more high-tech products.

TABLE 4

Typical gravity model: analysis of inward FDI stock by the technological content of trade

	All trade flows	Low technology	Medium-low technology	Medium-high and high technology
$lnGDPPC_{jt}$	-0.056 [0.105] (-.54)	0.024 [0.102] (.24)	-0.457*** [0.191] (-2.40)	-0.501*** [0.213] (-2.35)
$lnPOP_{jt}$	0.847*** [0.029] (29.23)	0.709*** [0.028] (25.33)	1.104*** [0.052] (21.12)	1.038*** [0.058] (17.77)
$lnDIST_{ij}$	-0.324*** [0.056] (-5.79)	-0.201*** [0.054] (-3.71)	-0.624*** [0.101] (-6.17)	-0.577*** [0.113] (-5.11)
$lnFDIIn_{it}$	0.700*** [0.019] (35.83)	0.541*** [0.018] (28.68)	0.865*** [0.035] (24.54)	1.086*** [0.039] (27.59)
$lnROYALTYRCPT_{it}$	0.082*** [0.015] (5.31)	0.037*** [0.015] (2.47)	0.146*** [0.028] (5.24)	0.009 [0.031] (.30)
Constant	-6.055*** [0.969] (-6.24)	-4.04*** [0.937] (-4.31)	-8.889*** [1.749] (-5.08)	-7.429*** [1.954] (-3.80)
Adjusted R^2	0.915	0.882	0.837	0.838

Source: Prepared by the authors.

Note: The sources of the individual variables are available in table 3. Standard errors are reported in the square brackets. The figures in parentheses are the t-test values.
*** Significant at 1%.

models assessing inward FDI. The results for the distance variable ($DIST_{ij}$) are also similar to those found in the previous estimation. By contrast, the estimated coefficient for the royalties receipts variable ($ROYALTYRCPT_{it}$) is more irregular where outward FDI is concerned. The internationalization strengths of MERCOSUR countries measured in relation to outward FDI vary according to the technological content of exports, but to a lesser extent than in relation to inward FDI. These findings support the evidence presented in the related literature: the generation of internal capabilities fosters internationalization in both investment and trade.

TABLE 5

Typical gravity model: analysis of outward FDI stock by the technological content of trade

	All trade flows	Low technology	Medium-low technology	Medium-high and high technology
$lnGDPPC_{jt}$	0.212*** [0.104] (2.05)	0.234*** [0.099] (2.35)	-0.128 [0.194] (-0.66)	-0.081 [0.210] (-0.39)
$lnPOP_{jt}$	0.835*** [0.028] (29.59)	0.700*** [0.027] (25.83)	1.087*** [0.052] (20.61)	1.019*** [0.057] (17.80)
$lnDIST_{ij}$	-0.296*** [0.054] (-5.42)	-0.179*** [0.052] (-3.42)	-0.587*** [0.102] (-5.75)	-0.534*** [0.110] (-4.82)
$lnFDIOut_{it}$	0.568*** [0.015] (36.81)	0.441*** [0.014] (29.71)	0.698*** [0.028] (24.18)	0.883*** [0.031] (28.19)
$lnROYALTYRCPT_{it}$	0.002 [0.015] (0.16)	-0.025* [0.014] (-1.68)	0.049* [0.029] (1.68)	-0.114 [0.031] (-3.63)
Constant	-5.055*** [0.939] (-5.38)	-3.287*** [0.902] (-3.64)	-7.586*** [1.755] (-4.32)	-5.887*** [1.905] (-3.09)
Adjusted R^2	0.919	0.889	0.833	0.843

Source: Prepared by the authors.

Note: The sources of the individual variables are available in table 3. Standard errors are reported in the square brackets. The figures in parentheses are the t-test values.

* Significant at 10%. *** Significant at 1%.

In the last stage of our study, we use an adapted gravity model that reflects certain institutional characteristics. We have included the Gini index as a control variable for institutional set-up —unprecedented in previous research on the topic— with the aim of providing a more precise assessment of the bloc under analysis (see tables 6 and 7). The estimations show that the population variable (POP_{jt}) is again consistently positive and represents a special distinction for the case of medium-high technology trade within MERCOSUR, which could indicate the import profile of the leading economy in this context. The distance variable ($DIST_{ij}$) is again negative (see table 6). The role of inward FDI is similar to that seen in the previous estimations and we thus assume that it will have the same implications as already mentioned above. Although findings coincide with the model that estimated the influence of inward FDI on trade by technological content (see table 4), they indicate that GDP per capita remains negative and that the income distribution variable has no significant effect. When we analyse trade flows controlling for their technological content, income inequality does not seem to have any marked effect as the Gini coefficients are not found to be significant.[10] The results for outward FDI are dramatically different (see table 7): this variable is significant across all the estimations, which shows that the home countries of MNEs experience a positive effect. Meanwhile, GDP per capita is positive in the estimation of all trade flows and low-tech trade, and the Gini index is positive and significant in the whole set of models. The remaining variables follow the same patterns seen in the previous estimations.

These last two estimations incorporating the Gini index provide some interesting insights: the Gini coefficient offsets the effect of GDP per capita in MERCOSUR as it is correlates positively with trade flows in relation to outward FDI. Our findings proved the significance of countries' internationalization capacity —as both host and home countries of MNEs— in terms of trade within the bloc. This finding was especially significant in the case of inward FDI stock, revealing the positive influence of MNEs on these countries' trading patterns, which could lead, in particular, to a stronger capacity to invest abroad and the increased competitiveness of domestic companies. When looking at outward FDI in relation to the Gini index, outward FDI is significant and has a positive coefficient that increases in line with the technological content of exports and also with the values of the Gini index. The relationship between income distribution inequality and technological capabilities offers a profusion of possibilities for further study beyond the scope of this paper; however, our findings provide some support for a positive association between technological content and inequality.

[10] The GINI coefficient is significant only for the estimation pertaining to "all trade flows". Since the results in relation to the different levels of technological content are not significant, we have no evidence to support that inequality is an important factor to consider in the model.

TABLE 6

Gravity model: analysis of inward FDI stock by the technological content of trade, controlling for income inequality using the Gini index

	All trade flows	Low technology	Medium-low technology	Medium-high and high technology
$lnGDPPC_{jt}$	-0.215 [0.140] (-1.53)	-0.115 [0.135] (-0.85)	-0.540** [0.255] (-2.12)	-0.705** [0.284] (-2.48)
$lnGINI_{jt}$	-0.920* [0.538] (-1.71)	-0.814 [0.521] (-1.56)	-0.481 [0.980] (-0.49)	-1.187 [1.091] (-1.09)
$lnPOP_{jt}$	0.903*** [0.043] (20.69)	0.759*** [0.042] (17.96)	1.134*** [0.079] (14.27)	1.111*** [0.088] (12.55)
$lnDIST_{ij}$	-0.322*** [0.055] (-5.79)	-0.199*** [0.053] (-3.70)	-0.623*** [0.101] (-6.15)	-0.575*** [0.112] (-5.09)
$lnFDIIn_{it}$	0.708*** [0.020] (35.35)	0.549*** [0.019] (28.31)	0.869*** [0.036] (23.86)	1.097*** [0.040] (27.03)
$lnROYALTYRCPT_{it}$	0.081*** [0.015] (5.25)	0.035** [0.014] (2.39)	0.145*** [0.028] (5.19)	0.007 [0.031] (0.25)
Constant	-2.033 [2.544] (-0.80)	-0.485 [2.462] (-0.20)	-6.785 [4.627] (-1.47)	-2.242 [5.155] (-0.43)
Adjusted R^2	0.916	0.883	0.836	0.838

Source: Prepared by the authors.

Note: The sources of the individual variables are available in table 3. Standard errors are reported in the square brackets. The figures in parentheses are the t-test values.
* Significant at 10%. ** Significant at 5%. *** Significant at 1%.

TABLE 7

Gravity model: analysis of outward FDI stock by the technological content of trade, controlling for income inequality using the Gini index

	All trade flows	Low technology	Medium-low technology	Medium-high and high technology
$lnGDPPC_{jt}$	0.471*** [0.133] (3.53)	0.417*** [0.130] (3.21)	0.301 [0.251] (1.20)	0.358 [0.273] (1.31)
$lnGINI_{jt}$	1.505*** [0.504] (2.98)	1.062** [0.491] (2.16)	2.504*** [0.949] (2.64)	2.565** [1.032] (2.48)
$lnPOP_{jt}$	0.746*** [0.040] (18.36)	0.637*** [0.039] (16.13)	0.939*** [0.076] (12.30)	0.867*** [0.083] (10.44)
$lnDIST_{ij}$	-0.301*** [.053] (-5.65)	-0.183 [.051] (-3.53)	-0.597*** [.100] (-5.95)	-0.543*** [.109] (-4.98)
$lnFDIOut_{it}$	0.563*** [0.015] (37.03)	0.437*** [0.014] (29.56)	0.689*** [0.028] (24.11)	0.874*** [0.031] (28.11)
$lnROYALTYRCPT_{it}$	0.004 [0.015] (0.31)	-0.023 [0.014] (-1.59)	0.052* [0.028] (1.84)	-0.110*** [0.031] (-3.56)
Constant	-11.741*** [2.422] (-4.85)	-8.007*** [2.357] (-3.40)	-18.706*** [4.554] (-4.11)	-17.278*** [4.953] (-3.49)
Adjusted R^2	0.923	0.891	0.839	0.848

Source: Authors – sources of individual variables are available in table 3.

Note: The sources of the individual variables are available in table 3. Standard errors are reported in the square brackets. The figures in parentheses are the t-test values.

* Significant at 10%. ** Significant at 5%. *** Significant at 1%.

V
Concluding remarks

In this paper we have explored the potential internationalization capacity of the MERCOSUR countries, considering both trade and FDI flows as engines for technological integration in the region. Results of our analysis show that MNEs still have a rather limited influence on technological integration in the region, with intra-bloc knowledge transfer being more likely to take place by trade. Building on the concept of absorptive capacities and the importance of national systems of innovation, our first conclusion is that the relationship between international flows and the common goal of improving regional innovation and competitiveness can be mutually reinforcing, and reinforced by the integration process in MERCOSUR. One indirect implication from our findings is the potential impact of MNEs inside the bloc through the generation and improvement of technological capabilities; however, this would require the definition of more precise common innovation policies that acknowledge the role of international companies in order to take advantage of their operations in the region. In the same vein, the potential of outward FDI from the MERCOSUR member countries should be explored and exploited to enhance the region's learning from its partners abroad. In fact, a look at the effect on trade in the largest (Argentina and Brazil) and smallest economies (Paraguay and Uruguay) highlights some important policy implications, as mentioned by Bekerman and Rikap (2009), such as the importance of harmonizing national technological capabilities through regional initiatives.

Other implications arise in relation to the expansion of gravity models to reflect internationalization and institutional factors. The "gravity variables" and the Gini index were treated as exogenous variables,[11] while improvements in export capacity —both in quantitative and qualitative aspects— depend largely on FDI stocks. Our findings reveal that policies aiming to promote outward FDI and attract inward FDI can boost a country's exports to its MERCOSUR partners, which suggests the need for more integrated economic and technology policies at the MERCOSUR level. Therefore, our future research will seek to explore the relationship between inequality and technological progress, on the basis that economic development should improve countries' absorptive capacity. In order to garner a more complete vision of developing countries, aspects of their institutional structure must be investigated. If our preliminary results were to be supported by further evidence, solid redistribution policies would be crucial to ensure a more sustainable international integration process for catching-up economies.

[11] Distance is exogenous by definition. GDP per capita, population size and the Gini index can be considered as relatively exogenous for the approach adopted here given its focus on institutional and technological aspects.

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Productive structure and the functional distribution of income: an application of the input-output model

Pedro Quaresma de Araujo

ABSTRACT

The ECLAC tradition views structural heterogeneity as one of the main causes of Latin America's unequal income distribution. Accordingly, industrial policy should aim to change the productive structure, while incorporating technical progress and raising productivity levels. Simulations performed using Brazilian input-output tables make it possible to discover and evaluate the effects of changes in the productive structure on the functional distribution of income and employment levels over the most recent business cycle. These simulations are an important tool for formulating industrial policies that simultaneously promote higher growth rates and a reduction in inequalities. The estimations made revealed that increasing the proportion of engineering-intensive sectors could help to improve distributive results, expand the share of wages in output, and create more jobs.

KEYWORDS

ECLAC, economic conditions, industrial policy, income distribution, input-output analysis, Brazil

JEL CLASSIFICATION

C67, O21, N16

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I
Introduction

Traditionally, the Economic Commission for Latin America and the Caribbean (ECLAC) has considered structural heterogeneity to be the cause of the region's unequal income distribution. Since its founding, ECLAC has provided independent theoretical thinking on the specifics of the economic development process in Latin America, and has recommended the adoption of industrial policies to foster changes in the productive structure and stimulate domestic and external convergence in terms of productivity levels.

In the 1980s, the external debt crisis and the intensification of the inflationary process interrupted the import substitution industrialization process in the region. At the same time, liberal thinking gained ground in developed countries, and its recommendations for trade and financial liberalization attracted increasing support in Latin America. This point of view increasingly criticized State intervention — particularly in terms of industrial policy — for interfering in market self-regulation and causing distortions in relative prices and inefficient allocation. This period also saw wide dissemination of the belief that the best industrial policy for a country would be no industrial policy at all.

Nonetheless, just as the economic growth of the "golden years" did not generate positive distributional effects, the liberal reforms also failed to fill the "empty box" — described by Fajnzylber — of Latin American countries that have simultaneously raised their economic growth rates and improved the income distribution. Thus, issues relating to State action in the economy reappeared in the economic debate in the decade of 2000. Recent cases, such as exchange-rate policy management in Argentina and the new Brazilian industrial policy, are examples of the use of heterodox tools to bring about changes in the productive structure, through government action.

Since 2003, the Brazilian economy has striven to fill the aforementioned "empty box"; and the country has been achieving positive results in terms of growth and income distribution — the latter particularly when the measurements are made in functional terms, in other words considering how income is shared between wages and profits.

According to the ECLAC viewpoint, in which balance of payments constraints can impede growth, the large trade surpluses and the accumulation of reserves resulting from a sharp improvement in the terms of trade can be seen as fundamental factors for renewing Brazil's growth cycle. Nonetheless, despite the external boost, speeding up growth is overwhelmingly the task of domestic demand, particularly family consumption and investment driven by high levels of employment and income. Moreover, on the supply side, there has been a slight change in the productive structure, with the shares of agriculture and manufacturing industry sectors declining and that of services expanding.

What potential links could exist between changes in the productive structure and the income distribution? How can the effects of changes in the productive structure on employment and remuneration levels be measured? How can manufacturing industry, especially highly technology-intensive sectors, help to generate higher levels employment and wages? What is the role of industrial policy in overcoming the inequalities prevailing in the Latin American region? These are the key issues this article aims to investigate.

The analysis in this study considers inequality from the standpoint of the functional distribution of income, which is consistent with the classical notion that the productive process is where output shares are determined. The way the productive structure affects the functional distribution of income is evaluated using the input-output tables model, which was created by Leontief in 1941 and served as a major tool of economic analysis, planning and industrial policy-making throughout the twentieth century. The advantage of input-output tables is that they make it possible to combine the three facets of output: production, expenditure and income. The matrices also make it possible to perform simulations of employment, remuneration and production levels, by capturing the direct and indirect effects of observed (or hypothetical) changes in the productive structure on income shares, from a standpoint that takes account of inter-sectoral relations and their linkages.

At a time when the status quo of the last few decades is being called into question and the importance of State action in the economy is again being recognized, there is a chance to discuss public-policy alternatives for overcoming the region's historical inequalities. Reflection on the specifics of Latin American development has always been at the heart of the historical-structuralist debate, particularly the importance of fostering changes in the productive structure. In that context, the analysis of this article aims to contribute to the formulation of industrial policies that promote technical progress, to improve the sustainability of the region's exit from the notorious "empty box", while at the same time promoting high growth rates and improvement in the income distribution, increasing the share of wages in output and boosting job creation.

Section II, which follows this introduction, addresses the issue of structural heterogeneity and reviews ECLAC thinking and recommendations on Latin America's industrial development process. Section III assesses how the productive structure affects the functional distribution of income; and lastly, section IV offers final thoughts. The annex contains the Brazilian economy's input-output table for 2005.

II

Structural heterogeneity and the ECLAC tradition

1. The ECLAC tradition

Throughout the twentieth century, Latin America experienced far-reaching transformations in its productive structure, particularly after the World War II. As shown in table 1, the region progressed from a predominantly agricultural economy at the start of the century, to a period of intense industrialization with active State participation, in which the historical-structuralist theoretical tradition and policy recommended by ECLAC played a key role.

The perception that the economic development process in Latin America should be viewed differently than that of the central countries dates back to the founding of ECLAC. According to Bielschowsky (2000), for the supporters of industrialization, there was sort of "theoretical vacuum"; and scepticism of existing economic theory caused perplexity given the lack of theories that could be adapted to the economic and social realities they were striving to understand and change. Thus, ECLAC thinking since the 1950s fulfilled the function of formulating a regional development theory consistent with the Keynesian heterodox hegemony, while taking account of economic reality in its specific details. While embracing different concepts and ways of formulating the issue, authors associated with ECLAC at that time propounded the same key message: the need to implement industrial policies to overcome underdevelopment and poverty.

The ECLAC inaugural text, written by Raúl Prebisch in 1949, was fundamental in that regard, asserting that "One of the most conspicuous deficiencies of general economic theory, from the point of view of the periphery, is its false sense of universality [...] An intelligent knowledge of the ideas of others must not be confused with that mental subjection to them from which we are slowly learning to free ourselves" (Prebisch, 1963).

TABLE 1

Latin America: productive structure, 1950, 1960, 1970,1980 and 1990
(Percentages)

Sector	1950	1960	1970	1980	1990
Agriculture	22.1	18.7	13.0	9.7	10.4
Mining and oil	3.2	3.6	3.0	3.2	3.7
Manufacturing industry	21.7	25.7	24.9	27.0	23.4
Public utility services	1.3	1.6	1.9	1.7	2.4
Civil construction	7.0	6.9	5.2	7.0	4.9
Commerce	20.1	20.2	18.5	14.6	13.1
Transport, storage and postal services	6.1	5.9	5.4	5.5	7.0
Financial services	4.1	4.1	11.0	14.0	15.3
Other services	14.5	13.4	17.2	17.4	19.9

Source: Economic Commission for Latin America and the Caribbean (ECLAC), 2010.

By pointing out the need for a Latin American theoretical formulation, Prebisch reveals one of the key ideas of his economic thinking: the relation between the centre and the periphery. In his pioneering formulation, the economic growth process, international trade and technical progress would not occur in the same way in both regions. In brief, based on the economic theory of comparative advantage, it can be seen that the international division of labour does not favour the industrialization of peripheral countries. Accordingly, these countries have no way to absorb technical progress, which is fundamental for raising productivity and improving the population's living standards, as can be inferred from the following statement: "Hence, the fundamental significance of the industrialization of the new countries. Industrialization is not an end in itself, but the principal means at the disposal of those countries of obtaining a share of the benefits of technical progress and of progressively raising the standard of living of the masses" (Prebisch, 1963).

Like Prebisch, Furtado also explains the Latin American economic reality from a historical perspective, arguing that underdevelopment is an autonomous process and not a development stage. He also stresses the need for technical progress to be generated domestically, since technology defines the set of goods to be produced and influences the choice of productive processes; and the fact that technological decisions are made in the central countries detracts from autonomous domestic decision-making in the periphery and accentuates technological dependency (Furtado, 1975).

This author also differentiates the paths of the central and peripheral countries, particularly in his analysis of the industrialization process; and he blames those differences for the periphery's bad income distribution. Unlike what happened in the central countries, labour supply in developing countries remained infinitely elastic, and the persistently small volume of labour employed allowed a hybrid and dual structure to emerge, in which capitalist sectors coexist with pre-capitalist sectors, thereby preventing wages from rising above subsistence levels and discouraging the redistribution of income towards wage earners.

The notion of the coexistence of productive structures that vary in terms of productivity and technical progress dates back to the theoretical formulation of Aníbal Pinto, who, in the 1960s proposed the concept of structural heterogeneity. According to Pinto (1970), "dualism" originally predominated in the region, with highly productive export enclaves contrasting with the rest of the economy characterized by low productivity. For this author, the industrialization process experienced by Latin America in the post-war years would tend to reproduce the old heterogeneity prevailing in the agricultural-export period, by consolidating the creation of a non-exporting sector of well above-average productivity. Moreover, the inter-sectoral productivity differences between the countries of the region would be significantly greater than those seen in developed countries, thereby encouraging a more pronounced concentration of income, owing to the inverse relation between the size of employed population and the productive level of each sector.

In the 1990s, Fajnzylber participated in the debate on the causes of the unequal income distribution, identifying its origins in the productive process. In his article "Industrialization in Latin America: from black box to empty box", the author points out that no Latin American country had succeeded in combining positive indicators of economic dynamism (per capita income growth of above 2.4%) and equity (ratio between the incomes of the poorest 40% and richest 10% of around 0.4) in the period between 1970 and 1984. As the group of countries analysed included some with incomes similar to those in Latin America, such as Spain, the Former Yugoslav Republic of Macedonia, Hungary, Israel, Portugal and the Republic of Korea, Fajnzylber identifies insufficient incorporation of technical progress (black box) as a possible cause of those varying results, because:

> *The empty box would be directly related to what might be called an inability to open the "black box" of technical progress; this is partly due to the origin of Latin American societies, their institutional structure and a set of economic and structural factors which have a complex but indisputable bearing on the social and political environment.* (Fajnzylber, 1990).

A more recent study (ECLAC, 2007), entitled "Technical progress and structural change in Latin America", reconsidered the importance of the productive structure and technology as decisive factors for the convergence of per capita income growth rates, finding that performance in Latin America was clearly falling behind, particularly compared to Asia, not only in terms of per capita income, but also in the growth of gross domestic product (GDP), productivity and external competitiveness with the creation of good-quality jobs. On that point, Ferraz (2008) reiterates the importance of continuing to study the productive structure and technical progress in Latin America: the traditional interpretation sees human capital and macroeconomic stability as the main reasons for the better Asian performance. Nonetheless, in general, no progress is made in discussing issues that have always been important for the Latin American economies, particularly those most in line with ECLAC thinking, namely productive structure and technical progress.

ECLAC (2007) also performed an econometric exercise to compare the paths of per capita income for groups of countries, considering the diversification of their productive structures and indicators of investment in technical progress. The research showed that the countries which made most economic progress had a diversified industrial structure, focused on technology-intensive economic activities; and this led it to conclude that long-term development depends not only on the "traditional" variables, but also, and particularly, on the productive structure. At a time when industrial policies are undergoing a revival in Latin America, the study helped to refocus government action on the change in productive structure, particularly the importance of engineering-intensive sectors. Investment in those sectors fulfils a positive function in terms of the incorporation of technical progress and concentration of the productive chain, with repercussions for productivity and, consequently, for expanding income and employment and reducing inequality levels.

In relation to the importance of productivity, the document entitled "Time for equality: closing gaps, opening trails" (ECLAC, 2010) argues that two features distinguish the Latin American economies, namely the external gap and the domestic gap. In terms of the external gap, the region continues to lag behind in technological capacities: "Developed economies innovate in technology and disseminate it throughout their productive system more quickly than the countries of Latin America and the Caribbean are able to absorb, imitate, adapt and innovate in technology following international best practices" (ECLAC, 2010).

The domestic gap, in contrast, is defined by the glaring productivity differences that exist within and between sectors, and also between the firms of Latin American countries, which are much greater than those seen in developed countries. Large productivity differentials, compounded by the concentration of employment in sectors of very low relative productivity, can be seen as indicating the persistence of structural heterogeneity in the region. Table 2 shows the distribution of the occupational structure in Latin America, from 1990 to 2008. In the period analysed, the high-productivity sectors (mining, electricity and finance) represent a very small and essentially constant share of formal employment; and the share of medium-productivity sectors (manufacturing industry and transport) declines, while that of low-productivity sectors (agriculture, construction, trade and municipal and personal services) expands slightly.

TABLE 2

Latin America: occupational structure 1990,1998, 2003 and 2008
(Percentages)

Sector	1990	1998	2003	2008
High-productivity sectors	7.9	7.0	7.3	8.1
Medium-productivity sectors	23.1	20.7	19.7	20.0
Low-productivity sectors	69.0	72.3	73.0	71.9

Source: Economic Commission for Latin America and the Caribbean (ECLAC), 2010

Based on the document entitled "Structural heterogeneity largely explains acute social inequality in Latin America and the Caribbean" (ECLAC, 2010), ECLAC recommended countries to adopt industrial policies that promote convergence between sector productivity levels, with a view to improving the income distribution and combating social exclusion. In that regard: "a pivotal item on the agenda is the identification of key sectors, which will have to be selected on the basis of the specific features of each country's production structure and in accordance with the sector's capacity to generate and disseminate knowledge and innovation and to encourage linkages with other manufacturing and services activities. It will be the task of industrial policy to focus efforts on these sectors" (ECLAC, 2010).

Infante and Sunkel (2009) help to evaluate the relations that exist between structural heterogeneity and the income distribution, proposing a review based on input-output tables for the Chilean economy. According to these authors, despite a doubling of per capita income over the last few decades and a notable reduction in poverty indices, high levels of inequality and social exclusion have persisted in the country. Despite the positive results achieved, social policies are considered compensatory, so the authors argue that only a new, production-oriented, development strategy can achieve sustainable results in the fight against inequality: "although something can be achieved in that way, this paper argues that a different development strategy needs to be designed. The underlying problem is both the pace of growth and its composition, in other words, the profound differences in productivity and quality of the productive structure, in both goods-producing and service sectors" (Infante and Sunkel, 2009).

Thus, following Pinto's classification, the authors define structural heterogeneity by dividing the economy into three sectors: traditional, modern and intermediate, according to productivity levels. Using input-output tables, they note that the heterogeneity observed in the production sphere (domestic consumption and final demand) is also visible in employment (jobs and wages). In short, the Chilean economy is divided into high-productivity sectors which drive the economy and pay higher wages, and low- and medium- productivity sectors that contribute less to growth but absorb most employment. Lastly, a high proportion of the value added by low-productivity sectors corresponds to labour income (72.5%), despite the fact that pay in these sectors accounts for just 20.7% of total remuneration in the economy. In contrast, in the high-productivity sectors, pay accounts for 37.9% of value-added and 64.1% of total remuneration.

The aforementioned authors choose to use input-output tables, given the possibility of performing simulations based on different hypotheses, particularly in relation to the productive structure. The coefficients of the matrices make it possible to identify the contribution made by each of the productive factors (inputs, capital and labour) to each sector's output, and thus simulate the effect on total production of different hypothetical changes in aggregate demand, through the differentiated effects in the various productive sectors.

Infante (2007) provides additional tools for viewing the relations between structural heterogeneity and income distribution. According to this author, the persistence of productive heterogeneity is what gives rise to differential wages and unequal access to good-quality jobs. Furthermore, job quality (level of pay, formalization and social protection) is what best illustrates the link between the productive structure and the labour market. Nonetheless, as job quality is still not a sufficient condition to determine the wage, it is necessary to focus particularly on the prevailing types of labour relations and the bargaining power of labour unions, as fundamental factors.

2. Choice of the functional distribution of income

Classical political economy (Smith, Ricardo, Marx) viewed labour as the only wealth creator; so the generation and appropriation of income could only take place in the production process. This approach leads to the concept of the functional distribution of income.

Throughout the development of economic theory, new perspectives have been used to understand the distribution process. Various theoretical concepts aimed to explain how income is shared between wages and profits, ranging from those that argue the labour productivity is what determines wage levels, to Marxist value-added theories which argue that the wage only covers part of the value produced by labour in production, as a result of the distributive conflict between the classes (labour and the capitalist); so the wage level depends on workers' bargaining power to appropriate the surplus and productivity increases. According to the neoclassical tradition, the wage level is equal to the respective marginal productivity, with no space for distributive conflicts, since the wage seen as determined through a "natural" process that is perfectly balanced or tends to equilibrium. Under the liberal approach, differences in the distribution of income are now measured using inequality coefficients (Gini or others) or the income gap between the upper and lower extremes. Consequently, inequality is measured from a personal standpoint. Although those indicators measure important issues, such as education and training of the labour force, the key feature of this approach is that it makes no mention of the productive fabric in determining inequality. Correcting distortions is the task of social policies, which therefore calls for government fiscal action to formulate compensatory policies, outside the domain of the productive process.

Thus, the decision to analyse the functional distribution of income is consistent with the research objectives, namely to evaluate the productive linkages in determining the income distribution. In this regard, recognizing that action to overcome inequalities needs to be taken in the sphere of production, industrial policy could play a major role in increasing the share of wages in output. This will be the purpose of the simulations using input-output tables, because, as shown in the next section, it is possible to evaluate how changes in the productive structure can affect the functional distribution of income and the employment level, thereby becoming a tool industrial policy-making.

III

Evaluation of how the productive structure affects the functional distribution of income

1. The recent cycle of the Brazilian economy, growth with income distribution

From 2003 until the most recent international financial crisis, Brazil experienced the most significant expansionary cycle of recent decades. As shown in figure 1, growth was initially driven by the external sector, thanks to an improvement in the terms of trade and increased exports of commodities to China. Nonetheless, since 2004, domestic demand, particularly family consumption and gross capital formation, has been the main engine of growth, while a better income distribution has played a key role in expanding the domestic market.

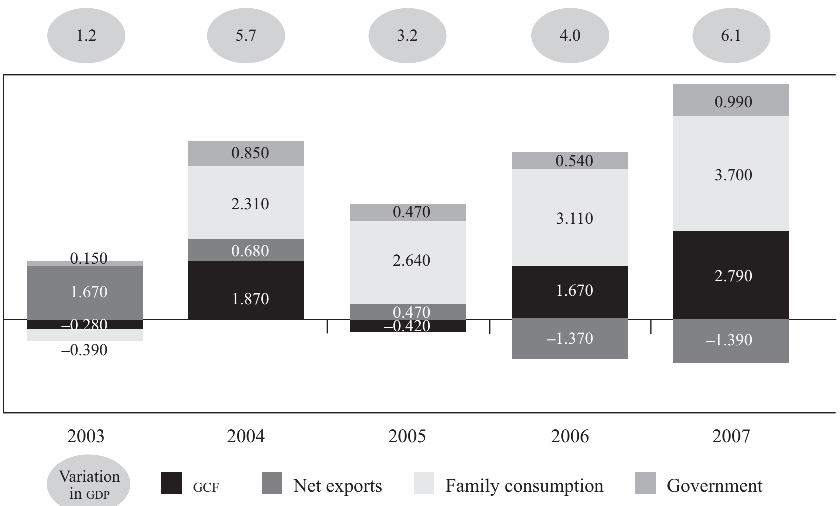
In terms of the income distribution, there were improvements during the period both in personal terms (Gini coefficients), and in the functional distribution (between wages and profits). After fluctuating between 0.58 and 0.61 in the 1990s, the Gini coefficient embarked on a steady downward trend in 2001, to reach 0.56 by 2007. Since 2003, the Gini coefficient has posted the best inequality indicators in its historical series (see figure 2).

In functional terms (see figure 3), following the sharp contraction in the share of labour income in output in the early 1990s, there was a recovery in this indicator in the initial years of the Real Plan, which was only interrupted by the financial crises that occurred towards the end of that decade. Since 2003, however, in keeping with the revival of the business cycle, the labour share grew systematically, to reach a level of 48.1% in 2007.

The larger share of wages in output could be reflecting both the larger number of jobs created and the rise in average pay (increase in real wages or a larger proportion of higher-paying sectors). Table 3 shows data for GDP, remuneration and employment from 2003 to 2007. While the volume of remuneration grew at an average rate of 5.3% during the period, employment grew by 3.0%. It is therefore possible to state that wages were more decisive than new job creation for the progress made in the functional distribution of income, so sector-level research is needed to identify the main determinants of this improvement in pay.

FIGURE 1

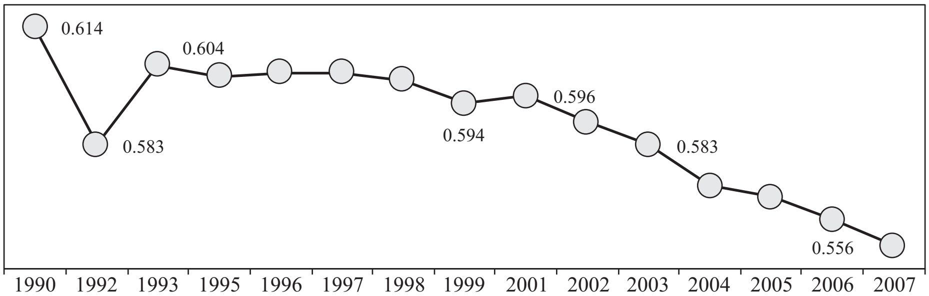
Brazil: contribution to growth, 2003, 2004, 2005, 2006 and 2007
(Percentage points)



Source: Prepared by the author on the basis of the economic and financial database (Ipeadata) of the Institute of Applied Economic Research ((IPEA).
GDP: Gross domestic product.

FIGURE 2

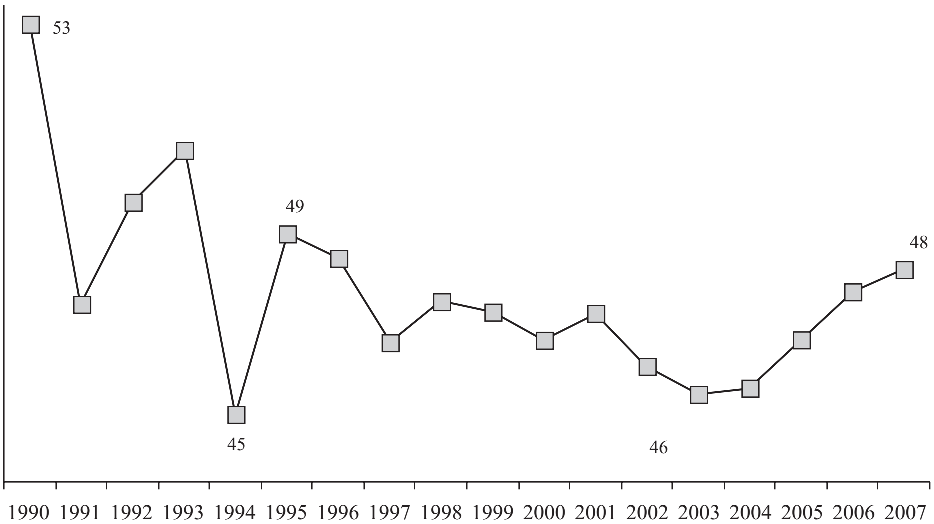
Brazil: Gini coefficient, 1990-2007



Source: Prepared by the author on the basis of the economic and financial database (Ipeadata) of the Institute of Applied Economic Research (IPEA).

FIGURE 3

Brazil: share of remuneration in output, 1990-2007
(Percentages)



Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 3

Brazil: GDP, remuneration and jobs, 2003 and 2007

	2003	2007	Annual growth (%)
GDP (R$ million, at 2007 prices)	1 894 452	2 287 858	4.8
Remuneration (R$ million, at 2007 prices)	895 962	1 099 903	5.3
Jobs	84 034 981	94 713 909	3.0
Average remuneration (R$ million, at 2007 prices)	10 662	11 613	2.2

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

Firstly, the sector productive structures are compared between 2003 and 2007 (see table 4). In this period, there were increases in the GDP shares of trade, financial services, mining, oil and public services, while agriculture, manufacturing industry and real estate and rental services all declined relatively. The trend of sector shares in terms of pay and jobs can also be analysed (see tables 5 and 6): trade and manufacturing industry increased their shares of total remuneration, while manufacturing industry, trade, public services and other services accounted for a larger share of jobs.

Other indicators are also available to evaluate the performance of remuneration and their relation to the productive structure, such as the share of remuneration in the output of each sector. As shown in table 7, manufacturing industry, in addition to displaying a large share of remuneration in value added, also records the largest increase in the share of remuneration in sector output over the cycle analysed, rising from 45.5% in 2003 to 51.8% in 2007.

Accordingly, as a result of the growth of jobs and the larger share of remuneration in sector output, manufacturing industry is a key contributor to the total variation in remuneration. As can be seen in table 8, it accounts for 20.2% of the growth in total remuneration, although this is less than the contribution made by the public administration sector.

TABLE 4

Brazil: productive structure, 2003 and 2007

(Percentages)

Sector	2003	2007
Agriculture	7.4	5.6
Mining and oil	1.7	2.3
Manufacturing industry	18.0	17.0
Public utility services	3.4	3.6
Civil construction	4.7	4.9
Commerce	10.6	12.1
Transport, storage and postal services	4.7	4.8
Information services	3.6	3.8
Financial services	7.1	7.7
Real estate and rental services	9.6	8.5
Other services	14.0	14.2
Administration, public health and education, and social security	15.1	15.5

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 5

Brazil: remuneration structure, 2003 and 2007

(Percentages)

Sector	2003	2007
Agriculture	5.3	4.2
Mining and oil	1.0	1.2
Manufacturing industry	17.9	18.4
Public utility services	1.8	1.5
Civil construction	3.2	3.3
Commerce	10.2	11.3
Transport, storage and postal services	4.5	4.5
Information services	2.5	2.7
Financial services	6.3	5.8
Real estate and rental services	0.5	0.6
Other services	18.0	17.7
Administration, public health and education, and social security	28.9	28.7

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 6

Brazil: occupational structure, 2003 and 2007

(Percentages)

Sector	2003	2007
Agriculture	21.0	18.6
Mining and oil	0.3	0.3
Manufacturing industry	11.9	12.8
Public utility services	0.4	0.4
Civil construction	6.4	6.6
Commerce	16.6	16.7
Transport, storage and postal services	4.2	4.3
Information services	1.7	1.9
Financial services	1.1	1.0
Real estate and rental services	0.6	0.7
Other services	25.2	25.9
Administration, public health and education, and social security	10.5	10.9

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 7

Brazil: Share of remuneration in sector output

(Percentages)

Sector	2003	2007
Agriculture	32.6	36.7
Extractive industry	27.6	25.1
Manufacturing industry	45.5	51.8
Public utility services	23.4	20.6
Civil construction	31.4	32.2
Commerce	43.8	44.7
Transport, storage and postal services	44.0	45.2
Information services	31.0	34.3
Financial services	40.4	36.5
Real estate and rental services	2.4	3.4
Other services	58.5	59.9
Administration, public health and education, and social security	87.4	89.2
Total	*45.7*	*48.1*

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

Lastly, comparing the sector-level variations in productivity and average pay, it can be seen that manufacturing industry was one of the main sectors passing productivity increases on to pay throughout the cyclical upswing. Whereas for the average of sectors during the period analysed, remuneration outpaced productivity growth by 1.3 percentage points, in the case of manufacturing industry, the difference was 3.3 points (see table 9).

The combination of those results focuses attention on the performance of manufacturing industry, which, despite losing share in the productive structure in terms of value added, recorded increases in terms of the number of jobs and the volume of remuneration. This is probably attributable to the far-reaching changes that occurred in the composition of Brazilian industrial output during the period. Table 10 shows the composition of industrial output by technological intensity, using the ECLAC classification, revealing the increased share of engineering-intensive sectors — although Brazil still displays an industrial structure that is very different than that of the United States, for example, which is considered the global technology frontier.

TABLE 8

Brazil: remuneration by sector

(R$ million)

Remuneration	2003	2007	Variation	Contribution to the variation (%)
Agriculture	47 151	46 680	(471)	-0.2
Extractive industry	9 296	13 497	4 201	2.1
Manufacturing industry	160 746	201 926	41 180	20.2
Production and distribution of electricity and gas, water, sewerage, and urban cleaning	15 692	16 845	1 153	0.6
Civil construction	28 838	35 799	6 961	3.4
Commerce	91 025	124 060	33 035	16.2
Transport, storage and postal services	40 351	49 618	9 267	4.5
Information services	22 057	30 110	8 053	3.9
Financial intermediation, insurance, and complimentary pension and related services	56 144	64 114	7 970	3.9
Real estate and rental services	4 567	6 628	2 061	1.0
Other services	160 924	194 997	34 073	16.7
Administration, public health and education, and social security	259 170	315 629	56 459	27.7
TOTAL	*895 962*	*1 099 903*	*203 941*	

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 9

Brazil: productivity and remuneration

Sector	Productivity (Valor value added by occupation, R$)			Average remuneration (R$)			Variation of average remuneration/ Variation of productivity (B)/(A)
	2003	2007	Variation in productivity (A)	2003	2007	Variation in average remuneration (B)	
Agriculture	6 150	7 228	4.1%	2 002	2 651	7.3%	3.0%
Extractive industry	99 963	182 263	16.2%	27 599	45 837	13.5%	-2.3%
Manufacturing industry	26 536	32 213	5.0%	12 073	16 695	8.4%	3.3%
Production and distribution of electricity and gas, water, sewerage, and urban cleaning	141 614	210 307	10.4%	33 086	43 313	7.0%	-3.1%
Civil construction	12 744	17 884	8.8%	3 998	5 757	9.5%	0.6%
Commerce	11 170	17 509	11.9%	4 895	7 831	12.5%	0.5%
Transport, storage and postal services	19 254	27 079	8.9%	8 474	12 239	9.6%	0.7%
Information services	38 119	50 039	7.0%	11 818	17 174	9.8%	2.6%
Financial intermediation, insurance, and complimentary pension and related services	113 357	181 041	12.4%	45 792	66 098	9.6%	-2.5%
Real estate and rental services	259 904	286 431	2.5%	6 279	9 763	11.7%	9.0%
Other services	9 736	13 274	8.1%	5 693	7 949	8.7%	0.6%
Administration, public health and education, and social security	25 267	34 412	8.0%	22 092	30 706	8.6%	0.5%
TOTAL	*17 500*	*24 155*	*8.4%*	*7 995*	*11 613*	*9.8%*	*1.3%*

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

In addition to their larger share in industrial output, in the period analysed engineering-intensive sectors made a major contribution to remuneration growth and to a lesser extent to job creation (see table 11). This suggests that the shift in the productive structure towards more intensive technology use could have benefited aggregate wage growth in industry as a whole, given the higher wages paid in those sectors.

TABLE 10

Brazil (2003 and 2007) and the United States (2007): industrial output by category of technology-use intensity
(Percentages of GDP)

Intensity of technology use	Brazil 2003	Brazil 2007	United States 2007
Natural resources	10.3	8.2	2.8
Labour	3.3	3.8	2.0
Engineering	4.3	5.0	6.5
Manufacturing industry	18.0	17.0	11.3

Source: Prepared by the author on the basis of data from Economic Commission for Latin America and the Caribbean (ECLAC).

TABLE 11

Brazil: manufacturing industry, contribution to the variation (2007/2003) by category of technology-use intensity
(Percentages)

Intensity of technology use	Value-added	Wages	Jobs
Natural resources	22.5	18.9	35.1
Labour	36.9	42.3	36.2
Engineering	40.6	38.8	28.7

Source: Prepared by the author on the basis of data from Economic Commission for Latin America and the Caribbean (ECLAC).

2. The input-output model and the methodology used for the simulations

(a) *Historical review of the input-output model*

The input-output tables model was created by Leontief in 1941, largely inspired in the economic frameworks developed by Quesnay in the eighteenth century. Thanks to the pioneering work of organization, formalization, and improvement of studies on inter-industrial relations, the input-output table became a major tool of economic planning and industrial policy-making throughout the twentieth century, mainly in the planned socialist economies, but also in market economies.

As commonly defined, an input-output table is a matrix of direct technical coefficients indicating how many units of the goods produced by other sectors in a given activity are required by a sector to produce a monetary unit of its own good. Nonetheless, according to the Brazilian Geographical and Statistical Institute (IBGE, 2008), construction of the matrix involves a series of studies and decisions that start with the definition of the concepts adopted for the variables in its database through to the hypotheses made on the technology to be used to calculate the technical coefficients effectively.

Input-output tables are constructed by combining the indicators contained in the system of national accounts under the three approaches for measuring output: production, expenditure and income. This makes it possible to perform sector analyses, evaluating, among other issues, the importance of a given industry in terms of generating jobs, income and taxes, as well as sector-level capital and import needs.

Another important application of input-output tables are impact analyses, as noted earlier in Infante and Sunkel (2009). According to United Nations (2000) in "Handbook of input/output table compilation and analysis", these impact analyses can be conducted from two standpoints: (i) the impact of other activities on the industry being studied; and (ii) the impact of that industry on other activities.

In that handbook, the basic impact equation with input-output models consists of evaluating the effects of the growth path of the complete vector of final demand (by sectors) on sector outputs; in other words evaluation of the direct and indirect effects of variations in demand on the productive structure. The United Nations study stresses that the input-output analysis is done on an integrated basis, considering all sectors together, to be able to fully capture the inter-industry linkages prevailing in each productive structure.

Other techniques used to analyse impact are multipliers and backward and forward linkages. The multipliers basically serve to measure the total effect on production, employment or value-added caused by a unit increase in the output of a given sector. They can be used to calculate forward or backward linkages in the productive chain, in other words output and input multipliers, through the sum of the lines relating to the column of a given sector in matrices of inter-sectoral repercussions and national coefficients. It is worth noting that there is a risk of mistaken interpretations when analysing multipliers, particularly when concluding that a sector with a larger multiplier is the one that should be exclusively promoted — hence the importance of inter-sectoral impact analyses being made of final demand as a whole. Lastly, multipliers can also be used to measure the employment and income effects of a variation in final demand; in other words they are analytical instruments that belong to a typically Keynesian approach.

The backward and forward linkages are obtained, respectively, from the sum of the columns or rows relating to a given sector in a matrix of direct coefficients. Backward linkages are simply the product's own multipliers.

Input-output tables to some extent summarize the objectives of this study, as they represent the most appropriate tool for jointly evaluating variations in the productive structure and in the functional distribution of income. Apart from the work of Infante and Sunkel (2009), other authors have used that methodology to evaluate the effects on the income distribution, including Muñoz and Riaño (1992), who use input-output tables to analyse changes in the national income distribution between the fundamental groups of society: workers and employers. In that case, the study aimed to calculate the distribution frontiers for Colombia, in other words analyse the effects of variations in profit rates on the functional distribution of income in that country.

(b) *Simulation methodology*

The exercise proposed in this study consists of using the input-output tables model to evaluate the level of employment and volume of remuneration generated different productive structures, consistently with the impact analyses based on employment and remuneration multipliers.

In the case of employment, the direct requirements vector (L) is calculated, by dividing jobs created (E) by total production (VBP) in each of the sectors analysed.

$$L = E / VBP \tag{1}$$

The direct employment requirements vector is then diagonalized, to obtain a diagonal matrix L^d. The next step consists of multiplying this diagonal matrix L^d by the Leontief direct and indirect requirements matrix ($(I\text{-}A)_{nxn}{}^{-1}$), thereby making it possible to include the indirect effects of one sector's production on the other sectors. This gives the direct and indirect requirements matrix (L_{nxn}):

$$L_{nxn} = L^d{}_{nxn} \text{ X } (I\text{-}A)_{nxn}{}^{-1} \tag{2}$$

From L_{nxn} it is possible to estimate the level of sector employment that corresponds to a given exogenous final demand, also expressed at the sector level (equation 3). Then the sector employments can be added together to obtain the level of employment that corresponds to a given productive structure (equation 4).

$$E_{nx1} = L_{nxn} \text{ X } Y_{nx1\,;} \tag{3}$$

$$E = \Sigma\, E_i \tag{4}$$

The model for remuneration is exactly the same as for employment, with jobs (E) being replaced by remuneration (R). Equations (1) to (4) can then be rewritten as (1') to (4'), considering W as the vector of direct requirements for remuneration:

$$W = R/VBP \tag{1'}$$
$$W_{nxn} = W^d{}_{nxn} \text{ X } (I\text{-}A)_{nxn}{}^{-1} \tag{2'}$$
$$R_{nx1} = W_{nxn} \text{ X } Y_{nx1\,;} \tag{3'}$$
$$R = \Sigma\, R_i \tag{4'}$$

The use of input-output tables to perform simulations is subject to a number of constraints. Firstly, the matrices are formulated on the basis of the economy's performance in a given year, so they need to reflect prevailing conditions in terms of income-elasticity, productive process, technology, productivity and distribution of income between wages and profits, among other things. The simulations that can be performed should therefore be seen from a comparative-statics perspective, to provide a general overview of job-creation and remuneration trends.

To perform a dynamic analysis it would be best to compare the results using matrices from different years. This is even more necessary when considering the existence of increasing returns to scale (the Kaldor-Verdoorn effect), which would require taking account of productivity increases arising from the output expansion cycle. The input-output tables assume constant returns to scale, which means that the same relative combinations of productive factors will be used for any amount produced.

Lastly, it should be noted that these simulations do not consider the possibility of intra-sectoral functional redistribution over the business cycle. It is possible that factors such as wage negotiations, an increase in workers' bargaining power, taxation and productivity, among others, could cause changes in the share of labour income in each sector.

3. Results of the simulations

As it is known how to calculate the level of employment and remuneration associated with a given structure of value-added, it is possible to simulate the effects of a structural change on the functional distribution of income and level of employment. The simulations shown below used the input-output tables published by the, IBGE, for 2005 at the 55-subsector level

The use of input-output tables from a different year than that used to construct the productive structure vector could cause inaccuracies in the simulation results obtained, owing to changes in technology, production processes and productivity levels. Nonetheless, the period of analysis in question is too short for major changes, and the most recent input-output table published in official Brazilian statistics is for 2005, since Brazil publishes these indicators much more frequently than other countries. Thus, using a 2005 matrix would be unlikely to induce errors that are important enough to make its use unviable, duly adjusted to the purposes of this study.[1]

(a) *Evaluation of the effect of structural change*

The first simulation basically consisted of breaking down the observed variation in remuneration and employment to evaluate the extent to which this was due to the change in productive structure that occurred between 2003 and 2007. For that purpose, the remuneration and employment results were calculated as if there had been no change in the productive structure — in other words, as if the sector shares of value-added had been the same in 2007 as in 2003. Equation (5) shows the variation actually observed from 2003 to 2007.

$$\Delta E = (E_{2007}^{\text{estruc 2007}} - E_{2003}^{\text{estruc 2003}}) \tag{5}$$

As an algebraic device, equation (5) includes the 2007 employment level, assuming that the 2003 structure of value added ($E_{2007}^{\text{estruc 2003}}$). Equation (6) separates the total change into two effects. The first summation refers to the effect of structural change, in other words, the extent to which the total variation of employment can be attributed to a change in the productive structure. The second summation refers to the effect of demand, because both employment levels (observed and estimated) are associated with the 2003 productive structure:

$$\Delta E = (E_{2007}^{\text{estruc 2007}} - E_{2007}^{\text{estruc 2003}}) + (E_{2007}^{\text{estruc 2003}} - E_{2003}^{\text{estruc 2003}}) \tag{6}$$

Table 12 shows the results of applying this exercise to the Brazilian economy in relation to employment levels, remuneration and the functional distribution of income.[2] This shows that the changes in productive structure that occurred between 2003 and 2007 had contrasting effects in terms of employment and pay. The level of employment actually observed in 2007 was lower than it would have been if there had been no changes in the productive structure. In contrast, remuneration and, hence, the functional distribution of income, benefited from the growth of total remuneration, because 0.7 percentage points of the 2.3 percentage point increase can be attributed to the change in the productive structure. Thus, the calculations show that the effect of the structural change was negative for employment (24.4%) and positive for pay (8.8%). Thus, in keeping with the observed growth cycle, it can be seen that the effect of demand is positive for both the level of jobs and remuneration.

[1] The sum of the estimations of values added, employment and remunerations had to be adjusted by a common factor calculated in each of those categories, since a 2005 matrix was used to evaluate 2007 structures.

[2] In all of the results of the simulations performed in this research, the first and third columns referred to actually observed levels, while the second column reports the result of the estimation.

The concept of structural heterogeneity helps to explain the divergent effects of the productive structure on employment and remuneration. By way of illustration, figure 4 relates the sector distribution of the employed population to average sector remuneration. The dotted line represents average total remuneration of R$11,600; and it can be seen that roughly 70% of the employed population works in sectors with below-average pay. This is not the case of the manufacturing industry, however, which, as the figure shows, accounts the largest population group employed in sectors with above-average pay. Moreover, just three sectors (financial services, mining and public utility services) absorb just 2.2% of employment, but their pay levels are almost triple the level of aggregate average remuneration.

In that context, understanding the divergent behaviour of remuneration in relation to jobs requires calculating the sector breakdown of the difference between the results observed in 2007 and the hypothetical estimate assuming no structural change. Table 13 sets out the results, ranked in ascending order of average sector remuneration in 2007. In the lowest-paid sectors, particularly agriculture, which has the lowest sector-average remuneration, there was an aggregate loss of jobs owing to the changes are productive structure. In contrast, sectors with above average pay levels, in addition to having generated positive job creation, accounted for nearly 80% of the total change in remuneration, thereby making a large contribution to the improvement in the functional distribution of income.

TABLE 12

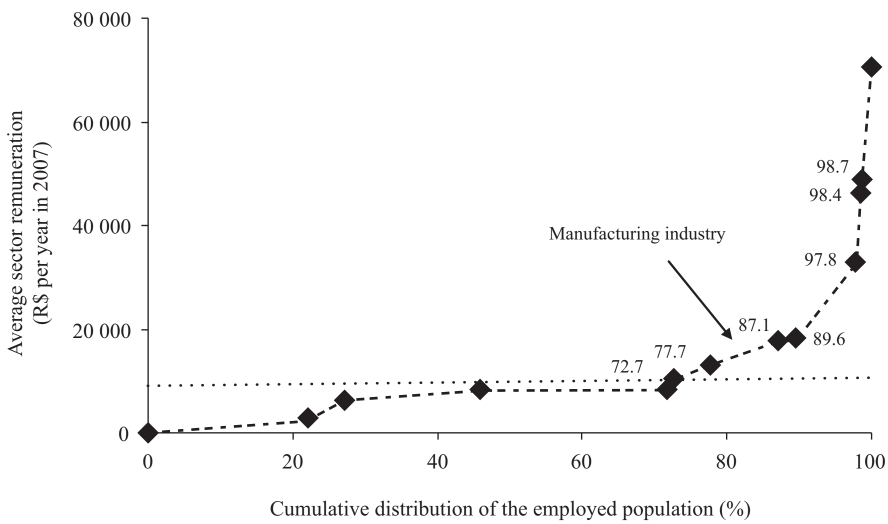
Simulation: productive structure of 2003

	2003	2007 simulated	2007
Jobs	84 034 981	97 324 264	94 713 909
Remuneration (R$ thousand)	895 961 738	1 082 019 140	1 099 903 000
Labour income (% of value-added)	45.7	47.3	48.1

Source: Prepared by the author.

FIGURE 4

Brazil: cumulative distribution of the employed population by average sector remuneration
(Percentages)



Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

TABLE 13

Breakdown of the effect of structural change by sectors

Sector	Variation in remuneration (R$ million)	Variation of jobs (thousands)	Jobs (Percentages en 2007)	Average remuneration (R$ per year)
Agriculture	(13 344)	(6 231)	22	2 833
Construction	898	1 431	5.0	6 152
Commerce	14 886	(720)	18.8	8 368
Other services	1 593	378	25.9	8 494
Real estate services	(1 087)	(270)	0.9	10 432
Below-average remuneration	2 945	(5 411)	72.7	
Transport services	1 288	(657)	5.0	13 078
Manufacturing industry	(1 732)	2 537	9.4	17 840
Information technology services	2 089	(720)	2.5	18 352
Public service	6 260	2 048	8.2	32 811
Public utilities	667	(180)	0.6	46 283
Mining industry	29	(30)	0.3	48 980
Financial services	5 209	(197)	1.3	70 630
Above-average remuneration	13 810	2 801	27.3	16 611
TOTAL	*16 755*	*(2 610)*	*100.0*	*11 613*

Source: Prepared by the author on the basis of data from the Brazilian Geographical and Statistical Institute (IBGE).

(b) *Simulations with an increased industry share*

The notion that better economic results depend on industrialization is a familiar one. Accordingly, two simulations are now performed in which manufacturing industry would have a 19.2% share of the structure of Brazilian GDP, this figure being chosen because it is the highest level achieved by this indicator since economic stabilization in 1994.

— Share of Brazilian industry in value-added equal to 19.2%; the share of the other sectors is proportional to the current structure

The first simulation considered an increase in the industry share, with the rest of the sectors being distributed proportionately to their value-added shares in 2007.

The results shown in table 14 confirm that increasing the manufacturing industry share of value-added does not necessarily improve employment and pay levels. The productivity differences arising from structural heterogeneity are such that progress in industry without changes in the intra-sectoral structure, in terms of intensive technology use, combined with a reduction in the share of sectors with higher job creation potential, fail to produce positive results in terms of either employment or remuneration.

— Share of Brazilian industry in value added equal to 19.2%, with technology-use intensity similar to that of the United States

The second simulation considered an increase in the industry share, with the rest of the sectors distributed proportionately according to the technology-use intensity of industrial output in the United States. Basically, an intra-sectoral restructuring was performed with shares measured by United States technology-use intensity. This means that the share of engineering-intensive sectors had to increase, from 5.0% to 9.8% of total value-added, while the natural resource and labour-intensive sectors were adjusted respectively from 8.2% to 4.2% and from 3.8% to 3.1%[3].

The results shown in table 15 confirm the importance of technological progress for increasing the share of remuneration in output. Unlike the previous simulation, when the structure of industrial output is changed the share of remuneration in output exceeds the 2007 level. Employment, however, continues to report a result inferior to that actually observed.

[3] An adjustment was also made to ensure that the subsectors comprising each of the technological-intensity groups proportionally matched their share in the Brazilian industrial structure of 2007.

TABLE 14

Simulation: percentage of manufacturing industry = 19.2%

	2003	2007 simulated	2007
Jobs	84 034 981	91 349 316	94 713 909
Remuneration (R$ thousand)	895 961 738	1 098 549 498	1 099 903 000
Labour income (% of value added)	45.7	48.0	48.1

Source: Prepared by the author.

TABLE 15

Simulation: percentage of manufacturing industry = 19.2%, with United States technology-use intensity

	2003	2007 simulated	2007
Jobs	84 034 981	92 406 926	94 713 909
Remuneration (R$ thousand)	895 961 738	1 104 357 094	1 099 903 000
Labour income (% of value added)	45.7	48.3	48.1

Source: Prepared by the author.

(c) *Simulations with the productive structure of the United States*

Lastly, simulations were performed based on comparisons with the structure of the United States economy, which is viewed as the global technology frontier. In fact, according to the publications reviewed, those exercises aimed to evaluate the effects of productive convergence in the Brazilian economy on employment and remuneration. Two types of convergence were considered: industrial value-added and GDP.

— Industrial structure equal to that of United States, considering the intensity of technology use and share of industry in value added of 17.0%

The first simulation aimed to evaluate the effects of a change in the industrial productive structure, by technology-use intensity, while holding the manufacturing industry share at 17.0%. The results are presented below for employment, remuneration and the income distribution, compared to the figures actually observed in 2003-2007 (see table 16).

As can be seen, the simulated structure produced progress in terms of the functional distribution of income, but with a lower level of employment than actually recorded in 2007. This confirms the tendency for a structure with a larger proportion of engineering-intensive sectors to boost remuneration levels, albeit with less job creation.

— United States GDP structure

The second simulation provides a more in-depth view of change in the productive structure, by considering how job creation and remuneration in the Brazilian economy would behave if its GDP were distributed similarly to that of the United States. For ease of reading, a comparison of the productive structure of GDP in Brazil and the United States is provided below in table 17.

TABLE 16

Simulation: percentage of manufacturing industry = 17.0%, with United States technology-use intensity

	2003	2007 simulated	2007
Jobs	84 034 981	92 943 457	94 713 909
Remuneration (R$ thousand)	895 961 738	1 104 913 772	1 099 903 000
Labour income (% of value added)	45.7	48.3	48.1

Source: Prepared by the author.

TABLE 17

Productive structure of Brazil and the United States, 2007
(Percentages)

Sector	Brazil	United States
Agriculture	5.6	0.9
Mining and oil	2.3	1.6
Manufacturing industry	17.0	11.3
Public utility services	3.6	1.6
Civil construction	4.9	5.5
Commerce	12.1	13.4
Transport, storage and postal services	4.8	2.9
Information services	3.8	3.6
Financial services	7.7	8.2
Real estate and rental services	8.5	8.7
Other services	14.2	30.3
Administration, public health and education, and social security	15.5	11.7

Source: Brazilian Geographical and Statistical Institute (IBGE) and Bureau of Economic Analysis (BEA).

The main differences between the GDP structures are the smaller share of the agriculture and manufacturing industry sectors in the United States, and a larger share of other services (basically owing to business services, health and commercial education). When that productive structure is simulated for the Brazilian economy, the results reported in table 18 are obtained:

TABLE 18

Simulation - productive structure of the United States

	2003	2007 simulated	2007
Jobs	84 034 981	96 916 468	94 713 909
Remuneration (R$ thousand)	895 961 738	1 180 901 144	1 099 903 000
Labour income (% of value added)	45.7	51.6	48.1

Source: Prepared by the author.

The results of this latter simulation are highly significant in terms of improvements in the functional distribution of income and a higher level of employment. With the United States GDP structure, wages represent more than 50% of output, which reinforces the idea that the productive structure is a decisive factor for the functional distribution of income. Another interesting point is that this result was obtained despite a reduction in the industry share of GDP. This shows that the importance of industrialization is not measured in terms of its share in value-added, because many of the jobs and much of remuneration paid in the industrial sector depends on articulation with other sectors in terms of the productive chain, as noted above.

4. Summary of the simulations performed

Lastly, table 19 provides a summary of the simulations performed throughout the study. In functional-distribution terms, the best result was obtained from the simulation in which the GDP structure mirrored that of the United States — as would be expected, given the major change involved in that hypothetical case. In terms of jobs, the largest volume was obtained by maintaining a productive structure equal to that of 2003. This result is based on the positive relation between technology and the generation of high wages, as seen in simulations in which the industrial structure reproduces the technology-use intensity of the United States economy. Nonetheless, that case produces a lower figure for the number of jobs, thereby indicating a trade-off between job creation and remuneration in the hypothetical cases where engineering-intensive sectors account for a larger share of manufacturing industry.

TABLE 19

Summary of simulations performed

	Functional distribution (Share of remuneration in output)	Jobs
Results obtained		
2003	45.7	84 034 981
2007	48.1	94 713 909
Simulations		
Simulation GDP of 2007 with 2003 structure	47.3	97 324 264
Simulation of manufacturing industry = 19.2%	48.0	91 349 316
Simulation manufacturing industry = 19.2%, United States technology-use intensity	48.3	92 406 926
Simulation manufacturing industry = 17.0%, United States technology-use intensity	48.3	92 943 457
Simulation GDP distribution of United States	51.6	96 916 468

Source: Prepared by the author.

GDP: Gross domestic product.

IV
Final thoughts

From the standpoint of structuralist theory, which sees heterogeneity in the productive structure as one of the key factors explaining the historical inequalities that characterize the Latin American economic development process, it can be stated that, in the recent cycle, the Brazilian economy showed some signs of having filled Fajnzylber's infamous "empty box", combining a revival of growth with improvements in the functional distribution of income. The change in the industrial productive structure, with a larger proportion of engineering-intensive sectors, played a fundamental role in promoting a larger share of labour income in output, despite a reduction in the share of manufacturing industry in GDP throughout the 2003-2007 cycle. Moreover, the structural change observed produced side-effects that mainly benefited remuneration, because employment would have been even greater if the productive structure had not suffered changes in the period.

This article has also sought to highlight the importance of input-output tables as a tool of economic planning and industrial policy. As this is an instrument in which the three approaches to the breakdown of output can be combined, the matrices make it possible to relate the effects of the productive structure on the functional distribution of income, and to confirm the classical and structuralist principles that output shares are determined in productive process. The use of the matrices also revealed the importance of inter-sectoral articulations for analysing aggregate results in terms of jobs and remuneration. The results of one sector often depend on what happens in the other sectors, so only an integrated analysis of the economy produces satisfactory results in terms of economic planning

It is therefore timely to stress another relevant point of this research: the fact that a larger industry share does not necessarily produce better results in terms of employment and income distribution. More important is the function fulfilled by technical progress leading to increase in the share of engineering-intensive sectors. Nonetheless, the tendency for those sectors to create fewer jobs raises the issue of the trade-off between job creation and wages.

The methodology proposed in this study is considered useful as a tool of industrial policy-making in Latin American countries. Consequently, a more in-depth analysis is needed of the recent sector performance of the other Latin American economies. For that purpose, it would be very important for research institutes to update their input-output tables more frequently. Other relevant research would consist of comparing the economic paths of countries in different periods, thereby making it possible to dynamically evaluate changes in the productive structure and income distribution, considering the technological changes and those that occurred in the production process.

Lastly, further progress could have been made in this research if the productivity dimension had been analysed in greater depth. According to the ECLAC tradition, overcoming structural heterogeneity and inequalities depends on bringing domestic and external productivities into line. In that regard, exercises that combine structural and productivity adjustment hypotheses in explicitly overcoming those gaps would contribute greatly to the structuralist analysis. Special attention could also be paid to the import effects of changes in the productive structure, consistently with balance-of-payments-constraint models — an application that could be used with the input-output model.

As can be seen, the productive structure plays an important role in job creation and remuneration, particularly in heterogeneous economies such as those of Brazil and other Latin American countries. To analyse those effects, it was proposed to revive the input-output models of economic planning, the results of which can guide industrial policy formulation in the region. In fact, the main objective of this article has been to provide an empirical basis for analysing the roots of inequality and the formulation of public policies to overcome it. At a time when the economic status quo is being challenged, industrial policy could play a role in overcoming Latin America' historical challenges and collaborate in defining a new sustained socioeconomic development path that combines economic growth with reductions in inequality.

ANNEX

Brazil: input-output table for 2005

The Brazilian Geographical and Statistical Institute (IBGE) presents the input-output table for 2005, based on tables of resources and uses. The process of producing the input-output table can be viewed in two stages. The first consists of the task of compiling various data sources and preparing basic production and consumption tables. The second stage involves applying a mathematical model which, based on those tables and on hypotheses regarding technology, are used to calculate a matrix of technical coefficients according to the model developed by Leontief. The Brazilian matrices used models for calculating the technical coefficients that had small changes in their formulation

The IBGE publishes the results of the matrices at two levels of economic-activity aggregation: level 12 and level 55. As an illustration of the sectoral inter-relations prevailing in the Brazilian economy in 2005, the Leontief matrix of inter-sectoral impacts and the table of uses of goods and services at consumer prices are presented for the 12-economic-activities level.

ANNEX 1

TABLE A1

Brazil: Leontief matrix

Sector	Agriculture	Mining and oil	Manufacturing industry	Public utility services	Civil construction	Commerce	Transport storage and postal services	Information services	Financial services	Real estate and rental activities	Other services	Public services
Agriculture	1.136053	0.031459	0.144723	0.015871	0.041238	0.01312	0.039742	0.015427	0.009803	0.002449	0.030883	0.013768
Mining and oil	0.030290	1.079399	0.084589	0.050569	0.033204	0.007916	0.022308	0.009133	0.005626	0.001621	0.015621	0.008092
Manufacturing industry	0.430881	0.312399	1.583156	0.156302	0.413684	0.129652	0.396527	0.150019	0.094689	0.024123	0.265715	0.127596
Public utility services	0.028241	0.073559	0.069264	1.296158	0.023515	0.030838	0.040689	0.033250	0.015892	0.002837	0.042569	0.029696
Civil construction	0.001621	0.016647	0.004414	0.002153	1.022438	0.002486	0.002304	0.007581	0.008303	0.023718	0.008198	0.026701
Commerce	0.067389	0.048929	0.088996	0.027464	0.078135	1.035860	0.063871	0.029376	0.020773	0.004657	0.052319	0.025984
Transport, storage and postal services	0.050472	0.139542	0.080737	0.039839	0.040493	0.059455	1.117527	0.041226	0.022356	0.003691	0.043073	0.021846
Information services	0.015969	0.062771	0.034608	0.031176	0.015124	0.027148	0.031280	1.210599	0.062448	0.003978	0.080727	0.066850
Financial services	0.028747	0.039324	0.045616	0.028522	0.024293	0.029488	0.039913	0.040030	1.137310	0.005249	0.022736	0.086142
Real estate and rental services	0.005917	0.013326	0.012105	0.007170	0.005696	0.024794	0.009633	0.031508	0.009722	1.003632	0.014693	0.019984
Other services	0.026390	0.094315	0.062310	0.075690	0.040136	0.074733	0.091721	0.128319	0.096790	0.013274	1.085023	0.094432
Public services	0.002456	0.005582	0.004597	0.007805	0.002481	0.003171	0.004777	0.004413	0.002914	0.000434	0.003688	1.003175

Source: Brazilian Geographical and Statistical Institute (IBGE).

TABLE A2

Brazil: table of uses of goods and services – basic prices
(R$ million)

Sector	Intermediate consumption	Exports	Government consumption	Family consumption	Gross fixed capital formation	Variation in inventories	Final demand	Total demand
Agriculture	122 709	18 043	0	28 195	11 193	(-) 848	56 583	179 292
Mining	78 738	27 728	0	235	0	2 028	29 991	108 729
Manufacturing industry	682 178	224 412	0	320 604	97 073	4 356	646 445	1 328 623
Public utility services	100 163	0	0	34 537	0	0	34 537	134 700
Civil construction	25 482	946	0	0	140 613	0	141 559	167 041
Commerce	116 185	13 217	0	139 835	25 363	0	178 415	294 600
Transport, storage and postal services	112 836	10 059	0	56 344	4 086	0	70 489	183 325
Information services	102 623	953	0	37 861	0	0	38 814	141 437
Financial services	103 341	1 653	1 541	92 360	0	0	95 554	198 895
Real estate and rental services	33 956	2 506	0	158 344	3 895	0	164 745	198 701
Other services	152 147	24 550	10 069	218 393	1 102	0	283 250	435 397
Administration, public health and education, and social security	0	0	415 943	0	0	0	415 943	415 943
Total	*1 630 358*	*324 067*	*427 553*	*1 086 708*	*283 325*	*5 536*	*2 156 325*	*3 786 683*

Source: Brazilian Geographical and Statistical Institute (IBGE).

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Income polarization, the middle class and informal employment in Greater Buenos Aires, 1974-2010

Fernando Groisman

ABSTRACT

This article examines the social structure of Argentina's main conurbation, Greater Buenos Aires, over the past four decades. The research focused on identifying changes in society by stratifying it into three social classes: high, middle and low. Contributions are made in three areas. First, the article engages with the renewed debates about methodology on the issue of which criteria are best suited to achieving an adequate demarcation of social classes, especially the middle class. Second, it uses a variety of approaches to document changes in the social structure with a view to identifying common trends. Lastly, it highlights certain dominant features of the workings of the labour market that appear to have left their mark on the social morphology of Argentina.

KEYWORDS

Social structure, social classes, middle class, labour market, family incomes, income distribution, cities, statistics, Argentina

JEL CLASSIFICATION

J31, D31, J21

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I
Introduction

Research into the characteristics and dynamics of the social structure has become a topical issue, and justifiably so, given the repercussions that far-reaching transformations in the international economic system have been having in recent times. The focus of attention has been on developments in the middle classes right across the world, although the research hypotheses this evolution entails can be seen to vary depending on the region or country concerned.

For one thing, the growth of middle-income sectors in a large group of Asian and Latin American countries has changed the face of global society and created an interest in comprehending the characteristics of this new social contingent (Kharas, 2010; Ravallion, 2010; Castellani and Parent, 2011; Franco, Hopenhayn and León, 2011). A variety of factors underlie these transformations, chief among them being the incorporation into the global market of the giant populations of China and India, with the consequent rise in global demand for commodities that has benefited the producer economies of Latin America. Per capita gross domestic product (GDP) growth has been such that it has impacted the monetary incomes of sectors historically situated in the poorer strata and has enlarged the middle-income population in both regions. Traditionally, much of the thinking about the importance of a vibrant middle class has been devoted to gauging its effects on economic development and the consolidation of democratic societies (Easterly, 2001; Easterly, Ritzen and Woolcock, 2006).

Distributional trends in the more developed countries over the two closing decades of the last century foreshadowed some of the issues driving the concern with studying the social structure at the present time. Rising inequality, especially in the Anglo-Saxon countries, raised new questions about the depth of the changes that were occurring. In the United States, for example, the debate about whether there was an incipient trend towards the disappearance of the middle class began, quite vigorously, as early as the mid-1980s (Thurow, 1984; Rosenthal, 1985; Blackburn and Bloom, 1985; Bradbury, 1986; Horrigan and Haugen, 1988). The subject remains topical in the central countries, with a strong impetus given to research into income polarization (Pressman, 2007; Atkinson and Brandolini, 2011). In addition, the international crisis that began in 2007 and its effects on employment and income, especially in the northern hemisphere, have reactivated concern about worsening distribution and its social impact.

In this context, it is important to stress the relevance of analysing what has happened to the social structure in Argentina. For much of the last century, the country had a vigorous middle class, a high degree of upward social mobility and low levels of inequity, giving rise at an early stage (by the standards of Latin America generally) to high levels of social integration. This began to change in the mid-1970s with the onset of a stage marked by a persistent decline in the living standards of the middle- and lower-income sectors (with the exception of some short subperiods), culminating in late 2001 with unemployment of 25% and over half the population living in poverty. Since then, there has been a shift in tendency that has proved lasting. It is clearly of interest, then, to learn whether and how the remarkable increase in GDP in the first decade of this century led to a reorganization of the social structure and, if this happened, what its scale and particular characteristics were.

The aim of this article is to use different approaches and methodologies from economics and sociology to document the evolution of the social structure in Greater Buenos Aires[1] from the mid-1970s until 2010. The purpose of the research was to provide a long-term overview of the size of the social classes and to evaluate the determinants of membership in each of them between the beginning and end of the period. The workings of the labour market were specifically addressed.

The article is organized into five sections. Section II sets out some of the theoretical and methodological background of most relevance to the aims of the research, the methods of analysis used in this study and the characteristics of the data source employed. Section III presents the results of the stratification criteria used and the distributional situation during the period under review, before going on to analyse the labour market. Section IV discusses the workings and broad characteristics of the labour market. Lastly, section V offers conclusions.

[1] The country's largest conurbation, containing about 30% of the total population and 40% of the total urban population.

II
Methodology

1. Background

The study of the systems organizing modern societies has always been inseparably linked to people's employment relations, so that the classification systems developed have been based on certain job characteristics, the construction of occupational scales, or both. Sociological theory, whether in the variants that draw more on Marxist ideas (Wright, 1997 and 2009) or on Weberian thought (Erikson and Goldthorpe, 1992; Goldthorpe and McKnight, 2006), has routinely set out to conceptualize national social structures by examining the particular distribution of individuals in the world of work. Whether the emphasis is on membership of a social class (or group) or on the status (prestige) enjoyed by individuals as structuring elements of the social order and determinants of power relationships, people's occupations were inevitably the empirical variable taken.[2]

While this sociological tradition remains the dominant conception in the specialist literature, it has been subjected to other analytical approaches because of the growing heterogeneity that now seems to characterize occupational strata or groups, something that severely limits the usefulness of these groupings in adequately explaining social conduct or behaviour such as voting decisions, consumption patterns and the spatial distribution of population. Underlying these observations is what has been called "the end of the wage-earning society" (Rosanvallon, 1995; Castel, 1997). The crisis of the labour market as a mechanism for social integration in modern societies has not only excluded people from employment status (especially the traditional status of the full-time wage earner) but has increased the frequency of movement between the different social states (wage employment, non-wage employment, unemployment, inactivity) in a way that has made households' social status and incomes more unstable. Against this background, emphasis has been laid on the undesirability of using discrete variables for social stratification, instead of which sliding scales taking account of individuals' and households' resource (or asset) endowments have increasingly been used to determine their position in the social structure (Prandy, 1990; Gershuny and Yee Kan, 2006; among others).

From the perspective of economic theory, conversely, the focus has been on monetary incomes as the independent variable for determining social groups and classes. The method traditionally used has been to define a priori the population size of the strata to be considered, before going on to evaluate the share of each group as thus defined in the mass of total incomes (Levy, 1988; Solimano, 2009). The lower class usually includes those in the bottom deciles of the income distribution, while the high class is composed of those at the top of the distribution. What is left over is defined as the middle class, which thus generally ranges from 40% to 60% of the population. By the same logic, thresholds have been set with reference to the poverty line, especially to define the high class (Atkinson, 2008; Eisenhauer, 2008). Whatever the rationale behind this kind of demarcation of social groups, clearly one of the main limitations of this approach is that it is not sensitive to changes in the size of social classes.

In view of this, a degree of consensus has formed around the alternative classification of the population into fixed-income strata or intervals. Thus, intertemporal comparison of population groups so defined will reflect changes in the size of their membership. Absolute limits have been used, especially for developing countries (Banerjee and Duflo, 2008), but the predominant tendency has been to set an income interval whose upper and lower bounds are fixed with reference to a central tendency statistic for income distribution, usually the median (Thurow, 1987; Birdsall, Graham and Pettinato, 2000; Foster and Wolfson, 2010). Sometimes the two approaches have been combined, with an absolute lower bound and a relative upper bound being taken (Birdsall, 2010). Although the main advantage of this approach is its sensitivity when it comes to computing increases or decreases in the size of social groups, it is subject to certain caveats, since such changes will be partly a result of the boundaries of whatever interval has been chosen.

Meanwhile, the question of what has been happening to the middle class has provided the motivation for the development of a family of distribution indicators based on the concept of polarization (Esteban and Ray, 1994;

[2] A review of the main contributions to the study of Latin American social structures can be found in Filgueira (2007).

Duclos, Esteban and Ray, 2004; Foster and Wolfson, 2010). The central idea is that income polarization occurs as the result of two forces: identification with or closeness to the group belonged to, and alienation or differentiation vis-à-vis others. By contrast with the two previous approaches, the income bounds determining membership of each group, and the number of members, will vary over time. The result is a synthetic indicator that can be used to quantify the degree to which the middle part of the income distribution is shrinking or expanding.

In summary, sociological studies of social structure and those conducted from an economic perspective are based on different methodological traditions, but are closely related. In general, a particular ranking based on individuals' occupational characteristics or employment relations usually ties in closely with the current distributional situation in society. Indeed, it is routine to validate whatever stratification systems are chosen by their explanatory power vis-à-vis income dispersion. The two approaches are thus complementary, and their combined contributions seems to be increasingly necessary to a better understanding of the evolving physiognomy of modern societies. This article makes use of five indicators (three derived from economics and two more closely aligned with the sociological outlook), detailed in the following subsection, with a view to making a contribution in this area.

2. Methods and data sources

The study made use of the three economic approaches just mentioned (strata fixed by the number of members, income interval relative to the median and synthetic polarization indicator) for the explicit purpose of ascertaining what they can bring to an understanding of changes in the social structure of Argentina.

People were divided into social classes by their position in the income distribution as follows: low class (deciles 1 and 2), middle class (deciles 3 to 8) and high class (deciles 9 and 10). The interval defining the middle class relative to median income was 0.75 to 1.5. Those below 0.75 and over 1.5 were placed in the low and high classes, respectively. Lastly, the polarization index employed was the one proposed by Foster and Wolfson (2010):

$$(T-G)\mu/m$$

where μ and m are average and median per capita family income respectively, G is the Gini coefficient and T is the ratio between the average distance from the median of those above it and those below it. Given that $(T\text{-}G)$ is equal to the Gini coefficient between the upper and lower halves of the distribution, minus weighted intragroup inequality, it follows that the greater the inequality between the two groups (upper and lower halves), the higher both inequality and polarization will tend to be. Conversely, greater intragroup inequality (keeping a fixed distance between those above and below the median) means higher inequality but lower polarization.

This was complemented by a further two criteria for demarcating social groups based, respectively, on individuals' educational attainments and occupational status. Education has historically proved to be one of the main mechanisms for upward social movement and remains a powerful predictor of incomes. Consequently, it is relevant to compare changes in the distributional structure with alterations in the educational level of the population. To this end, three classes were constructed by the highest educational level attained: a low class (up to complete primary), a middle class (up to complete secondary) and a high class (incomplete or complete higher education).

As regards the second complementary criterion, occupational status, its relevance derives, as noted in the previous subsection, from the postulates of the sociological tradition of social class analysis. In addition, emphasis has increasingly been laid on the importance of the "employment stability" dimension as one of the most consistent determinants of people's position in the social structure (Goldthorpe and McKnight, 2006). The research used a combination of the idea of informal employment and educational level. This choice was based precisely on the way these tied in with employment instability. The idea of informal working serves to characterize a certain specificity of labour markets in developing countries.[3] In the absence of general social protection mechanisms in these economies, informal (low-productivity) jobs are usually the method whereby a quite substantial proportion of people earn their living. Thus, informality is associated with unstable employment paths involving high turnover between economic activity (employment and unemployment) and inactivity. Furthermore, informal workers' incomes are different to those of formal workers, being lower. This earnings penalty, which implies a segmented labour market, may result in membership of a particular social class.

[3] The original perspective was provided by the International Labour Organization in the early 1970s (ILO, 1972) and has recently been updated (Hussmanns, 2004).

With the categorization used, people can be classified into the economically active and inactive, with the former being further subdivided into the employed and the unemployed. The grouping arrived at was as follows: the low class (employees not registered with the social security system,[4] domestic service workers, the unemployed, the inactive and, where appropriate, beneficiaries of job creation schemes),[5] the middle class (own-account workers with up to incomplete university education and registered workers of a similar educational level) and the high class (employers, professional own-account workers and registered employees with complete higher education). To focus attention on households with a greater dependence on the labour market, the universe of analysis was composed of household heads aged between 30 and 59, a central age range encompassing those who can be expected to be economically active.

[4] Under Argentine law, wage employment is understood as an open-ended working relationship that does not require any specific contract to be signed between employer and worker. Although there are exceptions to this general rule, they have to be duly justified. Consequently, the employees who enjoy most stability are those in jobs registered by their employers with the social security system. Employees in unregistered jobs lack the protection provided by national employment contract law, some of whose sections provide for protection against dismissal, union representation and coverage by collective labour agreements.

[5] Various job creation schemes have been implemented since 2001, with participants providing labour in return for benefits.

The statistical data source used was the Permanent Household Survey (EPH) prepared by the National Institute of Statistics and Censuses (INDEC). The EPH is conducted in the main cities of the country and covers about 70% of the total urban population. Its geographical coverage has been expanding since 1974, the year it began. Because the present study analyses events since that year, only information from Greater Buenos Aires could be used. From 1974 to 2003, the EPH was a non-continuous survey carried out twice a year, in May and October. It underwent a major change in the latter year; in terms of fieldwork, it became a continuous survey producing quarterly estimates for some variables and half-yearly ones for others. In addition, changes were made to the questionnaire that restricted data comparability for certain categories of analysis. It is possible to analyse changes over time, however, as there is a period that is common, or might reasonably be considered common, to both survey methods: the second quarter of 2003. The last non-continuous survey round was held in May. The decision was taken not to carry out the adjustment for this article, however, as correcting the estimates from 2003 onward by the application of a "splicing coefficient" entails a reduction of some 7% to 8% in the estimates, which does not alter the essential results. Furthermore, there are other methodological issues with this variant.

The income variables to be used were per capita family income and monthly earnings from the main occupation.

III

Distribution and the social structure

1. The distributional situation and income polarization

The evolution of inequality in income distribution over the past three and a half decades took the form of an inverted U.[6] There was a marked distributional deterioration during the period from 1974 to 2001, with the Gini coefficient rising by about 50% between the two years, from 0.353 to 0.531 (see table 1). Following the convertibility crisis of late 2001 and the subsequent drop of about 30% in real incomes because of the devaluation implemented in early 2002, a vigorous process of distributional improvement began in 2003, with the Gini index falling by somewhat over 20%, from 0.537 to 0.431. Nonetheless, the degree of inequity was still higher in 2010 than it had been in 1974.[7] A similar situation of deteriorating distribution during the last quarter of the twentieth century and subsequent progress towards equity can be seen in the evolution of the ratio between average and median incomes (see table 1).

[6] It should be stressed that these developments bear no resemblance whatsoever to Kuznets' thesis that income distribution tends to be less equitable in the early stages of growth and only later becomes more equal. Argentina is an example of the opposite: greater/lower output has usually been accompanied by lower/greater inequity.

[7] Regarding the potential comparability of data, see the "Methods and data source" subsection.

TABLE 1

Distribution indicators[a] in Greater Buenos Aires, 1974-2010

	Oct-1974	Oct-1980	Oct-1986	Oct-1991	Oct-1996	Oct-2001	Q4-2003	Q4-2006	Q4-2010
Gini coefficient	0.353	0.394	0.423	0.463	0.495	0.531	0.537	0.484	0.431
Polarization index (Foster and Wolfson)	0.638	0.793	0.913	1.098	1.271	1.427	1.411	1.120	1.010
Real median per capita family income (1974=1)	1.000	0.867	0.707	0.479	0.410	0.419	0.356	0.509	(0.62-0.97)[b]
Mean/median	1.206	1.266	1.390	1.561	1.583	1.661	1.655	1.516	1.388
Income share *(percentages)*									
Quintile 1	6.7	5.8	5.2	4.9	3.6	2.6	2.8	3.9	4.7
Quintile 2	11.8	10.8	10.0	9.2	8.2	6.9	7.2	8.2	9.7
Quintile 3	16.6	15.3	14.8	13.4	13.1	12.0	12.1	13.4	14.8
Quintile 4	22.8	22.6	21.9	20.9	21.1	21.0	20.8	21.7	22.6
Quintile 5	42.2	45.5	48.1	51.6	54.0	57.5	57.1	52.8	48.2
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Population falling within per capita family income bands relative to the median *(percentages)*									
<40	5.6	9.2	9.7	9.2	15.5	19.2	19.9	16.1	14.4
40 to 50	5.1	6.4	6.5	5.8	6.8	6.6	6.6	7.9	7.1
50 to 60	4.8	7.3	6.7	6.9	5.5	6.6	5.7	7.7	6.4
60 to 75	12.6	10.2	9.3	10.0	9.5	7.1	10.0	8.5	10.7
75 to 100	16.8	15.4	16.6	18.4	12.9	11.2	11.0	12.8	14.4
100 to 125	16.1	12.6	10.1	9.2	10.0	7.8	8.2	9.3	10.5
125 to 150	9.1	10.0	10.1	8.6	7.3	7.1	6.6	7.7	8.5
150 to 200	13.8	11.1	12.2	12.2	10.5	9.8	10.3	9.7	11.8
200 to 300	10.8	11.0	10.3	9.7	10.5	10.2	10.7	10.8	9.1
>300	5.4	7.0	8.5	10.0	11.6	14.4	11.0	9.6	7.2
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Income shares of the groups defined in the panel above *(percentages)*									
<40	0.9	1.9	1.7	1.6	2.3	2.4	2.7	2.7	2.8
40 to 50	1.7	2.1	2.1	1.6	2.0	1.8	1.9	2.5	2.5
50 to 60	2.0	3.0	2.6	2.4	2.0	2.2	2.0	3.0	2.7
60 to 75	6.3	5.2	4.4	4.3	4.1	2.9	4.3	4.0	5.5
75 to 100	11.1	10.0	10.3	10.5	7.4	5.9	6.3	7.8	9.7
100 to 125	13.9	10.5	8.0	6.7	7.2	5.2	6.0	7.4	9.2
125 to 150	9.6	10.2	9.6	7.6	6.5	5.8	5.9	7.4	9.0
150 to 200	17.8	14.3	14.8	13.7	11.7	10.3	11.6	11.9	15.9
200 to 300	19.2	19.7	17.7	15.5	16.7	15.0	16.8	18.4	17.1
>300	17.4	23.1	28.8	36.1	40.1	48.5	42.6	34.9	25.7
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).
Note: The EPH data gathering methodology was altered in 2003. Various methods of splicing the data series from before and after that date can be used to deal with this. However, correcting the estimates from 2003 onward, when a "splicing coefficient" is applied, entails an adjustment of some 7% or 8%. As it does not alter the primary results, the decision was taken to dispense with this variant, with which there are methodological issues.

[a] All distribution estimates were based on per capita family income.
[b] Alterations in the method of measuring the consumer price index in 2007 mean that values prior and subsequent to that year are not directly comparable. For this reason, two estimates were made, and from these it can be concluded that the value of the concept of interest falls within the interval reported.

Polarization, which, as discussed earlier, is related to inequality but is not identical with it, followed a similar pattern. It will be recalled that this phenomenon reflects an accentuation of the extremes (top and bottom) of the income distribution, so that greater polarization directly squeezes those in the middle part of the distribution. From the mid-1970s until the early twenty-first century, there was a pronounced and steady increase in polarization, outstripping even the distributional deterioration already discussed (see table 1). Even by 1996, the degree of polarization in the income distribution was twice what it had been in 1974, while the inequity coefficient declined by about 40% over the same period. The trend of this indicator went clearly into reverse from 2003 and for the rest of the decade. As with the Gini coefficient, however, this reversal from 2003 was not enough to make up for the cumulative deterioration of the earlier phase.

The discrepancy between the change in the Gini coefficient and the situation revealed by analysis of the degree of income polarization suggests that there were substantial changes in the social structure. This approach thus provides a more sensitive way of capturing the consolidation of groups composed of individuals sharing common attributes, i.e., groups that are reasonably homogeneous in their composition. Table 1 provides further information to justify this claim, and it can be appreciated that the increase in income concentration and polarization occurred simultaneously with a cumulative drop in real per capita incomes totalling almost 60% between 1974 and 2001. A further piece of information reflecting the combined effects of the drop in real household incomes and the worsening distribution is that the proportion of households with incomes below 40% of the average per capita family income value virtually quadrupled to 19% between 1974 and 2001, while the proportion with incomes exceeding that value by over 300% almost tripled from 5.4% to 14.4%. Again, when the share of income appropriated by each income stratum is considered, it can be concluded that the bulk of the poor ended that quarter century even poorer, while the rich (whose number also increased) appropriated more resources (see the last panel of table 1). These trends were reversed in the period of expansion from 2003 to 2010, albeit to varying degrees in the different social groups. The following section addresses this.

2. Changes in the social structure

It will be recalled that the study employed five criteria to measure these social groups: (i) groups with a numerically constant membership defined by their position in the income distribution; (ii) classes delimited by the position of income recipients relative to a central tendency statistic for income distribution; (iii) a derivation of the first two, taking the income share of social groups defined by a fixed income interval; (iv) taking the education level of the household head; and (v) taking the employment position of household heads of working age.

(i) *Delimitation by income quantiles*

Using this measurement criterion, it was found that the low and middle classes (in that order) experienced a substantial drop in their income shares in the final quarter of the last century, whereas in the seven-year period beginning in 2003 they were able to recover much of that share. The low class, comprising the poorest 20% of the population, underwent a dramatic reduction in income share of about 60% between 1974 and 2001 (from 6.7% to 2.6%, see table 2). The middle class, comprising the 60% of the population belonging to the second, third and fourth quintiles, also saw its income share decline, albeit to the much lesser extent of just over 20% (from 51.1% to 39.9%). Consequently, and strikingly, the income distribution share of the high class, comprising the wealthiest 20%, rose by some 35% (from 42.2% to 57.5%). These trends were reversed over the following stage, from 2003 to 2010, although not to the extent of restoring the situation of the mid-1970s. The recovery was greatest for the low class. If table 2 is examined again, it can be seen that the share of the lower stratum increased by about 70% (from 2.8% to 4.7%), while that of the middle swathe rose by some 18% (from 40.1% to 47.1%). The share of resources going to the high class accordingly fell by some 16% (from 57.1% to 48.2%). A review of the figures shows that the strength and persistence of this process of resource reallocation was unparalleled in Argentine economic history since at least the mid-1970s.

Between the beginning and end of the extended period (1974 to 2010), however, the total income share of the members of the high class increased, so that by the end of the first decade of the twenty-first century they were wealthier than they had been 36 years earlier. Similarly, the poorest still had less in the way of monetary resources than in 1974. Lastly, the middle class had not been restored to its income share of that period either, although of all three classes it came closest.

It is worth noting that these adjustments between social classes closely track the Gini coefficient (whose characteristic is that it is more sensitive to changes in the middle part of the distribution), but diverge more from the path of income polarization, which, it will be recalled, was 60% greater in 2010 than it had been in 1974. In other words, the distributional improvement in the first decade of the twenty-first century took the form of a marked recovery of incomes in the middle sector and, albeit to a lesser degree, in the low class.

TABLE 2

The social structure in Greater Buenos Aires, 1974-2010

(Various approaches)

	Oct-1974	Oct-1980	Oct-1986	Oct-1991	Oct-1996	Oct-2001	Q4-2003	Q4-2006	Q4-2010
Income share (by income quantile of which member)									
Low class (bottom 20%)	6.7	5.8	5.2	4.9	3.6	2.6	2.8	3.9	4.7
Middle class (middle 60%)	51.1	48.9	46.7	43.5	42.4	39.9	40.1	43.3	47.1
High class (top 20%)	42.2	45.4	48.1	51.6	54.0	57.5	57.1	52.8	48.2
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
By position in the income distribution (relative to the median)									
Low class: below 75%	28.1	33.0	32.2	32.0	37.3	39.5	42.2	40.1	38.5
Middle class: between 75% and 150%	42.0	37.9	36.8	36.2	30.2	26.1	25.8	29.8	33.4
High class: over 150%	29.9	29.1	31.0	31.8	32.6	34.5	32.0	30.1	28.1
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Income share (of groups defined by position in the income distribution relative to the median)									
Low class: below 75%	11.0	12.2	10.8	9.9	10.4	9.2	11.0	12.2	13.5
Middle class: between 75% and 150%	34.6	30.7	27.9	24.7	21.1	16.9	18.1	22.6	27.9
High class: over 150%	54.5	57.1	61.3	65.3	68.5	73.9	70.9	65.2	58.6
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
By educational level of household head									
Low class: up to complete primary	64.1	62.5	51.2	48.2	42.8	40.0	37.7	34.7	30.5
Middle class: secondary (incomplete and complete)	26.2	25.5	33.0	34.4	35.5	35.7	35.6	37.8	37.1
High class: higher (complete and incomplete)	9.7	12.0	15.8	17.5	21.7	24.3	26.6	27.5	32.3
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
By instability of employment (household heads aged between 30 and 59)									
Low class: employees, unstable	19.0	20.7	20.9	25.9	34.4	37.6	37.1	34.6	30.1
Middle class: stable, medium grade	70.1	67.1	65.4	59.4	50.1	46.3	45.9	47.0	49.5
High class: stable, higher grade	10.9	12.2	13.8	14.6	15.5	16.1	17.1	18.4	20.4
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

(ii) *Social classes by income interval relative to the median*

When social classes are defined by an income gap from the median,[8] alterations in their size over the period studied reveal a situation that, while consistent overall with the two phases that have been identified, 1974 to 2001 and 2003 to 2010, provides additional information that is helpful in categorizing the kind of transformation undergone by the social structure of Argentina.

Using this demarcation, it can be seen that the size of the low class increased by about 40% between 1974 and 2001, from 28.1% of the population to 39.5% (see table 2). In other words, households that were formerly in the higher social strata, and particularly the middle ones, entered this social class. Indeed, one peculiarity of this process of downward social mobility in the income distribution was that it was accompanied by a sharp contraction of the middle class, which shrank by somewhat over 35% (from 42.0% to 26.1% of the total). This figure is a stark reflection of the dissolution of the middle class in Argentine society already referred to by numerous earlier studies. It should be stressed that the

8 It will be recalled that the delimitation used in this study was <75; 75 to 150; and >150.

thinning of the middle strata mainly took place during the last decade of the twentieth century. The middle class had accounted for 37.9% of the population in 1980; by 1991, the figure was 36.2%.

Not all the reduction in the middle class went to swell the lowest stratum of society. In fact, the middle stratum of the population shrank by more than the low class grew, and the size of the high class increased accordingly. Thus, this social group expanded by 46%, with its share of the population rising from 29.9% in 1974 to 34.5% in 2001. Taken together, this evidence illustrates the kind of income polarization experienced in Argentina, characterized by rising shares of the population in the social groups at the top and bottom of the income distribution. Similar processes have been documented for other economies, examples being the United States and the United Kingdom in the period covering the 1980s and the 1990s (Jenkins, 1995; Burkhauser and others, 1999).

At this point, a methodological observation should be made to put the findings just discussed into perspective. The approach used here to demarcate the three social classes is distributional, and consequently refers to the position occupied by earners in the per capita family income classification. It says nothing, on the other hand, about whether needs are being met or about the level of consumption these relative positions entail for those in them. Thus, growth or contraction in the membership of the lower, middle and high classes has coincided with changes in the absolute poverty or wealth of each of them. When this information is incorporated, it needs to be appreciated that the increase in the size of the low class was also accompanied by a decline in this group's living standards, as measured by the purchasing power of incomes (see table 1).

Partly counteracting this process, in the phase of improving distribution between 2003 and 2010 the low class shrank by about 10%, from 42.2% to 38.5% of the total. The greatest change, though, was in the middle layers of society, whose membership increased by 30% from 25.8% of the population in 2003 to 33.4% in 2010. Consequently, the high class shrank by about 15%, from 32.0% to 28.1%, between the beginning and end of this seven-year period (see table 2).

The end result of developments in the social classes as variable units supports a view of Argentine society as being still affected by a high degree of social segmentation, something that is also consistent with the income polarization results. The growth in the middle class was a remarkable development, however, as virtually 8% of the population entered its ranks, with half (4 percentage points) having experienced what must be considered upward mobility (from the low class) while as many again came from the top segment. The latter movement seems to have been due to the changing distribution in the period together with the rising purchasing power of incomes, as the median per capita family income increased by 43% in real terms between 2003 and 2006.

As a corollary of the trends documented for the three main social classes, after some four decades the high class ended up at virtually the same level, while the share of the middle class was down by 9 percentage points, from 42.0% to 33.4%, and the low class had gained the same amount, with its share rising from about 28.1% to 38.5%.

(iii) *The income shares of the social classes as defined above*

The time has now come to introduce the results of the third measurement approach, which, as already noted, can be used to gauge income appropriation by the social groups, defined on this occasion by taking variable boundaries. In this case, the distances from the median income settled upon to demarcate the social classes in (ii) will be retained and the income appropriated by each will be assessed.

It can be established that in the subperiod from 1974 to 2001, the income share of the low class (whose size increased) fell dramatically, by some 35% (see table 2). To put it differently, not only did the membership of the most disadvantaged group increase, but those in it received a smaller share of income as a class, meaning that in per capita terms they were poorer than they had been 25 years before. The middle class, which contracted greatly, was also affected by a sharp reduction (of over 50%) in its income share. Indeed, this shrank by more than that class's membership, confirming that, as happened with the members of the low class, those of the middle class had lower incomes on average in 2001 than in 1974. Not only was there downward mobility in the period, but those who succeeded in remaining within the middle stratum lost income. Only the high class was able to achieve the virtuous double of increasing its membership while increasing its income share by even more—some 50%.

In the following period, 2003 to 2010, the situation was reversed, albeit only in part, and followed the pattern already discussed. The improvement was greatest for the middle class, whose income share grew by about 50%, and somewhat lesser for the lowest class, with a figure of about 23%. The income share of the high class, on the other hand, fell by 16%, which was slightly greater than the decline in its membership over the same period.

This provides important evidence that, by contrast with earlier stages, those remaining in the best-off sector of society experienced a reduction in the income available to them as a class.

Between the beginning and end of the extended period of almost four decades starting in 1974, the situation was still far from the level achieved in 1974. By late 2010, the high class had a larger income share than in the mid-1970s. The low class had not recovered the share of resources available to it then, while the middle class was in deficit by about 20%.

(iv) *The educational level of household heads*

As was to be expected, the educational level of household heads improved steadily and indeed substantially over the whole period. Whereas in 1974 about two in every three household heads had complete basic schooling or less, having never even started secondary school, by 2010 this group accounted for only 30.5% of the total (see table 2). Similarly, the number who had commenced higher education more than tripled between 1974 and 2010. Taken together with the social structure just described, these developments suggest a growing mismatch between people's educational attainment and their position in the social structure. This gap can be seen both in the trends of the different indicators of distribution and in those of occupational instability (see point (v) below). In other words, the shrinking of the middle class and the swelling of the low class during the 1974-2001 period, and the reversal of both processes between 2003 and 2010, took place in a context of sustained improvement in the educational level of the population. This characteristic, the devaluation of educational credentials, seems to have become a rather particular feature of the path followed by Argentine society. By contrast with what had happened in the past, educational attainment did not fully play its role in protecting incomes and employment quality during phases of deteriorating economic and social conditions. Its capacity for restoring people to similar positions in the social structure during upturns was also reduced.

(v) *The employment position of household heads in mid-life*

Some 70% of the population live in households whose heads are aged between 30 and 59. In addition, these household members provide about 70% of total earnings (see table 4). These two facts warrant a closer look at their participation in economic activity.

The evolution of the social structure thus demarcated very closely matches the first three approaches used. The proportion of households whose heads were working in unstable occupations practically doubled between 1974 and 2001, while the intermediate segment of families with heads in stable jobs fell by about 25% (see table 2). As a result of these two developments, the group of households with heads in stable higher-grade work increased its share from 10.9% to 16.1%. The evolution of income distribution (increased concentration) and growing polarization (the shrinking of the middle class) clearly have a connection with the rising instability of employment among household heads. It can also be seen that in the seven-year period beginning in 2003, improved distribution, reduced polarization and the expansion of the middle class were accompanied by an increase in the instability of household heads' occupations.

IV

The workings of the labour market [9]

1. General characteristics

There is a great deal of evidence that the shifting workings of the labour market gave rise to the changes in the social structure that have been discussed. Between 1974 and 2001, unemployment and informal working rose sharply, while the employment rate fell (see table 3). Again, in the 2003-2010 period, both open unemployment and informality declined while the employment rate increased substantially.

It is now time for a more detailed analysis, focusing on the economic participation of household heads.[10]

[9] The references to social classes in what follows are based on the stratification carried out using criterion (ii): social classes by income interval relative to the median.

[10] It has already been mentioned that the occupational characteristics of household heads belonging to each of the three social classes identified provide the information needed to assess the deeper causes of changes in the social structure. Households' monetary income derives essentially from the work of their members, and particularly their heads (see table 4).

TABLE 3

The labour market in Greater Buenos Aires, 1974-2010
(Percentages)

	Oct-1974	Oct-1980	Oct-1986	Oct-1991	Oct-1996	Oct-2001	Q4-2003	Q4-2006	Q4-2010
Activity rate	49.1	48.3	49.0	49.7	53.8	52.8	57.7	57.8	56.6
Activity rate without job creation scheme beneficiaries						52.2	54.9	57.0	56.2
Employment rate	47.9	47.4	46.8	47.1	43.7	42.6	48.9	52.4	52.1
Employment rate without job creation scheme beneficiaries						42.1	46.0	51.5	51.6
Unemployment rate	2.4	2.2	4.5	5.3	18.8	19.3	15.5	9.7	8.0
Unemployment rate without job creation scheme beneficiaries						19.5	16.3	9.9	8.1
Informal jobs	37.7	38.0	42.0	47.0	46.9	48.6	55.3	51.2	42.1
Informal jobs without job creation scheme beneficiaries						47.9	52.5	50.4	41.6
Unregistered employees[a] as share of all employees	19.0	17.1	21.1	30.0	33.3	33.5	39.1	36.4	28.1

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

[a] Excludes domestic service and job creation scheme beneficiaries.

TABLE 4

Structure of households and family incomes in Greater Buenos Aires, 1974-2010
(Selected years)

	Oct-1974	Oct-1986	Oct-1996	Q4-2003	Q4-2006	Q4-2010
Percentage of households						
Households with heads aged under 30	11.7	9.8	9.9	9.9	9.6	8.6
Households with heads aged between 30 and 59	60.3	57.4	58.5	58.6	58.2	59.0
Households with heads aged over 59	28.0	32.8	31.5	31.6	32.2	32.5
Total	*100*	*100*	*100*	*100*	*100*	*100*
Percentage of population						
Households with heads aged under 30	10.8	9.6	8.7	8.9	8.3	7.8
Households with heads aged between 30 and 59	68.5	67.7	69.1	68.5	67.9	68.0
Households with heads aged over 59	20.7	22.7	22.2	22.7	23.8	24.2
Total	*100*	*100*	*100*	*100*	*100*	*100*
Percentage of total family income from main occupation of family members						
Households with heads aged under 30	91.6	88.2	83.9	83.3	77.8	83.6
Households with heads aged between 30 and 59	84.1	86.7	86.3	77.1	82.7	87.4
Households with heads aged over 59	41.4	40.8	36.0	46.3	43.2	45.0
Percentage of earnings contributed by head (main occupation)						
Households with heads aged under 30	79.1	81.2	82.0	76.3	79.2	77.3
Households with heads aged between 30 and 59	77.1	77.6	75.7	74.4	68.6	68.3
Households with heads aged over 59	47.8	50.4	47.5	63.3	52.4	50.2

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

The first thing to highlight is the economic participation rate of this group. This is an indicator of willingness to work in a remunerated activity in the market, i.e., it is the sum of the employed and the unemployed relative to the total reference population, and its value will consequently tend to be greater in mid-life than at either end of the life cycle. For the universe taken here, consisting of household heads aged from 30 to 59, this value can be expected to be very close to 100%. Any shortfall is the result of family decisions about which members are going to participate in economic activity, and of situations in which people are more or less motivated to seek a job because of the greater or lesser likelihood of obtaining one. Between 1974 and 1996, there was a gradual reduction in inactivity among household heads, bringing their activity rate up from 91% to 94%, while from 2003 to 2010 the trend reversed and the rate fell from 96% to 92%, or held steady at about 91% if beneficiaries of job creation schemes are treated as spuriously active (see table 5). The reasons for this change are beyond the scope of this article, but suffice to say that it could be due to the drop in real household incomes in the first period and a degree of weakness in the demand for employment in the second. Support is given to this interpretation by the fact that the economic activity rate in the low class had risen to just 85% or so by 2010, whereas the figures were 92% in the middle class and 97% in the high class.

The trend of open unemployment provides a more detailed picture. Whereas in 1974 the unemployment rate among household heads was marginal (around 1%), this figure increased tenfold over the next two decades, rising to about 11% by 1996. This development was particularly felt in the low class, with unemployment rising from less than 3% in the mid-1970s to almost 25%. If the seven-year period from 2003 to 2010 is taken, by contrast, it transpires that the unemployment rate was already back to single digits by 2003 and had fallen by about 50% by 2010 (it will be recalled that beneficiaries of job creation schemes are shifted from the unemployed to the employed category). The differing evolution of this indicator by social class should once again be noted. About 7% of household heads in the low class were actively seeking work, while the proportion of unemployed in the middle and high classes was about 2.7% and 1.4%, respectively, in 2010.

Where employment quality is concerned, stress should be laid on the high level of informal working (own-account workers, unregistered employees, domestic service and beneficiaries of job creation schemes) throughout the period; furthermore, this behaved procyclically relative to unemployment. The rate of informal employment rose from 27% to 35% between 1974 and 1996, while in the later phase, from 2003 to 2010, the combined share of all types of informal employment dropped from 46% to 36%. Again, whereas growth in own-account working was the most dynamic component of informal employment between 1974 and 1986, the variable underlying the change in the share of informal working thereafter was the expansion of jobs not registered with the social security system. From the mid-1980s onward, there was little change in the employment shares of either own-account workers (ranging from 18% to 20%) or domestic service workers (ranging from about 3% to 5%). In the expansionary period from 2003 to 2010, the reduction in informal working among household heads was due to the relative decline of unregistered jobs, own-account working and participation in job creation schemes, in that order.

In summary, the proportion of household heads working in formal employment (defined as registered wage employment) plus employers peaked in 1974 at 63%, bottomed out in 2003 at 43.1% and then rose strongly again to 52.3% in 2010, although this was still below the mid-1970s level (see table 5).

The general pattern described was seen in all three social classes, but to differing degrees, with lack of convergence a notable characteristic. In the low class, just 30% of household heads had a formal job in 2010, whereas in the middle and high classes the figures were 55% and 70%, respectively. In 1974, on the other hand, the figures had been 55%, 64% and 67% for the low, middle and high classes, respectively. The fall-off was sharpest in the low class, especially between 1986 and 1996, when the share declined by over 20 percentage points, from 51% to 30%.

Between 2003 and 2010, the amount of formal employment was somewhat smaller, in relative terms, in the low class: whereas the gap for this indicator between the high and low classes was 35 points in 2003, by 2010 it had widened to 39.5%. Something worth highlighting is that the degree of dispersion between classes for this indicator was much greater in 2010 than in 1974. The decline or expansion of unregistered employment, together with the evolution of unemployment, thus emerge as important determinants of changes in the social structure (see table 5). Nor can the existence of earnings gaps by occupational category and social class be overlooked (see table 6).

TABLE 5

Employment status of household heads aged between 30 and 59 in Greater Buenos Aires, in total and by social class, 1974-2010
(Percentages)

	Oct-1974	Oct-1986	Oct-1996	Q4-2003	Q4-2006	Q4-2010
All household heads						
Employers	7.1	6.4	4.9	4.4	4.4	4.5
Own-account workers	18.0	20.7	18.1	20.1	19.3	17.6
Registered employees	55.9	52.0	42.7	38.7	41.8	47.8
Unregistered employees	6.3	6.8	13.9	17.6	17.2	13.2
Domestic service	2.7	3.6	3.2	3.7	5.6	4.6
Unemployed	1.1	3.1	10.9	6.7	3.9	3.6
Inactive	8.8	7.3	6.3	4.2	6.3	8.0
Job creation scheme beneficiaries	0	0	0	4.6	1.5	0.7
Total	*100*	*100*	*100*	*100*	*100*	*100*
Low-class household heads						
Employers	2.6	1.9	0.4	2.4	1.7	1.4
Own-account workers	13.8	18.0	14.4	20.0	21.0	20.5
Registered employees	52.6	49.4	30.1	21.5	25.4	29.3
Unregistered employees	8.5	9.8	16.6	21.0	22.4	20.0
Domestic service	5.9	4.7	4.5	3.8	8.1	6.5
Unemployed	2.6	7.4	24.6	13.1	7.6	7.0
Inactive	14.0	8.5	9.4	6.2	9.7	14.6
Job creation scheme beneficiaries				11.5	3.9	0.7
Total	*100*	*100*	*100*	*100*	*100*	*100*
Middle-class household heads						
Employers	6.4	3.8	2.0	2.9	2.3	3.9
Own-account workers	17.9	20.7	15.6	24.7	21.0	15.8
Registered employees	57.8	53.8	48.2	42.2	43.4	50.9
Unregistered employees	5.9	6.0	16.0	17.7	18.1	13.6
Domestic service	2.6	5.4	3.7	3.2	6.7	5.0
Unemployed	1.1	1.8	7.9	3.0	2.9	2.7
Inactive	8.3	8.5	6.7	4.6	5.0	6.8
Job creation scheme beneficiaries				*1.6*	*0.6*	*1.4*
Total	*100*	*100*	*100*	*100*	*100*	*100*
High-class household heads						
Employers	10.9	12.1	10.6	7.0	8.7	7.9
Own-account workers	20.9	22.7	22.8	17.2	16.3	16.5
Registered employees	55.8	52.1	48.2	51.9	55.7	62.4
Unregistered employees	5.4	5.5	10.4	14.4	11.8	6.6
Domestic service	*0.8*	*1.1*	*1.7*	*3.8*	*2.4*	*2.5*
Unemployed	*0.1*	*1.3*	*2.6*	*3.3*	*1.2*	*1.4*
Inactive	6.1	5.2	3.8	2.1	4.0	2.8
Job creation scheme beneficiaries						
Total	*100*	*100*	*100*	*100*	*100*	*100*

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

TABLE 6

Relative earnings of household heads aged between 30 and 59 in Greater Buenos Aires, 1974-2010, in total and by social class[a, b]
(Percentages)

	Oct-1974	Oct-1986	Oct-1996	Q4-2003	Q4-2006	Q4-2010
All household heads						
Employers	158	232	237	188	188	168
Own-account workers	104	103	97	78	74	77
Registered employees	97	91	99	126	125	118
Unregistered employees	70	67	72	78	73	66
Domestic service	43	40	37	42	30	34
Low-class household heads						
Employers	74	59	53	55	37	62
Own-account workers	59	46	35	35	36	39
Registered employees	71	53	52	67	73	76
Unregistered employees	54	44	37	43	49	46
Domestic service	37	34	30	29	22	19
Middle-class household heads						
Employers	131	99	104	103	94	118
Own-account workers	95	80	72	59	63	74
Registered employees	89	72	72	92	104	103
Unregistered employees	64	61	59	72	69	68
Domestic service	44	39	34	46	31	42
High-class household heads						
Employers	190	292	260	240	235	206
Own-account workers	133	156	139	139	129	124
Registered employees	123	136	141	165	160	147
Unregistered employees	93	103	126	122	117	117

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

[a] Average for each year = 100.
[b] Monthly earnings from the main occupation declared.

2. The determinants of social class

The evidence just provided suggests that changes in the employment structure and in relative earnings have acted as determinants of social class in Argentina. One way of addressing this issue more precisely is to use multinomial logistic regression analysis. These models are a variation on conventional logit estimates and are appropriate when the dependent variable comprises more than two categories, in this case the three classes: low, middle and high (base category). The universe of analysis comprised household heads aged between 30 and 59 (version 1) and the subset of employed people belonging to this group (version 2). The variables of interest were the status of household heads as employed and inactive versus unemployed (version 1) and the occupational categories of employer, registered employee, unregistered employee and domestic service worker versus that of own-account worker (version 2). The rest of the independent covariates were sex, age and age squared, educational level, household size and the number of working family members. Both versions of the model were estimated for 1974 and 2010 (see tables 7a and 7b).

In version 1 of the model, controlling for the set of variables incorporated into it, the fact of the household head having been employed made membership of the low class less likely. Conversely, the likelihood of forming part of the low class was not significantly different for inactive heads and unemployed heads. To a somewhat lesser degree, the same finding was obtained for the likelihood of belonging to the middle class (always relative to the high class). These two findings held good for both 1974 and 2010 (see table 7a). This highlights the fact that access to a job for the household head has historically been a powerful determinant of membership of the middle and high social classes.

With version 2, it is possible to go on to identify the effect of a particular occupational status. The model revealed that in 1974, being an unregistered worker was associated with a greater chance of belonging to the low class (see table 7b). To a lesser degree, close to the limit of statistical significance, a similar picture emerged for the likelihood of belonging to the middle class (relative to the high class). This finding confirms that there was an income penalty for employees in undeclared jobs, who were relegated to the lower social stratum. Again, the absence of a negative likelihood of belonging to the low class for employees in registered jobs reflects the fact that earnings differences between these and own-account workers (the omitted category in the model) were not significant at the time. This is consistent with the existence of a "quasi-formal" type of own-account work that provided incomes similar to (and in some cases even higher than) those earned by registered workers.

TABLE 7A

Estimates of the determinants of social class in Greater Buenos Aires, 1974 and 2010
(Multinomial logistic regression models)

	Universe: all household heads aged between 30 and 59					
	Oct-1974			Q4-2010		
Dependent variable: low class						
Independent variables	Coefficient	Standard error	P>|z|	Coefficient	Standard error	P>|z|
Male	-1.551	0.260	0.000	-1.369	0.225	0.000
Age	-0.155	0.109	0.155	-0.054	0.129	0.676
Age squared	0.001	0.001	0.263	0.000	0.001	0.767
Education: up to incomplete secondary	-1.358	0.180	0.000	-2.160	0.521	0.000
Education: up to incomplete higher	-3.583	0.309	0.000	-3.597	0.534	0.000
Education: complete higher	-6.107	0.625	0.000	-5.885	0.596	0.000
Working	-4.767	1.155	0.000	-3.417	0.526	0.000
Inactive	-2.180	1.177	0.064	-1.000	0.640	0.118
Number of members in household	1.516	0.076	0.000	1.831	0.100	0.000
Number of working members in household	-2.481	0.144	0.000	-2.354	0.161	0.000
Constant	7.868	2.646	0.003	6.131	2.818	0.030
Dependent variable: middle class						
Independent variables	Coefficient	Standard error	P>|z|	Coefficient	Standard error	P>|z|
Male	-0.617	0.194	0.001	-0.766	0.181	0.000
Age	-0.044	0.082	0.593	-0.010	0.106	0.924
Age squared	0.000	0.001	0.685	0.000	0.001	0.943
Education: up to incomplete secondary	-0.894	0.144	0.000	-1.616	0.484	0.001
Education: up to incomplete higher	-1.746	0.191	0.000	-2.475	0.490	0.000
Education: complete higher	-3.766	0.367	0.000	-3.561	0.507	0.000
Working	-2.595	1.134	0.022	-1.490	0.519	0.004
Inactive	-1.536	1.153	0.183	-0.260	0.628	0.679
Number of members in household	0.857	0.057	0.000	1.124	0.084	0.000
Number of working members in household	-1.137	0.091	0.000	-1.159	0.129	0.000
Constant	3.938	2.142	0.066	3.082	2.367	0.193
Observations	1991			1479		
Pseudo R^2	0.255			0.335		
Base variable: high class						

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

TABLE 7B

Estimates of the determinants of social class in Greater Buenos Aires, 1974 and 2010
(Multinomial logistic regression models)

	Universe: working household heads aged between 30 and 59					
	Oct-1974			Q4-2010		
Dependent variable: low class						
Independent variables	Coefficient	Standard error	P>|z|	Coefficient	Standard error	P>|z|
Male	-1.184	0.336	0.000	-0.868	0.290	0.003
Age	-0.161	0.123	0.192	-0.261	0.150	0.081
Age squared	0.001	0.001	0.302	0.003	0.002	0.101
Education: up to incomplete secondary	-1.318	0.198	0.000	-1.844	0.596	0.002
Education: up to incomplete higher	-3.481	0.336	0.000	-3.113	0.609	0.000
Education: complete higher	-6.232	0.731	0.000	-5.601	0.692	0.000
Employer	-1.326	0.425	0.002	-3.142	0.596	0.000
Registered employee	0.238	0.225	0.289	-2.301	0.288	0.000
Unregistered employee	1.421	0.370	0.000	0.429	0.365	0.239
Domestic service	3.422	0.592	0.000	0.733	0.507	0.148
Number of members in household	1.663	0.084	0.000	2.147	0.120	0.000
Number of working members in household	-2.525	0.160	0.000	-2.787	0.192	0.000
Constant	2.156	2.633	0.413	7.176	3.238	0.027
Dependent variable: middle class						
Independent variables	Coefficient	Standard error	P>|z|	Coefficient	Standard error	P>|z|
Male	-0.267	0.236	0.258	-0.629	0.212	0.003
Age	-0.057	0.087	0.513	-0.180	0.116	0.122
Age squared	0.001	0.001	0.581	0.002	0.001	0.138
Education: up to incomplete secondary	-0.843	0.154	0.000	-1.738	0.538	0.001
Education: up to incomplete higher	-1.722	0.202	0.000	-2.486	0.544	0.000
Education: complete higher	-3.633	0.382	0.000	-3.683	0.562	0.000
Employer	-0.573	0.256	0.025	-1.303	0.411	0.002
Registered employee	0.162	0.159	0.306	-0.735	0.228	0.001
Unregistered employee	0.602	0.280	0.032	0.577	0.320	0.072
Domestic service	1.830	0.531	0.001	0.363	0.453	0.424
Number of members in household	0.923	0.062	0.000	1.297	0.097	0.000
Number of working members in household	-1.176	0.096	0.000	-1.333	0.143	0.000
Constant	0.969	1.892	0.609	5.549	2.532	0.028
Observations	1797			1306		
Pseudo R^2	0.2808			0.3814		
Base variable: high class						

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

In 2010, the situation changed and the fact of a household head working in a registered job reduced the likelihood of belonging to the low class, while being employed in a job that was not registered with the social security system did not increase it. This was because relative pay levels changed to such a degree that the fact of not having a registered job became a determinant of low class membership. The parameters estimated suggest both a widening of the earnings gap between registered and unregistered employees and a narrowing of the gap between the latter and own-account workers.

The evidence set out in the previous section documented an expansion of the unregistered workers segment in 2010 relative to the situation in the mid-1970s (see table 5). Similarly, a widening of the average pay gap between registered and unregistered employees had already taken place (see table 6). One way of ascertaining whether this outcome was due to occupational status or instead to other personal characteristics of wage earners is to estimate Mincerian earnings regressions (Mincer, 1974). Using least squares regression models to estimate individual earnings functions provides a way of ascertaining the average earnings difference between the formal (unregistered) and formal (registered) employees groups, after "controlling" for the effect of other characteristics of individuals and jobs usually considered to influence pay. The individual coefficients of the function correspond to different attributes that are included in the model specified and yield an earnings differential associated with that status. The dependent variable was the logarithm of the monthly wage and the independent variable of interest was employment in a job not registered with the social security system. Thus, the estimated parameter associated with this variable encapsulates a pay difference due to that attribute. The other covariates were educational level, sex, age, age squared, hours worked and sector of activity.

It can be seen that the penalty for holding an unregistered job doubled from 0.30 to 0.59 between 1974 and 2010 (see table 8). This shows that the rise of informality in the structure of Argentine employment in the twenty-first century has been accompanied by an increase in wage segmentation. As already seen, this has also affected the social structure, as the type of job a person is able to obtain has become a factor influencing social class membership.

TABLE 8

Estimates of wage determinants in Greater Buenos Aires, 1974 and 2010[a]
(Ordinary least squares regression models)

Dependent variable: natural logarithm of wage	Oct-1974			Q4-2010		
Independent variables	Coefficient	Standard error	P>|z|	Coefficient	Standard error	P>|z|
Unregistered employee	-0.303	0.045	0.000	-0.596	0.046	0.000
Age	0.025	0.016	0.115	0.050	0.023	0.032
Age squared	0.000	0.000	0.114	-0.001	0.000	0.052
Male	0.467	0.044	0.000	0.240	0.046	0.000
Up to complete primary	-0.406	0.046	0.000	-0.960	0.094	0.000
Up to incomplete secondary	-0.221	0.044	0.000	-0.671	0.051	0.000
Up to incomplete tertiary	0.064	0.049	0.197	-0.461	0.048	0.000
Sector dummies	Yes			Yes		
Hours	0.006	0.001	0.000	0.011	0.001	0.000
Constant	7.107	0.345	0.000	6.705	0.495	0.000
Observations	1724			922		
R^2	0.310			0.503		

Source: prepared by the author on the basis of data from the Permanent Household Survey (EPH).

[a] Controlling for sample selection.

V

Conclusions

The evolution of inequality in income distribution in Greater Buenos Aires between the mid-1970s and the end of the first decade of the twenty-first century hinted at far-reaching changes in the social structure. Meanwhile, measuring income polarization provided confirmation that the evolution of the middle class was one of the most prominent features of these changes. Another simultaneous development, furthermore, were large fluctuations in real per capita incomes throughout the period. This situation was confirmed by the different social stratification criteria used in the study.

Two starkly dissimilar stages emerge. Between 1974 and 2001, the middle sections of society shrank rapidly and the low class expanded substantially. Between 2003 and 2010, these trends were sharply reversed, but to differing degrees in the different social strata. The middle and low classes, in that order, saw a strong recovery in incomes over those seven years, and this resulted in a sustained distributional improvement. Practically 8% of the population were absorbed in the ranks of the middle class as it expanded.

The recovery of the middle sections in Argentine society was unprecedented since at least the mid-1970s. It is worth emphasizing that it was the result both of upward social mobility (the shrinking of the low class) and of the contraction of the high class. These developments imply that income redistribution mechanisms were at work, increasing the resources of those in the low and middle segments of the social structure but without producing a shift on a similar scale at the top.

These mechanisms do not seem to have operated in isolation from the workings of the labour market. The decline in unemployment and informal working, especially in the unregistered wage employment category, stands out as the main factor behind the fluctuating movements in the social classes in the long period under analysis. Thus, when the characteristics of occupational status were examined (from a stratification perspective that drew particularly on the tradition of sociology), it was possible to ascertain that there had been an increase in the number of jobs providing greater stability to those holding them. This partially reversed the strong increase in occupational instability that had characterized the last quarter of the twentieth century. It should also be considered that this improvement in job quality went together with more vigorous collective bargaining between workers and employers and periodic increases in the minimum wage, among other factors. These mechanisms tend to compress the pay distribution, as their greatest effects are at the lower end of the income scale. The application of lump-sum pay increases for all workers will have operated in the same direction, as will various social protection measures implemented in the period, with job creation schemes, expanded coverage of pension benefits and the extension of family allowances to the children of informal workers being among the most important.

Besides the overall improvement in the dynamics of the social structure, this study also revealed the persistence of labour market segmentation. In other words, those who succeeded in obtaining a registered job enjoyed a pay advantage over employees in jobs that were not registered with the social security system. Likewise, access to a formal job remained elusive for a quite considerable proportion of individuals in the lowest social stratum. This being the case, it is not surprising that the type of employment obtained should have resulted in social differentiation persisting at increasingly high levels over the long period from 1974 to 2010. In other words, it was possible to ascertain that the wage gap between registered and unregistered workers (and the widening of this gap), together with the high proportion of employment accounted for by the latter, influenced households' membership of a particular social class.

Taken together, all this evidence confirms the urgent need for efforts to reduce the level of undeclared employment in the Argentine economy. It seems unlikely that higher levels of social integration can be achieved unless obstacles to registered employment are removed. It should be recalled that the wage penalty for unregistered wage workers doubled between 1974 and 2010, and has not fallen in the new century so far. Efforts should at least begin in certain sectors where the level of non-registration is very high, prime examples being retail, construction, the textile and apparel industry and domestic service. In the meantime, it is necessary to enhance and extend the implementation of different social protection measures aimed at reducing the earnings gap between those who obtain a formal job and those who remain trapped in informality.

Lastly, it is worth emphasizing the potential for new research that incorporates methodological contributions from economics and sociology in the examination of changes in the social structure. The present study is an effort in this direction. By using different indicators and criteria drawn from the two disciplines to demarcate social groups, it was possible to establish certain links between distributional shifts, certain prominent features of the labour market and membership of a social class. Continued work along this line of analysis would probably yield detailed knowledge of the vicissitudes of social structures in the twenty-first century.

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Inequality and academic achievement in Chile

Pablo Muñoz H. and Amaia Redondo S.

ABSTRACT

This work uses a set of panel data to contribute new evidence on the impacts of socioeconomic determinants on academic achievement in Chile. Socioeconomic determinants are found to have a statistically significant effect, which rises over time, on academic achievement. The evidence shows that two individuals of different socioeconomic levels (SEL) who achieve the same score in Chile's Educational Quality Measurement System (SIMCE) in eighth grade, are separated by a gap of over 70 points on average four years later, when they sit the University Selection Test (PSU). It is concluded that in a context of great income inequality and high returns on tertiary education, academic achievement indexes throw up barriers to access to tertiary education, principally for the population of low socioeconomic level, thereby perpetuating poor income distribution.

KEYWORDS

Social structure, students, school achievement, social aspects, social classes, measurement, econometric models, Chile

JEL CLASSIFICATION

I22, I24, I25, I31, J31

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I
Introduction

A number of studies prepared by international agencies, including the Economic Commission for Latin America and the Caribbean (ECLAC), the World Bank and the Inter-American Development Bank (IDB), have identified persistently high levels of income distribution inequality as a hallmark of Latin America. Around 2005, the Gini coefficient was about 0.53 and Latin America was more unequal than sub-Saharan Africa, East Asia and the high income countries by 18%, 36% and 65%, respectively.

In *Declining Latin American Inequality: Market Forces or State Action*, Luis López-Calva and Nora Lustig (2010) showed that inequality in the region began to decline in 2000. In Mexico, Argentina, Peru and Brazil two main factors underlie the decrease in inequality: narrowing of the income gap between skilled and unskilled workers, and an increase in government transfers to the most vulnerable sectors. Nevertheless, a projection of constant inequality decline is unlikely, because the low-income population which has managed to gain access to primary and secondary education still faces a range of access barriers when it comes to tertiary education.[1]

Within the region, Chile has posted outstanding rates of economic growth in the past few decades and poverty has declined as a result. However, it has been shown empirically that in high-growth conditions, poverty reduction and variations in income inequality are not necessarily correlated.[2] In this regard, Chile is a fairly unequal country; its Gini coefficient is the highest within the Organization for Economic Cooperation and Development (OECD), and relative poverty is high as well (approximately 1 in 5 are poor in relative terms). Differences in education level among the workforce have traditionally been cited as a possible explanation for income inequality.[3] That is, graduates from tertiary education capture higher returns, because demand for skilled labour exceeds supply in the Chilean labour market, but this is not the case for unskilled labour.

A series of reforms were made to education in Chile in the early 1980s. A voucher system was created whereby publicly funded schools (administered by municipalities) and subsidized private schools receive a direct subsidy for each student enrolled. The main quality assurance mechanism in Chile's education system is free entry to the education market and competition between schools, with little State intervention.

Following this reform, the number of subsidized private schools burgeoned, from 30% of total enrolments in 1986 to 48% in 2008, while the percentage of students attending fully private schools (7%) varied little. Generally speaking, students in fully private schools come from families with a high socioeconomic level, whereas those in municipal schools come mainly from the first two income quintiles. Students attending subsidized schools come from families with differing socioeconomic levels,[4] mainly quintiles 3 and 4, although the income level of these quintiles is well below that of the middle class in other OECD countries (Chile's average adjusted household income is 38% the OECD average[5]).

Chile has improved education coverage in the past few decades, but not its quality or equity. The reform increased socioeconomic and cultural segregation,[6] while the voucher system has not driven competition capable of guaranteeing greater efficiency, but has led to a state of equilibrium in which schools skim the market to minimize risk and gain quality at the cost of stratification.[7] This skimming process, as suggested by Epple and Romano (1998), has restricted the quality of education available to the poor.[8] In practice, the most expensive private schools have far more resources per student than municipal schools, or than the subsidized schools located in the most vulnerable areas. Several studies show that student socioeconomic background is one of the main determinants of learning outcomes, while the socioeconomic level of fellow students can have an even stronger impact (OECD, 2007). Teaching

[1] Luis López-Calva and Nora Lustig (2010) note that these barriers relate basically to the low quality of primary and secondary education in Latin America.
[2] See Contreras (1996).
[3] See Contreras and Gallegos (2011).

[4] This is because a shared financing system operates in Chile: the State subsidizes school establishments and families make a co-payment as well.
[5] According to the OECD Better Life Index (2012).
[6] See Valenzuela (2006).
[7] See Contreras, Sepúlveda and Bustos (2007).
[8] See Hsieh and Urquiola (2006).

students at social risk is difficult and therefore costly, especially if they are concentrated in the same school. Other data show that parents have little information about school quality (Elacqua and Fábrega, 2004), and access to and use of this information depends, as well, on socioeconomic status. Lower-income parents also attribute particular value to the distance between home and school, regardless of the quality of education (Chumacero, Gómez Caorsi and Paredes, 2008; Gallego and Hernando, 2009).

All this reduces the incentive for schools to improve quality to attract students. And Chile's greatest challenges lie precisely in quality, since although the country's scores in the Programme for International Student Assessment (PISA) improved considerably between 2000 and 2009, the scores for 15-year-olds in science, reading and mathematics remain well below the OECD average, even after adjusting for income level. In Chile PISA scores fall, depending on the type of school, in direct relation to students' socioeconomic background.

Since the 1981 reform, the system of tertiary education in Chile has been divided into two main groups: the private universities and those grouped under the Council of Rectors of Chilean Universities (CRUCH). CRUCH universities account for the largest portion of matriculations in tertiary education and they select students by means of a common admissions system.[9] Since 2003, the admissions system under CRUCH consists of using the results of the various university selection examinations (University Selection Test, PSU, in language, maths, science and history) as discrimination factors, in combination with applicants' average secondary education grade (*nota de enseñanza media*, NEM).[10] The 2013 admissions process included an additional measurement instrument, which ranks students by academic achievement in secondary school and rewards relative position within each educational establishment.[11] The rationale for this measure was the fact, as shown by various authors, that indices such as relative ability not only lessen socioeconomic exclusion, but are also good predictors of performance in tertiary education, even after controlling for PSU scores.[12]

The factors mentioned are weighted differently depending on each particular course and university, with a view to predicting academic success over the university career. Those with higher scores therefore have more options to choose between universities and courses, and thus have better access to the high returns which some of these offer.

It has been shown that results in Chile's Educational Quality Measurement System (SIMCE) are heavily conditioned by socioeconomic factors[13] and that social mobility is limited (Núñez and Risco, 2004). Several authors[14] consider education a key determinant and attribute inequality in learning quality to socioeconomic variables. One of these variables is the students' socioeconomic background, which is determined by family income and by the type of school they attended.[15]

This research offers new evidence with respect to the impact of certain socioeconomic determinants on academic achievement. First, it demonstrates that socioeconomic variables are statistically significant in explaining levels of achievement in both PSU and SIMCE. Second, using a set of panel data and tracking individuals at two points in time (at the time of the SIMCE and PSU), it re-examines the role of socioeconomic determinants, now controlling for two categories: high and low socioeconomic level. The evidence shows that two individuals of different socioeconomic level —as measured by family income and parents' level of education—who achieve the same SIMCE scores in eighth grade, have a gap of over 70 points on average four years later when they sit the PSU. In other words, the academic achievement gaps do not narrow, but grow wider. This is all the worse because the outcomes of PSU determine access to tertiary education and the high private returns it brings.[16] This represents evidence that the Chilean education system has not been efficient in offsetting differences of origin among students.

Following this introduction, section II se examines the panel data containing the results of the SIMCE and PSU tests, in the light of the corresponding variables. Section III uses production function and value added approaches to analyse the results of those tests as a function of a vector of socioeconomic variables. Section IV sets forth and discusses the findings of the research. Section V concludes.

9 Information from the Council of Rectors shows that eight private universities, as well as the 25 traditional CRUCH universities that participated previously, entered the common admissions process in 2012.
10 See Contreras, Gallegos and Meneses (2009).
11 See DEMRE (2012) and CRUCH (2012).
12 See Contreras, Gallegos and Meneses (2009).
13 See Mizala and Romaguera (2000).
14 See Brunner and Elacqua (2003); Cornejo (2005).
15 See Contreras and Macías (2002).
16 The evidence presented here also shows that the gap in SIMCE achievement is widening.

II
Data

This article uses a set of panel data, which includes the SIMCE and PSU scores of the full sample of students (a total of 99,736) in secondary education in 2001 and 2004. Specifically, the scores used were the SIMCE obtained in 2000 (eighth grade) and the PSU obtained in 2004 (twelfth grade school-leavers) by each of the students. That is, the scores available were those obtained by the same individual at two different points in time.

The NEM variable corresponds to the grades obtained in secondary education, which are used in this article to identify each student's relative position within his or her school.

The dataset also includes a series of variables corresponding to student socioeconomic characteristics at the time of taking the PSU, and other factors relating to the schools they were attending when they took the SIMCE. The socioeconomic variables considered included gender, income of the family group and the parents' level of education. With respect to the school, the variables include administrative type, geographical area and modality of education.

Students who did not sit the PSU in 2004 were excluded from the SIMCE, as were those who did not graduate from secondary school that year.

The description of the variables is shown in table 1.

Table 2 shows the descriptive statistics of the variables used.

TABLE 1

Description of variables

Variable	Description
SIMCE score	
Language	Score obtained in SIMCE language test
Mathematics	Score obtained in SIMCE mathematics test
Average	Average of SIMCE scores in language and mathematics
PSU score	
Language	Score obtained in PSU language test
Mathematics	Score obtained in PSU mathematics test
Average	Average of PSU scores in language and mathematics
Student variables	
Sex	1= Female, 0 = Male
NEM	Relative position in school by secondary education grades
Socioeconomic variables	
Income of family group	1 = [CH$ 0 - CH$ 278,000]; 2 = [CH$ 278,000 - CH$ 834,000]; 3 = [CH$ 834,000 - CH$ 1,400,000]; 4 = [CH$ 1,400,000 or more]
Level of education mother/father	1= no schooling, 2 = incomplete primary, 3 = complete primary, 4 = incomplete secondary, 5 = complete secondary, 6 = incomplete TT, 7 = complete TT, 8 = incomplete university, 9 = complete university, 10 = other studies
School variables	
Administrative type:	
-Municipal	1= municipal, 0 = other
-Subsidized private	1 = subsidized private, 0 = other
-Fully private	1= paid private, 0 = other
Geographical area	1 = rural, 0 = urban
Modality	0 = technical/vocational, 1 = science/humanities

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

TT: technical training.
NEM: average grades in secondary school.

TABLE 2

Descriptive statistics of the variables

Variables	Average	Deviation	Minimum	Maximum
SIMCE score				
Language	276	47	109	395
Mathematics	277	47	118	382
Average	276	42	128	388
PSU score				
Language PSU	499	111	167	850
Mathematics PSU	501	112	150	850
Average	500	104	198	840
Student variables				
Female	54%	0.50	0	1
Scores	0.52	0.29	0.001	1
Sociocultural variables				
Family income:				
– Level 1 = [CH$ 0 - CH$ 278,000]	55%	0.50	0	1
– Level 2 = [CH$ 278,000 - CH$ 834,000]	31%	0.46	0	1
– Level 3 = [CH$ 834,000 - CH$ 1,400,000]	7%	0.26	0	1
– Level 4 = [CH$1,400,000 ormore]	7%	0.26	0	1
Education mother	5.4	2.2	1	10
Education father	5.6	2.4	1	10
School variables				
Administrative type:				
– Municipal	40%	0.49	0	1
– Subsidized private	43%	0.49	0	1
– Fully private	17%	0.37	0	1
Rural	6%	0.23	0	1
Science/humanities modality	77%	0.42	0	1
Total no. observations 99 736				

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

The SIMCE scores are observed to range from just over 100 to just under 400 points, with an average of around 280, while the PSU scores range from 150 to 850, with an average of 500. The gross SIMCE score is adjusted or standardized to obtain a median of 250 points and a deviation of 50 points. This is because the sample for this study includes the SIMCE scores only of those students who also sat the PSU in 2004. In other words, the data exclude the SIMCE scores of those who did not sit the PSU in 2004.

Females represent 54% of the sample. Students who take the PSU have an average relative ranking in their schools of 0.52, with a deviation of 20%.

Most of the students belong to the first income level (55%), 31% to the second and only 7% to each of the higher levels. With respect to school administrative type, 40% of students attend municipal schools, 43% subsidized private schools and only 17% fully private schools.

The average level of parental education is around 5, corresponding to complete secondary education, and is slightly higher among fathers than mothers.

Lastly, 6% of students study in rural areas, and 77% attend science/humanities schools, with the remaining 22% attending vocational training schools.

It is important to bear in mind the average SIMCE and PSU scores for the different income levels, and the average schooling of parents and composition of the sample of the different types of schools by administrative type. Descriptive statistics are shown in annex table A1.

It stands out clearly that the higher the income level, the higher students' scores in language and mathematics in both SIMCE and PSU. It is also apparent that students from higher income levels have more highly educated parents, on average. Furthermore, students in municipal schools come essentially from the first income level, while subsidized schools have students mainly from the first and second levels. In private schools, the situation is just the reverse, with students mainly from the highest and second highest income levels.

III
Methodology

This study uses the results obtained by the same individual at two points in time in the SIMCE and PSU tests, which are instruments designed to assess student knowledge and are highly correlated (75%[17]). This work uses the production function approach proposed by McEwan and Carnoy (1999), with the test scores understood as the output of a set of student-linked variables. Accordingly, the results of the SIMCE and PSU tests are examined as a function of a vector of socioeconomic variables, which includes type of establishment, student characteristics and other factors. The results of this regression are presented in the annexes (general model, annex table A2) and confirm the potential of the socioeconomic variables in explaining the scores obtained.

Having confirmed the statistical significance of the socioeconomic determinants of student performance, the study then sets out to determine the extent to which conditions endogenous to the individual influence his or her levels of academic achievement. As noted above, the PSU and SIMCE tests are highly correlated, so that by controlling for one of them it may be supposed that the repercussion of the other variables corresponds to the effect on performance over time, i.e. the second-order effect of socioeconomic variables on achievement. It is proposed to estimate a specification using a fixed effects model, taking the results of the same individuals at two points in time. The model proposed therefore at least partly eliminates the effect of non-observable variables on the results.

In order to examine the contribution of socioeconomic variables over time, two dichotomous variables were chosen: SEL_{low}, which takes a value of 1 when the individual has a family income of less than 278,000 Chilean pesos (CH$), and SEL_{high}, whose value is 1 when the individual has a family income of over CH$ 1,400,000. An additional student classification by parental education level was estimated separately. This distinction was made from a cultural perspective, following Bourdieu and Passeron (1964), who argue that the great majority of students who do well in school come from families endowed with a high level of schooling, and therefore possess a cultural capital which their children inherit through socialization in the home from the earliest ages. These children are equipped with experiences, knowledge, language forms and attitudes which give them a considerable advantage with respect to school and the learning that occurs there. On this basis, two new dichotomous variables were created: low parental educational level ($Edlev_{low}$), whose value is 1 for students whose parents did not complete primary schooling, and high parental educational level ($Edlev_{high}$), for students whose parents have university studies. The main model is as follows:

$$\begin{aligned} PSU_t &= \alpha + \beta_1 \textit{ Subsidized priv.} + \\ &\beta_2 \textit{ Fully priv.} + \beta_2 \textit{ Modality} + \\ &\beta_4 \textit{ Gender} + \beta_5 \textit{ Parent education} + \varepsilon_t \end{aligned} \tag{1}$$

In equation (1) the dependent variable is the PSU score (average for language and mathematics), and the explanatory variables are: (i) school administrative type (subsidized private, fully private, and municipal as an omitted variable); (ii) the modality of studies (science/humanities establishments versus vocational training establishments); (iii) gender: which identifies the impact of being female; (iv) rural location; (v) average educational level of parents (from 1 = no schooling to 10 = postgraduate studies); (vi) family income grouped in four levels; and, lastly, (vii) the student's relative position in his or her establishment as defined by average secondary school grades (NEM).

The specification also includes the score obtained by the same student four years earlier in the SIMCE test as a regression factor. The aim is thus to ascertain the additional effect of variables already captured implicitly in the SIMCE score, given that:

$$\begin{aligned} SIMCE_{t-4} &= \alpha^- + \beta_1^- \textit{ Subsidized priv.} + \\ &\beta_2^- \textit{ Fully priv.} + \beta_2^- \textit{ Modality} + \beta_2^- \textit{ Gender} + \\ &\beta_5^- \textit{ Parent education} + \varepsilon_t \end{aligned}$$

[17] See details in annex table A3.

Equation (1) also reflects a value added approach in the estimation of an achievement production function. In this regard, the literature indicates that evidence based on this type of specification is generally preferred to that obtained from contemporary information (Hanushek, 1996; Krueger, 2000; Todd and Wolpin, 2003) because it clears, at least partially, the effect of non-observable variables on the results.

According to Todd and Wolpin (2003), a value added specification requires suppositions about the behaviour of non-observable variables and is therefore subject to endogeneity problems. One of the main criticisms levelled at this type of model is that if the behaviour of the agents is optimal, then families should be expected to take decisions based on the students' baseline achievement ($SIMCE_{t\text{-}4}$ in this case). In Chile, however, families are not informed of SIMCE results, so cannot take decisions on this basis. This adds value to the specification contributed in this study, because it lessens the endogeneity bias.

In conclusion, this model is intended to evaluate the effect and statistical significance of socioeconomic determinants on academic achievement. The specification also makes it possible to assess whether the impact of the factors increases over time.

The following models are defined in addition to equation (1):

$$PSU_t = \alpha + \beta_1\, SIMCE_{t\text{-}4} + \beta_2\, SEL_{high} + \beta_3\, SEL_{low} + \varepsilon_t \qquad (2)$$

$$PSU = \alpha + \beta_1\, SIMCE_{t\text{-}4} + \beta_2\, SEL_{high} + \beta_3\, SEL_{low} + \beta_4\, SEL_{high} SIMCE_{t\text{-}4} + \beta_5\, SEL_{low} SIMCE_{t\text{-}4} + \varepsilon_t \qquad (3)$$

Equation (2) tests for the PSU performance differential driven exclusively by socioeconomic level (SEL), for which it is necessary to control for SIMCE performance. Equation (3) includes interaction variables between SIMCE achievement and socioeconomic level, with a view to lessening the supposition that the difference between the two groups' achievement, if it exists, is constant. These specifications have been included in order to show clearly the effect of high and low socioeconomic level on PSU results, controlling for SIMCE.[18]

[18] Equations (2) and (3) do not consider the regression vectors from (1), because most of these controls are highly correlated with the average socioeconomic level. The sign and significance of the results is maintained if all the controls are included; this estimate is reported in annex table A4.

IV

Results and discussion

All the variables were significant and the effects were aligned with the classic model developed by Mizala and Romaguera (2000), which confirms that in Chile socioeconomic determinants impact academic achievement. In addition, however, new evidence is provided that the impact of these factors grows over time. This may be because individuals with better economic circumstances can keep making a larger investment over time and, therefore, may expect a higher return (in this case, a higher score). Nevertheless, the key point here is that greater exposure to an unfavourable socioeconomic context increases the limitations students face in securing a good PSU score and thus gaining access to tertiary education.

Table 3 shows the estimations of the model specified in equation (1).

TABLE 3

Determinants of the University Selection Test (PSU) score

Variables	PSU MATH	PSU LANG	PSU
Subsidized	7.542***	10.93***	8.505***
Private	33.35***	32.91***	30.46***
Modality	42.36***	35.87***	37.62***
Female = 1	-33.54***	-21.35***	-27.45***
Schooling parents	5.068***	6.488***	5.117***
Rural	-19.66***	-21.03***	-18.98***
Family income	10.46***	8.943***	9.095***
NEM (relative)	95.87***	94.38***	84.80***
SIMCE Math	1.174***		
SIMCE Lang		1.157***	
SIMCE			1.345***
Constant	58.51***	54.76***	18.81***
No. observations	87 417	87 417	87 417
R-squared	0.647	0.601	0.713

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

Note:***p<0.01.
PSU MAT: PSU mathematics.
PSU LENG: PSU language.
SIMCE Math: SIMCE mathematics.
SIMCE Lang: SIMCE language.
NEM: average grades in secondary school.

On the basis of these results, it was considered worthwhile to look in more detail at the impacts of the socioeconomic variables, for which the model specified in equation (2) was estimated. The results observed were as follows:

TABLE 4

University Selection Test (PSU), by income

Variables	PSU
SIMCE	1.710***
SEL_{high}	43.08***
SEL_{low}	-31.30***
Constant	41.50***
No. observations	99 706
R-squared	0.617

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: ***p<0.01.
SEL: socioeconomic level.

It may be directly observed that, on average, for the same SIMCE performance, individuals with a high socioeconomic level (SEL_{high}) performed better in the PSU than those with a low socioeconomic level (SEL_{low}), with the difference averaging 70 points.

One of this model's limitations is the assumption that the difference in the two groups' performance is constant. Accordingly, an interaction variable was included for SIMCE achievement level and the socioeconomic determinant, in order to capture the additional returns of each SIMCE point at the different socioeconomic levels. This is the return on the marginal variation in SIMCE performance. Estimation of the model specified in equation (3), then, gives the following results:

TABLE 5

University Selection Test (PSU), by income and interaction with SIMCE

Variables	PSU
SIMCE	1.784***
SEL_{high}	65.37***
SEL_{low}	3.637
SEL_{high} SIMCE	-0.0782***
SEL_{low} SIMCE	-0.126***
Constant	20.63
No. observations	99 706
R-squared	0.617

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: ***p<0.01.
SEL: socioeconomic level.

Given the parameters estimated in the previous regressions, and in order to analyse the results better, the PSU scores that would be expected by socioeconomic level are shown here:

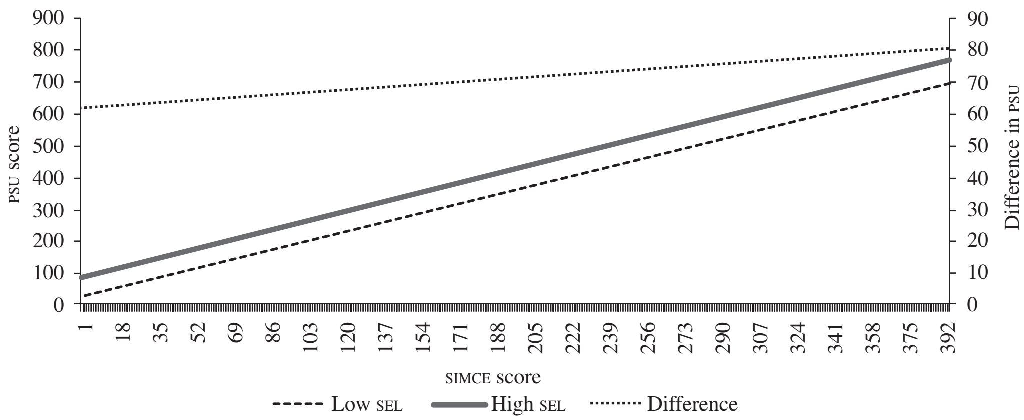
$$PSU\ (SEL_{high} = 1) = 85.9+1.71 * SIMCE$$
$$PSU\ (SEL_{low} = 1) = 24.3+1.66 * SIMCE$$

The statistical significance of both gradients was tested,[19] and the possibility of no significant difference between them was ruled out with a confidence level of 99%.

[19] The significance test is shown in the annex.

FIGURE 1

PSU compared with SIMCE, by socioeconomic level (SEL)



Source: prepared by the authors,using the results shown in table 5, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

On average, for the same SIMCE score, individuals with low socioeconomic level perform worse in the PSU for all SIMCE score levels. What is more, the higher the SIMCE score, the greater the effect of socioeconomic level on the PSU score.

The gap by socioeconomic level is close to 70 points on the PSU score, rising from 60 points for the worst performing students at SIMCE to 80 points for the best performing.

So, if two individuals with the same academic performance at one point in time (SIMCE) are picked at random, one with a high and the other with a low socioeconomic level, the first is then observed to score 70 points more than the second in the PSU. What is more, the gap in score is higher in students with better SIMCE scores: in other words, the higher the academic achievement at the earlier point in time, the greater the penalty or premium by level of income.

A PSU performance gap by socioeconomic level has therefore been shown to exist for students with the same SIMCE score. Individuals with favourable socioeconomic determinants achieve better scores than those in vulnerable situations, and the higher the SIMCE score, the larger the gap.

The model specified in equation (3) was also estimated using a cultural approach to socioeconomic level, i.e. linking it with the education level of parents. The results were as follows:

TABLE 6

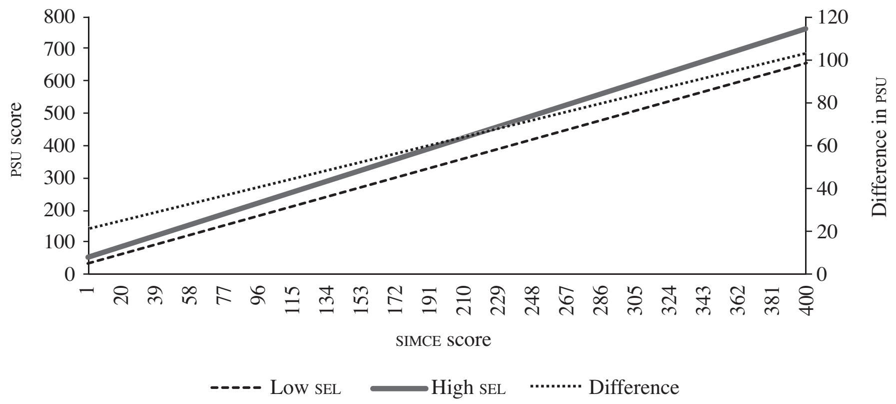
PSU by education level of parents and SIMCE interaction variable

Variables	PSU
SIMCE	1.742***
Low edlev	16.57**
High edlev	37.67***
Low edlev SIMCE	-0.175***
Low edlev SIMCE	0.0293*
Constant	13.88***
No. observations	87 638
R-squared	0.605

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note:***p<0.01, **p<0.05, *p<0.1
edlev: education level.

FIGURE 2

PSU compared with SIMCE score, by education level of parents



Source: prepared by the authors using the results shown in table 5, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

SEL: socioeconomic level.

As occurred with income level, for students with the same SIMCE score, there is a large gap in PSU scores between those with poorly educated parents and those whose parents are highly educated.

This gap, too, increases with respect to SIMCE performance: the higher the SIMCE score the larger the difference between the two groups, from 20 points for students with the lowest SIMCE scores to 100 points for those who scored high on SIMCE. On average, individuals with poorly and highly educated parents differ by 60 points in the PSU score.

In sum, the results show that socioeconomic factors impact significantly on scores obtained in both the SIMCE and PSU tests. What is more, the effect of these factors rises significantly over time: for the same individual, differences arise between the achievement level of PSU and that of SIMCE. After controlling for socioeconomic level, the evidence shows PSU gaps averaging 70 points by income level and 60 points by parental education level, for the same level of achievement in SIMCE.

The estimated effect of socioeconomic level on the results is also subject to selection bias, because the data used include only those students who sat the PSU in 2004. Given that students who reach the PSU are generally of higher socioeconomic level, the effects described here could be underestimated.

The significance of the results reported in this work is robust for a two-stage least square specification, with a full-information maximum likelihood estimation.[20] The robustness of the estimates performed in this study was verified using a new cohort of students taking the SIMCE (2006) and the PSU (2008), and the results obtained were consistent (in terms of the direction of the effect and its significance) with those reported here.[21]

For the purposes of estimation, parents' expectations regarding their children's future studies at the time of the SIMCE were taken as an identification variable. Intuitively, parents' expectations would influence the decision to take the PSU or not, but they do not affect the students' scores on the test, since parents who do not expect their child to enter university education will not provide the means or incentives for the child to register for the PSU, regardless of the students' abilities. Moreover, parents' expectations could reveal planning decisions such as having the student enter the labour market after completing obligatory schooling in order to help the family financially. Although the choice of identification variable could be debated, it may be considered the best option within the possibilities.

The estimate is reported in annex table A6 and confirms that —correcting for this selection bias— the results hold,

[20] Puhani (2000) finds that this estimation is preferable to the traditional two-stage Heckman method.

[21] The results of equation (3) with the new database are shown in annex table A5.

i.e. there is a significant gap in PSU achievement level by socioeconomic level, controlling for SIMCE score.

The findings presented here indicate that there is a potential talent loss, since a difference of 60 points in the PSU generates limitations on access to tertiary education. In addition, in Chile the PSU score determines not only possibilities of access to the various courses at each university, but also access to sources of financing, especially State subsidies.

It is evident that human capital formation occurs more intensively among those with greater resources, since there is some complementarity between monetary (and cultural) capital ad human capital, which sharpens inequality in income distribution over time.

V

Conclusions

Using panel data it was shown that socioeconomic factors have a positive influence, which grows over time, on student performance. The results also show a significant and growing gap in PSU scores by socioeconomic level (monetary and cultural). Two eighth grade students with the same SIMCE score, but from different socioeconomic levels, show gaps of around 70 points on average in the PSU score. Furthermore, the higher the initial SIMCE score, the wider this gap.

Assuming that non-observable variables (ability, motivation, and so forth) are constant, it may be affirmed that PSU achievement level and, therefore, the possibility of entering tertiary education, are conditioned by factors exogenous to the student, which prevent talent from being expressed in the academic and production arenas.

This work highlights the need to evaluate the potentially regressive nature of the instruments designed to control access to tertiary education. This is important for Chile —and for Latin America generally— because of two structural characteristics: the high returns on tertiary education and the region's high levels of income distribution inequality.

In Chile today, there is an excess demand for workers with higher levels of human capital. This opens up space for developing pro-equality policies, which should guarantee an even threshold for access to tertiary education, assigning human capital to those who are intellectually more productive, not those who randomly face fewer economic or cultural barriers.

It is hoped that the evidence presented will inspire further research into selection mechanisms and lead to policy innovation to promote social mobility, one of the routes towards more growth with equality.

ANNEXES

Descriptive statistics

TABLE A1

Characteristics by socioeconomic level (SEL)

Family income		Level 1	Level 2	Level 3	Level 4	Total
SIMCE	Mathematics	266.8	281.6	297.7	310.0	276.8
	Language	267.3	280.4	293.7	303.2	275.9
PSU	Mathematics	466.9	518.0	572.3	615.2	501.1
	Language	466.6	515.5	564.4	602.4	498.7
Education	Father	4.45	6.33	7.91	8.49	5.62
	Mother	4.37	6.09	7.32	7.94	5.38
Administrative type	Municipal	29 803	9 289	931	255	40 278
	Subsidized	23 335	16 077	2 308	720	42 440
	Private	1 352	5 243	4 171	6 252	17 018
	Total	*54 490*	*30 609*	*7 410*	*7 227*	*99 736*

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

— General model

The results of the score production function general model are presented for both SIMCE and PSU, on the basis of the socioeconomic variables described and using data from SIMCE 2000 and PSU 2004.

The model is as follows:

$$Score = \alpha + \beta_1\, Subsidized\ priv. + \beta_2\, Fully\ priv. + \beta_2\, Modality + \beta_4\, Gender + \beta_5\, Parent\ education + \beta_6 1$$

The parameters of the model were estimated both for the language and mathematics tests, and for the average of the two, for SIMCE and PSU separately. The results were as follows:

TABLE A2

Determinants of performance in SIMCE and PSU tests

Variables	PSU Math	PSU Lang	PSU	SIMCE Math	SIMCE Lang	SIMCE
Subsidized	12.03***	15.90***	13.97***	3.828***	4.292***	4.060***
Private	52.43***	48.59***	50.51***	16.26***	13.56***	14.91***
Modality	51.37***	46.10***	48.74***	7.670***	8.851***	8.261***
Female=1	-42.49***	-13.28***	-27.89***	-7.637***	6.962***	-0.337
Education parents	9.161***	10.93***	10.05***	3.482***	3.845***	3.664***
Rural	-28.52***	-29.80***	-29.16***	-7.573***	-7.597***	-7.585***
Family income	15.39***	11.93***	13.66***	4.216***	2.580***	3.398***
NEM (relative)	165.9***	158.5***	162.2***	59.62***	55.40***	57.51***
Constant	309.5***	294.5***	302.0***	213.7***	207.2***	210.5***
No. observations	87 441	87 441	87 441	87 417	87 417	87 417
R-squared	0.465	0.412	0.493	0.255	0.224	0.282

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: ***p<0.01.

SIMCE Lang: SIMCE language.
SIMCE Math: SIMCE mathematics.
NEM: average secondary school grade.

Almost all the variables were significant at the 99% confidence level and the models also proved to be well adjusted, given that a series of hard-to-measure variables (such as ability) were omitted.

The results coincide with the theory regarding the influence of sociocultural factors on school achievement. In general, parents' education, family income and average secondary education grade were found to have a positive influence on test scores. The school type —private, subsidized private, and science/humanities modality of education— influenced positively the level of achievement on all the tests. Geographically speaking, rural location had a negative impact on test performance, which could reflect the smaller number of schools in rural areas, or difficulties in travelling to place of study. Lastly, the evidence shows that female gender impacts negatively on achievement levels, except in the SIMCE language test.

— SIMCE-PSU correlation:

TABLE A3

Correlation between PSU and SIMCE test scores

Correlation	PSU	SIMCE
PSU	1	
SIMCE	0.7592	1

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

— **Significance test and impact of SIMCE by socioeconomic level.**

The null hypothesis, H_o, is given by:

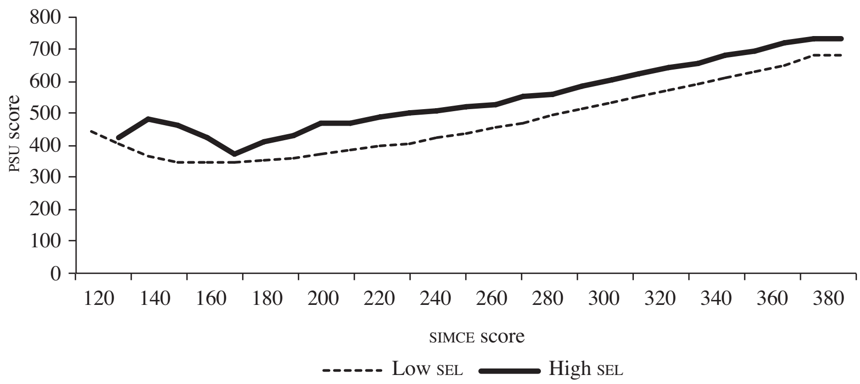
$$\text{Average SIMCE test} + \text{SEL}_{high}\ \text{SIMCE} = \text{Average SIMCE test} + \text{SEL}_{low}\ \text{SIMCE}$$
$$\text{SEL}_{high}\ \text{SIMCE} - \text{SEL}_{low}\ \text{SIMCE} = 0$$
$$F\ (1.\ 99700) = 5.22$$
$$\text{Prob} > F = 0.0223$$

The null hypothesis of non-significance is rejected with a confidence level of 97%.

— **Figure A1 shows SIMCE and PSU for the entire population, by socioeconomic level measured by family income:**

FIGURE A1

PSU compared with SIMCE, by socioeconomic level



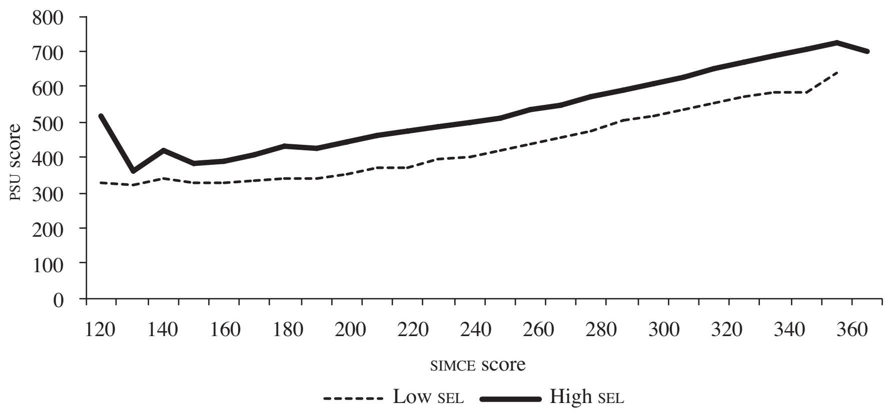
Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

SEL: socioeconomic level.

— **Figure A2 shows SIMCE and PSU for the entire population, by socioeconomic level measured by parents' level of education:**

FIGURE A2

PSU compared with SIMCE, by parental education level



Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.

SEL: socioeconomic level.

— **Equation (3) including controls for equation (1).**

TABLE A4

PSU by SEL, interaction with SIMCE and controls

Variables	PSU Math	PSU Lang	PSU
HighSEL	-39.52***	-71.29***	26.28***
LowSEL	-47.78***	-106.1***	4.022
HighSEL SIMCE	0.204***	0.302***	-0.0247
LowSEL SIMCE	0.138***	0.356***	-0.0440***
SIMCE			1.371***
SIMCE Math	1.106***		
SIMCE Lang		0.993***	
Subsidized	7.501***	10.51***	8.727***
Private	35.39***	35.24***	31.39***
Modality	42.48***	35.85***	37.83***
Female = 1	-34.04***	-19.90***	-27.59***
Parents' education	5.342***	6.733***	5.367***
Rural	-19.12***	-19.75***	-19.02***
NEM (relative)	95.16***	92.12***	84.70***
Constant	97.97***	118.2***	28.41***
No. observations	87 417	87 417	87 417
R-squared	0.647	0.606	0.713

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: *** p<0.01.

SEL: socioeconomic level.
NEM: average secondary school grade.
SIMCE Lang: SIMCE language.
SIMCE Math: SIMCE mathematics.

— **Two-stage least squares model (MC2E) to resolve selection bias.**

The results obtained using a cohort of students who took the SIMCE test in 2006 and the PSU in 2008 were consistent with those reported in this work. Table A5 shows the results of estimating (3) with the new database.

TABLE A5

PSU by income and interaction with SIMCE

Variables	PSU Lang	PSU Math	PSU
SIMCE			1.578***
Low SEL	-61.01***	22.76***	33.16***
High SEL	14.29***	24.00***	69.23***
LowSEL SIMCE	0.0971***	-0.217***	-0.252***
HighSEL SIMCE	0.167***	0.126***	-0.0409***
SIMCE Lang	1.512***		
SIMCE Math		1.286***	
Constant	84.01***	143.0***	64.87***
No. observations	145 413	144 762	144 624
R-squared	0.632	0.656	0.738

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: *** p<0.01.

SIMCE Lang: SIMCE language // SIMCE Math: SIMCE mathematics.
SEL: socioeconomic level.

The meaning and significance of the main findings are maintained using this new database. With this cohort, it is also possible to resolve the selection bias problem on the basis of a full-information maximum likelihood estimation, similarly to the MC2E methodology proposed by Heckman (1979).

For the purposes of estimation, parents' expectations regarding their children's future studies at the time of the SIMCE were taken as an identification variable. The results are reported in table A6.

TABLE A6

PSU by socioeconomic level and interaction with SIMCE, with Heckman correction for selection bias

Variables	PSU Lang	Selection	PSU Math	Selection	PSU	Selection
Expectations		0.131***		0.123***		0.118***
SIMCE					1.524***	0.00990***
Low SEL	-38.55***	-0.592***	30.22***	-0.353***	38.91***	0.0739*
High SEL	-15.19***	0.380***	9.247**	0.372***	50.88***	0.898***
LowSEL SIMCE	0.0372***	0.00120***	-0.236***	0.000214	-0.264***	-0.00153***
HighSEL SIMCE	0.241***	0.000878**	0.168***	0.000434	0.0126	-0.00150***
SIMCE Lang	1.380***	0.00795***				
SIMCE Math			1.252***	0.00735***		
Constant	134.6***	-2.163***	157.0***	-1.960***	84.75***	-2.590***
No. observations	225 265	225 265	225 265	225 265	225 265	225 265

Source: prepared by the authors, on the basis of data from the Educational Quality Measurement System (SIMCE) 2000 and the University Selection Test (PSU) 2004.
Note: *** p<0.01, ** p<0.05, * p<0.1.

SIMCE Lang: SIMCE language // SIMCE Math: SIMCE mathematics.
SEL: socioeconomic level.

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Determinants of structural heterogeneity in Mexican manufacturing industry, 1994-2008

Raúl Vázquez López

ABSTRACT

This article analyses the stagnation of productivity and the increasing structural heterogeneity of Mexican manufacturing industry in the period 1994-2008. Traditional indicators of dispersion are estimated for 200 activity classes, 50 branches and nine divisions of the manufacturing sector; and these corroborate the widening disparity in productive efficiency between globalized activities and traditional industries that has been reported in other papers. The study also provides a more detailed account of the intensification of this trend in the first decade of the present century and the specific characteristics of within-sector heterogeneity. Other results obtained using a shift-share technique show that structural change contributes very little to productivity growth, and that technological progress is concentrated in just a few activities that engage with the domestic economy in a variety of ways. Nonetheless, these activities have weak local linkages and add little value to the content of the goods they make.

KEYWORDS

Industry, industrial production, manufactured products, measurement, evaluation, productivity, industrial statistics, Mexico

JEL CLASSIFICATION

L60, O14, O40

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I
Introduction

The pioneering thinkers of the Economic Commission for Latin America and the Caribbean (ECLAC) used a historical-structural methodology to study how relations between the different segments of a nation — economic, political and social — change through time. This led them to highlight the importance of the modes of integration of the different strata of the productive system, along with progress in overcoming productive heterogeneity, for development in Latin American countries. In particular, Furtado (1961) and Pinto (1965 and 1970) pointed out that the modernization of developing and dependent structures does not necessarily diminish productivity gaps between different activities, but can maintain and even increase them.

This observation could explain why in the more advanced countries of Latin America such as Mexico (following its adoption of the "neoliberal" model implemented mainly through economic deregulation, privatization of strategic state industries and trade liberalization), the restructuring of manufacturing industry led to a stratification and polarization of the productive structure and, consequently, caused efficiency gaps between the different industrial sectors to widen (Mortimore and Peres, 2001). In fact, at the microeconomic level, growing asymmetries, in terms of modernization, between a small number of firms involved in global value chains (GVCs) led by transnational corporations (TNCs), and a broad group of small and medium-sized enterprises that were being increasingly left behind, has caused the widening productivity differentials between the different classes of activity to be replicated even within individual sectors (Kupfer and Rocha, 2005).

Against that backdrop, this article pursues several objectives simultaneously. Firstly, it aims to give continuity to and revitalize the structural perspective and debate proposed by Latin American development theory. Secondly, it aims to analyse, for the period 1994-2008, the trend of structural heterogeneity, as defined by this school of thought, in the case of Mexican manufacturing — a sector viewed as crucial in the external liberalization strategy implemented as from the mid-1980s in that country. Lastly, based on methodologies used recently by ECLAC, it will conduct statistical exercises, at the most disaggregated level possible, to evaluate in greater depth the effects of structural change on productivity levels and on the types of heterogeneity present in the sector.

Following this introduction, the rest of the article is organized as follows: section II addresses the topic of structural heterogeneity and the relevance of productive linkages, from the ECLAC structuralist standpoint; section III reviews recent studies that use similar methodologies to analyse productivity trends in Latin America, particularly in Mexican manufacturing industry. Section IV reports the results of the estimations of productivity levels and basic indicators of structural heterogeneity for different levels of aggregation of Mexican manufacturing. Section V firstly analyses the determinants of productivity trends and evaluates the effects of structural change on the efficiency of the sector's activity classes, branches and divisions through a Fabricant decomposition. It then makes a deeper analysis of some of the characteristics and modes of organization and operation of the "leading" industries in the Mexican specialization pattern. Lastly, section VI sets forth the main conclusions.

II

Structural heterogeneity in Latin American thought

From the 1950s onwards, the framework of theoretical analysis developed by ECLAC highlights two key characteristics that define the "peripheral" status of Latin American economies: (i) their specialization in a few sectors, especially primary and industrial ones with low technological intensity and low income elasticity of demand; and (ii) the existence of major differences in labour productivity compared to the central countries, and between the different "technical layers" that form their productive structure (Rodríguez, 1980). For Aníbal Pinto (1965, 1970 and 1971), who pioneered the concept of heterogeneity, the region's import-substitution-industrialization strategy made it possible to create a modern non-export sector, with productivity levels above the system average and even similar to those of the export complex. As a result, the fruits of "inward" diversification — the "dual" productive apparatus that was the stereotype for Latin American countries in their early phases of development— became one of structural heterogeneity. This feature is accentuated in the case of higher-level developing economies (Furtado, 1962) in phases characterized by the manufacture of intermediate goods and heavy consumer durables, based on modern technology and greater capital density.

In view of the historical experience of developed countries, Pinto then recommends transferring resources towards the modern sectors, so that technical progress can be disseminated to the rest of the productive apparatus through the "bandwagon effect" of the leading sectors, defined as those with higher productivity levels. Moreover, following the tradition of the models of structural change with unlimited labour supply — such as those of Lewis (1955); Jorgenson (1961), and Fei and Ranis (1961) — Furtado (1963) identifies the need to shift workers from the backward sectors to modern ones as a first step in revitalizing demand. His arguments include the principles of Keynesian analysis, because increasing productivity resulting from a change in the composition of employment justifies wage increases that diversify consumption and in turn make the productive structure more efficient.

To summarize, a productive apparatus of highly varied sectoral productivity, which is poorly integrated and lacks capacity to transmit and diversify technical progress, participates in the international economy under unfavourable terms by exporting products of low value-added. This produces an institutional fabric that is disinclined to accumulate capital and generate technology, resulting in surplus labour and wages that are overwhelmingly at the subsistence level, thereby asymmetrically stratifying the type of consumption and society as a whole (Bielschowsky, 2009).

Based on these premises, the topic of heterogeneity has recently been revived by ECLAC from a standpoint that stresses the importance of the effects of technological change on productive structures. This approach views structural bottlenecks as being reproduced basically because of the widening of the technology gap in relation to the advanced countries (Holland and Porcile, 2005); and the origin of heterogeneity of the productive fabric is studied "in terms of the strategic behaviour of economic agents, identification of the barriers to and determinants of the creation and dissemination of technological capacities" (Cimoli, 2005, p. 6). The analysis therefore stresses the relevance of each productive system's capacity to turn codified knowledge into skills used in firms; and it also extends the study of the relations between productive segments to a complex web of systemic links between enterprises, organizations and the institutional framework (Cimoli and Dosi, 1995).

Although this approach prioritizes the analysis of variables that are specific to the study of technological change, it maintains a key idea in classical development theory, namely that industry is the sector with the greatest bandwagon effects in the economy and includes activities which are naturally capable of assimilating, reproducing and generating technical progress (Prebisch, 1962; Singer, 1950). From this general standpoint, the growing productive duality between modern manufacturing activities (engaged in global dynamics) and other more backward activities (mainly serving a shrinking domestic market in which imports are increasingly important) is a consequence of rapid trade liberalization that calls into question the very essence of the model implemented since the 1980s in Mexico. More specifically, this view considers it essential for Mexican manufacturing structure to become less heterogeneous — both for national productive development and, in general, for a fairer distribution of income.

III

Studies of productivity trends in Mexico and Latin America

To capture and distinguish the importance of the shift of labour between productive sectors and technological change in determining productivity trends in the region, authors associated with ECLAC have developed different approaches to the topic of heterogeneity, using generic techniques based on the *shift-share* methodology.[1] ECLAC (2007) finds that the growth of value-added per job averaged 1% per year over a long time period (1960-2003), in a sample of nine economies. Nonetheless, the results show major differences between the indicators of the different countries, highlighting the importance of the effect of labour-force recomposition in the total variation of output per employee (structural effect): 70% of the average change in labour productivity in the region. In fact, in four of the nine countries (Bolivarian Republic of Venezuela, Mexico, Peru, Plurinational State of Bolivia), intrinsic productivity declined relative to technological progress,[2] "which indicates a move away from the productive frontier" (ECLAC, 2007, p. 32).

In contrast, the ECLAC study also shows that productivity in manufacturing industry grew by 22% in the period considered, because intrinsic productivity grew by 33%. On this point, the work of Holland and Porcile (2005) confirms that increases in this component are the main determinant of progress in the industry indicator in all countries of the sample (Argentina, Brazil, Chile, Colombia, Mexico and Uruguay). Apart from Mexico, in the 1990s these nations all reported industrial productivity growth rates that were significantly higher than those achieved in previous decades, reflecting the 63.9% increase in intrinsic productivity, which more than compensated for the decline in the contribution of structural-type effects, driven largely by the privatization, economic-deregulation and trade-liberalization processes being implemented in the region.

Considering the period 1970-2002, the results also confirm employment growth in lower-productivity industrial activities and the scant contribution made by structural change to productive efficiency, thereby increasing heterogeneity in the region's manufacturing complexes. In the specific case of Mexico following its adoption of the "neoliberal" model in the 1980s, labour productivity in the economy as a whole has tended to stagnate. This is shown in the study by Romero (2009) relating to the effects of trade openness, which estimates the average growth of labour productivity economy-wide in the period 1982-2003 at 0.5% per year — far below that recorded in the four previous decades, in which GDP per worker grew rapidly. The calculations presented by ECLAC (2007) confirm this observation: annual productivity growth in Mexico slowed from 3.7% in the 1960s to 1.3%, -1.8% and 0.3%, respectively, in the ensuing decades.

With regard to the determinants of these rates in Mexico, the work of Romero reveals the declining trend of the structural effect between 1961 and 2003, which means that the development process in Mexico has not triggered a long-term shift of labour towards dynamic activities. Moreover, the ECLAC document reports the general trend as negative, even though the structural effect is positive as a whole for this period, making it possible to offset a reduction in intrinsic productivity linked to the absence of technical change. Nonetheless, both studies clearly identify a deterioration in the contribution of the structural component to the trend of productivity from the 1980s onwards. In Romero (2009), the structural effect generates annual productivity growth of less than 1% in the period 1984-2003, with even negative rates in the years between 1992 and 1995. The ECLAC document shows that in the periods 1960-1972 and 1973-1981, the structural effect contributed an annual average of US$166 and US$215, respectively, at 2000 prices, to productivity growth measured as value-added per worker, whereas the contribution was no more than US$77 under the same constant-price terms in the period 1982-2003.

[1] This procedure makes it possible to separate total labour productivity growth in a given period into productivity growth within the activity branches, transfer of labour towards more productive branches (static transfer effect), and the transfer of labour toward more dynamic branches of activity, in other words those displaying the highest productivity growth rates (dynamic transfer effect).

[2] ECLAC defines the structural effect as the contribution to productivity growth made by the sectoral recomposition of the labour force; and the intrinsic effect as the variation in labour productivity attributable to changes in the intrinsic productivity of the sectors, in other words variations caused by technological progress (ECLAC, 2007).

The results are even more discouraging at the industry level; Holland and Porcile (2005) estimate a negative contribution for the interaction effect associated with the reallocation of workers to sectors of growing productivity in each of the decades between 1970 and 2000, and particularly in the 1990s (-1.26%, -3.31% and -8.44%, respectively). Meanwhile, ECLAC (2007) reports a contribution of US$11 per year at 2000 prices, to the growth of labour productivity in Mexican manufacturing throughout the period 1960-2003, as a result of the structural effect as a whole. This figure is in line with the reality of most Latin American countries, as shown by contributions also of US$11 in Brazil and Costa Rica, and US$12 in the Bolivarian Republic of Venezuela under the same terms, to give just a few examples. Lastly, Capdevielle confirms: "since the 1970s, the component that determined the increase in manufacturing productivity was its growth within each branch, whereas the change in the composition of production as a result of reallocation and interaction was insignificant" (Capdevielle, 2005, p. 115).

In terms of the trend of the intrinsic component, the figures are somewhat less clear, owing to discrepancies in the methodologies used and, particularly, the different levels of aggregation applied in the exercises. According to ECLAC, unlike what happened in Latin America generally, productivity growth generated by technological change in Mexican manufacturing in the period 1960-2003 was also small, and even less than the contribution of the structural effect (US$9 at 2000 prices). Nonetheless, the estimations made by Holland and Porcile suggest that the growth of intrinsic productivity in manufacturing (23.78% on average for the period 1970-2000), while less than the average of the countries in the sample, is greater than the worker-reallocation effect. Lastly, Capdevielle (2005) explains the increase in the indicator as a result of labour reallocation in the years 1988-2003 (67.07 pesos at 1993 prices) in terms of an increase in the efficiency of non-maquila activities which, nonetheless, are not based on technical improvements: "they could have originated from employee-rationalization processes in a context in which trade openness intensified the struggle for local markets" (Capdevielle, 2005, p. 115).

In short, and despite the statistical differences encountered, the few structural studies that exist on productivity trends in Mexican industry reveal the poor performance of the indicator in this sector, and the scant contribution (below the Latin American average) made by both structural change and technological progress to the efficiency of the manufacturing apparatus since the end of the import-substitution-industrialization strategy and, in particular, during the period of the "neoliberal" model. In this sense, the trends observed relate to Mexico's strategy of international productive engagement, consisting of specialization in certain activity branches and specific segments of production within selected "leading" industries, by exploiting low-skilled labour. This strategy is in fact compatible with the interests of the large transnational groups that relocate segments of the productive process to reduce costs (particularly labour costs) and thus increase efficiency and consolidate their global manufacturing networks (Gereffi, 1995).

IV

Trend of structural heterogeneity by activity classes in Mexican manufacturing in the period 1994-2008

In the framework of the polarization of Mexico's manufacturing structure and the deepening and apparent extension of heterogeneity to the within-sector level, a study with some degree of precision on the trend of productivity differentials in the sector would require statistical treatment at the most disaggregated level possible (non-existent today to owing to the lack of long and consistent official data series). To satisfy this requirement and analyse the within-sector heterogeneity highlighted by certain authors, a database was created which estimates monthly labour productivity, at constant December 2003 prices, for each of the years in the period 1994-2008, with respect to 200 classes of Mexican manufacturing activity. This exercise was based on the Monthly Manufacturing Survey (EIM) in the Mexican Activities and Products Classification

(CMAP) produced by the National Institute of Statistics and Geography (INEGI).[3] Fine-tuning the analysis, two equal subperiods were defined (1994-2001 and 2001-2008) to facilitate comparisons and take account of the widely acknowledged fact that the economic liberalization strategy fuelled employment growth in the first few years of its application in the country.

In general terms, the results show that during the periods 1994-2001 and 2001-2008, productivity levels in the Mexican manufacturing sector grew at moderate annual rates of 2.3% and 2.6%, respectively (see table 1). The tendency for these levels to stagnate in a context of continuous technological change clearly reveals the failure to generate positive externalities in the national manufacturing fabric and the lack of an adequate institutional productive infrastructure to increase the specific returns to each activity.

In the case of Mexico, there are also marked differences in the trend of the indicator both between different divisions, branches and classes of activity, and between the periods considered. In the first subperiod (1994-2001), activity branches involved in pharmaceutical manufacturing, the automotive industry, and cement, lime and gypsum factories (the latter associated with construction activity) posted productivity growth in excess of 5.5% per year; whereas the more traditional divisions, such as textiles and wood, as a whole reported reductions in their output-labour ratios (see table 1). The subperiod 2001-2008 is characterized by a stagnation of productivity levels in manufacturing generally, against a backdrop of recurrent episodes of contracting international markets. This is alarming since, historically, productivity has failed to grow in a very few periods only.

[3] After adding together the monthly values, the annual figures are deflated at 2003 prices, using the national producer price index for the manufacturing sector, published by Banco de México (BANXICO). The indicator is then estimated by calculating the quotient between total gross production and man-hours worked for the different activity groups. The productivity indicator cannot be calculated for five activity classes (321111, 382301, 383202, 384204, 385006) out of the 205 covered by the survey, because data on the value of output or man-hours worked in those activities are not available for the period 2003-2008.

TABLE 1

Trend of labour productivity of the divisions and selected branches of the manufacturing sector, 1994-2008

(Pesos per man-hour worked, at December 2003 prices, and percentages)

Division/branch	Output per man-hour worked			Annual growth rate	
	1994	2001	2008	1994-2001	2001-2008
I Food, beverages and tobacco	465.9	489.2	535.8	0.7	1.3
Branch 3112 Dairy product manufacturing	656.9	726.7	689.6	1.5	-0.7
Branch 3130 Beverage manufacturing	396.1	457.4	565.8	2.1	3.1
II Textile, apparel and leather manufacturing	197.0	168.8	187.2	-2.2	1.5
III Wood industry and wood product manufacturing	187.9	173.3	176.7	-1.1	0.3
IV Paper and paper product manufacturing, printing and publishing	360.8	372.7	365.8	0.5	-0.3
V Chemical, petroleum product, rubber and plastic product manufacturing	496.0	577.4	686.4	2.2	2.5
Branch 3512 Basic chemical manufacturing	831.1	909.9	1584.3	1.3	8.2
Branch 3521 Pharmaceutical-pharmochemical industry	568.0	826.0	760.4	5.5	-1.2
Branch 3522 Other chemical and chemical product manufacturing	606.5	707.3	741.2	2.2	0.7
VI Nonmetallic mineral product manufacturing except petroleum products and coal	406.2	455.5	479.5	1.6	0.7
Branch 3691 Cement, lime, gypsum and other non-metallic mineral product manufacturing	538.4	812.5	785.5	6.1	-0.5
VII Basic metal manufacturing	836.9	934.4	1942.7	1.6	11.0
Branch 3710 Basic iron and steel manufacturing	844.2	1043.6	2149.0	3.1	10.9
Branch 3720 Basic non-ferrous metal manufacturing	822.8	746.0	1559.6	-1.4	11.1
VIII Metal product, machinery and equipment manufacturing	519.4	711.4	755.3	4.6	0.9
Branch 3841 Automotive industry	895.0	1314.3	1377.6	5.6	0.7
IX Other manufacturing industries	189.3	174.7	189.6	-1.1	1.2
Total manufacturing	*446.1*	*523.4*	*625.0*	*2.3*	*2.6*

Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 clases de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL

In addition, between 2001 and 2008, the indicator displays high growth rates of above 10% in the two branches of basic metal manufacturing, and an 8.2% increase in the manufacture of basic chemicals (see table 1). Nonetheless, it needs to be stated, firstly, that the variations observed in productivity levels could be biased by the unequal trend of prices in the different manufacturing activities. Consequently, some industries could display productivity increases that are not related either to the adoption of processes, innovative machinery or both, or to greater investment in resources. On this point, the high growth rates of the output-labour ratio in the branches of basic metal manufacturing since 2001 largely reflects substantial increases in the value of the goods manufactured. In fact, the national producer price index (INPP) of division VII, corresponding to basic metal manufacturing, records an increase of 202.7% for the period 2002-2008, while the general index for total manufacturing rose by 56.3% in those years.[4]

Although, as noted by Romero (2009), the absolute values of the output-labour ratio vary according to each activity's specific capital-labour ratio, the gap between traditional industries and those with greater participation in the global arena has expanded as a result of trade liberalization. For example, whereas in 1994, productivity in the automotive industry was 4.5 and 4.8 times that recorded by the textile and wood manufacturing divisions, respectively, by 2008 these coefficients were 7.4 and 7.8 times.[5] It should be noted that in this case, the price effect could be considered residual, because in the three groups, the increase in the INPP is less than for the sector as a whole. From January 1994 to December 2008, the value of goods produced by the automobile and truck assembly branch grew by 235.4%, that of textile products by 197.5% and that of wood products by 204.1%, whereas the figure for manufacturing as a whole was 261.9%.[6]

On this point, traditional statistical indicators of dispersion reveal the increasing structural heterogeneity of the Mexican manufacturing sector, both horizontal — between the elements of the different aggregation levels — and vertical — within activity groups, whether divisions or branches (intra-sectoral heterogeneity). As shown in table 2, both the standard deviation and the coefficient of variation are higher at higher levels of disaggregation, which confirms the relevance of analysing horizontal heterogeneity by activity classes. Similarly, the trend of both indicators for the different samples broadly shows that after two short periods, 1994-1996 (rising) followed by 1997-1999 (falling), there is a clear and sustained trend for productivity gaps to widen across the sector from 2000 onwards, as shown in figure 1 in the case of the standard deviation.

In particular, it is worth noting the increase in the coefficient of variation and the standard deviation of productivity at the division level from 2001 to 2008 (59% and 108.4%, respectively). In fact, whereas in 2008 output per man-hour worked was less than 190 pesos at 2003 prices in three of the nine divisions, basic metal manufacturing posted an increase of 1,942.7 pesos (see

4 Calculated on the basis of Banco de México (BANXICO, 2011).
5 Calculated on the basis of the figures shown in table 1.

6 See BANXICO (2011).

TABLE 2

Indicators of the dispersion of labour productivity in the manufacturing sector at different levels of aggregation, 1994-2008

(Pesos per man-hour worked, at December 2003 prices, and percentages)

Years/period	1994		2001		2008		Growth rate 1994-2008		Growth rate 2001-2008	
Dispersion/aggregation	CV	SD	CV	SD	CV	SD	CV	SD	CV	SD
Divisions	51.5	209.3	58.6	264.2	93.2	550.6	90.0	163.1	59.0	108.4
Branches	69.1	304.1	79.1	373.6	89.7	520.1	29.8	71.0	13.4	39.2
Activity classes	85.5	371.8	93.9	427.1	112.9	621.7	32.0	67.2	20.2	45.6

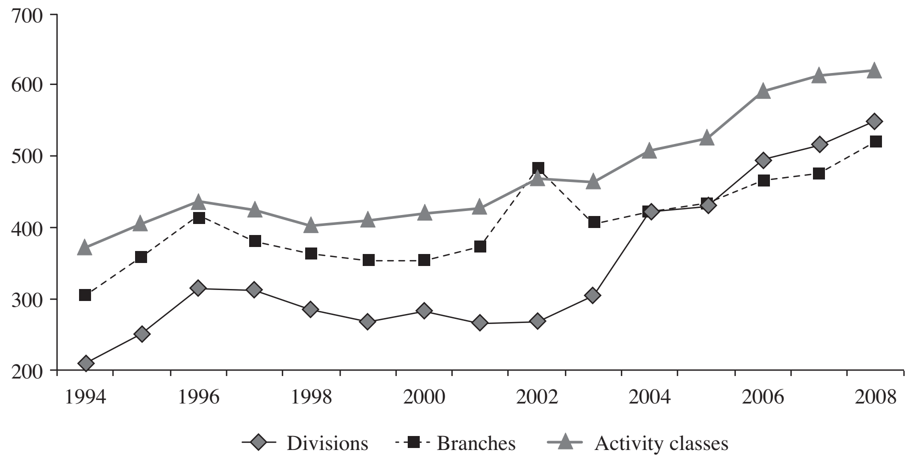
Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 clases de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL.

CV : Coefficient of variation.
SD : Standard deviation.

FIGURE 1

Standard deviation of productivity at different levels of aggregation, 1994-2008

(Pesos per man-hour worked, at December 2003 prices)



Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 clases de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL .

table 1). At the most detailed level possible, the analysis for the 200 activity classes shows that the standard deviation increased by 67.2% in the period 1994-2008, with a 45.6% rise between 2001 and 2008 (see table 2). In this latter subperiod (2001-2008) the process of expanding heterogeneity occurs alongside a general stalling of productivity, reflecting the progressive isolation of competitive activities associated with global operations.

In this regard, the results obtained are consistent with the findings of Holland and Porcile (2005), who show that Mexico experienced a process of sigma divergence between industrial sectors in the 1990s. In their estimations, the coefficient of variation calculated on the basis of productivity in just 28 sectors, increased by 35.6% from 1990 to 1999, and the Gini coefficient for that sample rose from 0.25 to 0.29 in the same period. The exercise performed here also makes it possible to complement and extend the analysis of these authors, in that during the first decade of the millennium, the response of labour productivity remained weak, and the increasing dispersion trend was not reversed; on the contrary it seems to have worsened as a result of a growth pattern which Holland and Porcile describe as one of low capacity to absorb underemployment and unemployment.

With regard to within-sector heterogeneity, the estimated productivity indicators of the activity classes within each division show that the gap-widening process was slower than that which occurred between sectors in the period 1994-2008, as suggested by the fact that the growth rates of the dispersion indicators are generally lower. There are also marked differences in the trend both of the standard deviation and of the coefficient of variation between the sectors considered. Whereas in the "Paper and paper product manufacturing, printing and publishing" division, these variations were in fact negative (-6.8% and -0.5%, respectively), in "Basic metal manufacturing" the standard deviation increased by 296.9% (see table 3).

Although the number of activity classes in each division could bias these results, making the indicators unstable — particularly in sectors with a small number of activities, such as basic metal manufacturing — the evidence is clear for the period 1984-2008 that there are manufacturing groupings in which intra-sectoral heterogeneity grew moderately or even declined (food products, beverages and tobacco; textiles, apparel and the leather industry; paper and paper product manufacturing, printing and publishing), and others where there was considerable growth (wood industry and wood products; chemicals, petroleum products, rubber and plastic products; nonmetallic mineral products, except petroleum products and coal; basic metal manufacturing; and metal products, machinery and equipment).

The differences in the rate of increase of the two types of heterogeneity defined above can be explained by interpreting the intra-sectoral phenomenon as a result of the intensification of a process in which the local productive apparatus is becoming less interlinked, owing to the way Mexican manufacturing participates in the global economy. From this standpoint, increasing productive duality is generally revealed between sectors as a result of an exclusive specialization process, explained by the change in the economic model and, more specifically, within each of the sectors as a result of the subsequent extension of the maquila process in more complex forms.

TABLE 3

Indicators of the dispersion of labour productivity across activity classes in each manufacturing division, 1994-2008
(Pesos per man-hour worked, at December 2003 prices, and percentages)

Years/ period	1994		2001		2008		Growth rate 1994-2008	
Dispersion/division	CV	SD	CV	SD	CV	SD	CV	SD
Food, beverages and tobacco (38 classes)	72.8	514.3	70.1	499.6	80.2	615.2	10.2	19.6
Textile, apparel and leather manufacturing (31 classes)	61.0	128.4	76.4	138.8	72.0	133.8	18.0	4.2
Wood industry and wood product manufacturing (5 classes)	31.6	59.8	38.6	71.4	54.3	104.7	72.2	75.1
Paper and paper product manufacturing, printing and publishing (9 classes)	42.2	154.4	39.9	147.9	42.0	143.9	-0.5	-6.8
Chemical, petroleum product, rubber and plastic product manufacturing (38 classes)	65.2	343.6	63.3	364.3	85.5	636.6	31.0	85.3
Nonmetallic mineral product manufacturing except petroleum products and coal (16 classes)	88.4	279.8	126.4	460.3	115.8	437.2	30.9	56.3
Basic metal manufacturing (7 classes)	53.2	378.6	60.8	503.5	83.4	1502.8	56.7	296.9
Metal product, machinery and equipment manufacturing (53 classes)	80.6	286.3	110.6	419.6	97.1	435.8	20.5	52.2
Other manufacturing industries (3 classes)	27.8	44.8	38.3	54.5	40.5	60.5	45.7	35.1
Total manufacturing industry	*85.5*	*371.8*	*93.9*	*427.1*	*112.9*	*621.7*	*32.0*	*67.2*

Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), “Encuesta industrial mensual (CMAP), 205 classes de actividad económica”, 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000020002#ARBOL.

CV : Coefficient of variation.
SD : Standard deviation.

V

Mexican manufacturing: analysis of the determinants of productivity and structural heterogeneity

Based on the methodology used by previous studies on the issue discussed at the start of this article, this section uses the productivity indicators constructed for the 200 activity classes of Mexican manufacturing for the period 1994-2008, for the purpose of evaluating the contributions made by technological progress and structural change to the trends observed in productivity and in the sector’s structural heterogeneity. Using a shift-share-type statistical technique (Maddison, 1952; ECLAC, 2007), variations in productivity levels are separated into two predefined effects (intrinsic and structural), for different levels of aggregation (division, branch and activity class) and periods of analysis.

In the generic breakdown known as the Fabricant formula, the importance of each factor (technological progress and structural change) is weighted by the coefficients S_i^t and P_i^0, as shown below:

$$\left(P^T - P^0\right) = \left[\left(P_1^T - P_1^o\right).\, S_1^T + \left(P_2^T - P_2^o\right).\, S_2^T\right] +$$
$$\left[\left(S_1^T - S_1^o\right).\, P_1^o + \left(S_2^T - S_2^o\right).\, P_2^o\right]$$

After changing the time-base of the weighting and generalizing the formula for *n* sectors, ECLAC (2007) obtains the following breakdown of the differential between two aggregate levels of productivity at two points in time:

$$\left(P^T - P^0\right) = \sum_{i=1}^{n}\left[\left(P_i^T - P_i^0\right),\left(S_i^0 - S_i^T\right)/2\right] +$$
$$\sum_{i=1}^{n}\left[\left(S_i^T - S_l^0\right).\ \left(P_i^0 - P_i^T\right)/2\right]$$

where P_i^t is productivity in sector i (i=1,2,...n) at time t= 0,T and S_i^t is the share of sector i (i=1,2,...n) in the total active employed population at t= 0,T. The first term on the right-hand side of the equation represents the variation in labour productivity attributable to changes in the intrinsic productivity of the *n* sectors. The second term indicates the contribution made by the sectoral recomposition of the labour force. If employment grows by more in sectors of high intrinsic productivity, the net effect will be positive; on the contrary, if the net recipients of labour are low-productivity sectors, then the final result of the factor recomposition will be negative (ECLAC, 2007, p. 28).

In the reformulation shown below, the estimation is performed for the years 1994 and 2008, for the 200 classes of manufacturing activity, so the share of each activity class, both in employment and in the trend of productivity, is measured in relation to the total manufacturing sector. For example:

$$\left(P^{08} - P^{94}\right) = \sum_{i=1}^{n}\left[\left(P_i^{08} - P_i^{94}\right).\left(S_i^{94} + S_i^{08}\right)/2\right] +$$
$$\sum_{i=1}^{n}\left[\left(S_i^{08} - S_l^{94}\right).\left(P_i^{94} + P_i^{08}\right)/2\right]$$

In this breakdown, the weightings depend on the average of the two randomly chosen reference years, so the results vary according to the degree of disaggregation being used; in other words, while in all cases the sum of the intrinsic and structural effects gives the same total productivity change between the two years considered, in contrast, the sum of each of the concepts does not give the same results if 200 activity classes, 50 branches or nine divisions are considered. Although the differences are not considerable and in no way alter the conclusions of the analysis, to avoid statistical discrepancies the results of the exercise presented for each branch and division are obtained by summing the values of the classes they encompass.

As shown in table 4, the findings firstly confirm what was noted above: the increase in productivity for manufacturing as a whole in the period studied (178.94 pesos at 2003 prices, or 2.4% as an annual average), and particularly in its first subperiod from 1994 to 2001 (77.27 pesos and 2.3%, respectively), should be considered small, compared to the 2.7% annual growth rate of that indicator between 1970 and 1990 (ECLAC, 2007 p. 62). Secondly, structural change makes virtually no contribution to the increase in the indicator; in other words, the shift of workers from low-productivity activity classes to other more efficient ones explains only 6.2% of the increase in output per man-hour worked over the period 1994-2008. One plausible hypothesis, which goes beyond the scope of this study, is that despite the changes that have taken place in manufacturing industry, there was no structural change in the sector. In contrast, the intrinsic effect, in other words productivity increases within each activity class owing to productive reorganization or technical progress, explains 93.8% of the growth of output per man-hour worked in manufacturing between 1994 and 2008, and 95.2% of its growth between 2001 and 2008.

TABLE 4

Determinants of productivity in total manufacturing, 1994-2008

(Pesos per man-hour worked, at December 2003 prices, and percentages)

Effects/period	Intrinsic	Structural	Total
1994 - 2001	66.37	10.90	77.27
2001 - 2008	96.75	4.92	101.67
1994 - 2008	167.91	11.02	178.94

Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), “Encuesta industrial mensual (CMAP), 205 classes de actividad económica”, 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL.

The estimations obtained also show that efficient practices are heavily concentrated in the manufacturing structure, and increasingly so, irrespective of the aggregation levels of the analysis. At the large-division level, while three divisions make negative contributions to the sector's productivity trend, another two hardly contribute at all, while the four remaining divisions account for 102.7% of the total effect on the indicator and 99% of the intrinsic effect in the subperiod 1994-2008. Similarly, at the branch level, just two of the 50 existing branches (motor vehicle manufacturing and the basic iron and steel industry) jointly account for 52% of productivity increase in Mexican manufacturing and 47.9% of the sector's total intrinsic effect in that period (see table 5).

TABLE 5

Determinants of labour productivity in the divisions and selected branches of the manufacturing sector, 1994-2008

(Pesos per man-hour worked, at December 2003 prices, and percentages)

Division/branch	Intrinsic effect	Structural effect	Total effect
I Food, beverages and tobacco	28.50	9.49	37.99
Branch 3112 Dairy product manufacturing	2.65	5.87	8.51
Branch 3130 Beverage manufacturing	14.78	-4.66	10.12
II Textile, apparel and leather manufacturing	-3.35	-4.61	-7.96
III Wood industry and wood product manufacturing	-0.31	-0.86	-1.17
IV Paper and paper product manufacturing, printing and publishing	-0.42	1.93	1.50
V Chemical, petroleum product, rubber and plastic product manufacturing	30.95	-2.70	28.25
Branch 3512 Basic chemical manufacturing	14.13	-4.94	9.19
Branch 3521 Pharmaceutical-pharmochemical industry	5.69	6.19	11.87
Branch 3522 Other chemical and chemical product manufacturing	4.62	0.93	5.55
VI Nonmetallic mineral product manufacturing except petroleum products and coal	5.84	-2.89	2.95
Branch 3691 Cement, lime, gypsum and other non-metallic mineral product manufacturing	5.71	-4.17	1.54
VII Basic metal manufacturing	50.02	6.66	56.68
Branch 3710 Basic iron and steel manufacturing	37.03	5.58	42.61
Branch 3720 Basic non-ferrous metal manufacturing	12.99	1.08	14.07
VIII Metal product, machinery and equipment manufacturing	56.74	4.17	60.91
Branch 3841 Automotive industry	43.44	7.01	50.45
IX Other manufacturing industries	-0.05	-0.16	-0.21
Total manufacturing	*167.91*	*11.02*	*178.94*

Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 classes de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL.

It is particularly significant that the branches that contribute most to the productivity increase per man-hour worked in manufacturing are also those with the highest levels of manufacturing in the structure. In fact, the eight branches with the highest output values in the sector in 2008 are also among the top nine contributors to labour productivity between 1994 and 2008. In brief, efficiency gains occur exclusively in the productive fabric's specialization hubs, and they generally involve large firms participating in global dynamics that are able to achieve economies of scale, thereby confirming the scant dissemination of technical progress in the structure or positive spillovers from the leading industries to the rest of the sector.

Several studies have documented these limited technological spillovers in Mexican manufacturing at the sector level; Arroyo and Cárcamo (2010) note the introduction of innovations and training, but also the persistence of a large majority of small and medium-sized enterprises (SMEs) using low technology, low-skill labour, and minimal design and management skills, in the post-trade-liberalization textile industry. Castañón, Solleiro and Del Valle (2003) make a compilation of the best technologies in several branches of the food sector, characterized by groups undergoing permanent modernization processes. Nonetheless, they stress the role of these changes as entry barriers for SMEs, and the consequent breakdown of local value chains owing to the failure to disseminate these advances in agriculture. Lastly, Álvarez (2002) highlights the fact that changes in the motor-vehicle industry, one of the most dynamic in Mexico's manufacturing sector, have left little room for domestic parts manufacturers to enter the productive chain, while at the same time encouraging new foreign firms to enter the domestic market.

As shown in figure 2, these claims are confirmed by the analysis at the most disaggregated level possible, because 10 of the 200 activity classes considered, or just 5% of the sample, contribute 72.3% of the growth in labour productivity in manufacturing, and 63.4% of productivity increases recorded in the indicator as a result of efficiency improvements within each of the classes in the subperiod 1994-2008. The concentration is even greater in the subperiod 1994-2001, where the total effect of the 10 classes that contribute most to the indicator exceeds that of manufacturing as a whole. This means that the 190 remaining activities record a net decrease in labour productivity and, consequently, a negative overall effect in those years. Thus 95% of the manufacturing sector as a whole made no productivity progress during the seven years following the entry into force of the North American Free Trade Agreement (NAFTA) in 1994).

Lastly, there are several key characteristics of the activity classes in which productivity increases are concentrated in the period studied (1994-2008) and which are also the activities with the largest weight in the sector's total output in 2008,[7] in other words, the industries that we could be identified as "leaders" of the current manufacturing specialization model. The first of these display low levels both in terms of the value-added percentage contained in the products of these classes, particularly considering the high level of plant modernization, and also in the extent to which they are integrated into the domestic productive fabric.

In fact, when one attempts to classify these leading activities by type, it turns out that only the beverage industry (brewing and soft drinks manufacturing) in 2008 reports linkage coefficients and value-added in production that are above the overall manufacturing-sector average.[8] Moreover, when these classes are plotted in a chart in which the axes measure these coefficients and the total sector data are at the origin, it is found that two of the six considered ("Automobile and truck manufacturing and assembly", and "Smelting, pressing, refining and extrusion of nonferrous metals") are in the bottom left quadrant, in other words, with a linkage coefficient and share of value-added in production below the manufacturing-sector average (see figure 3).

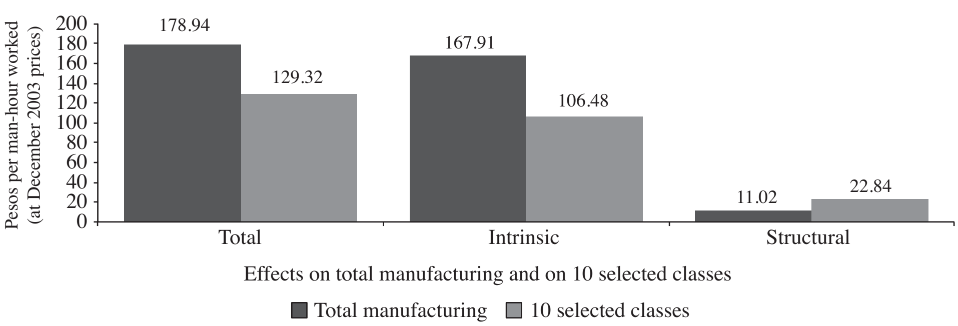
[7] The seven highest-output activity classes in the manufacturing sector in 2008 accounted for 36.5% of total manufacturing output in that year. Significantly, except for brewery activity, they are also those that report the largest increases in labour productivity during the period 1994-2008.

[8] Production is divided into two components: intermediate consumption and value-added, with data generated directly by INEGI. This study considers the share of value-added in production.

FIGURE 2

Determinants of productivity in total manufacturing and in 10 selected classes, 1994-2008

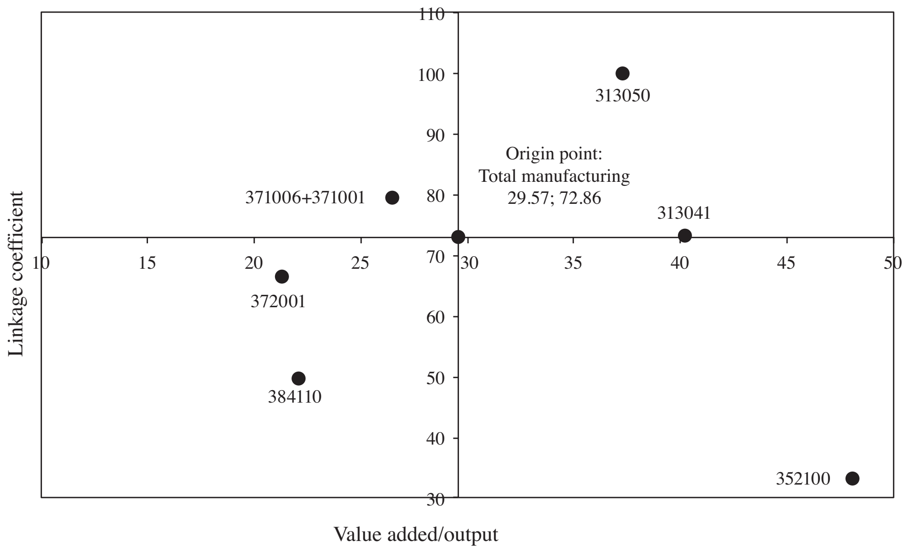
(Pesos per man-hour worked, at December 2003 prices, and percentages)



Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 classes de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL.

FIGURE 3

Linkage coefficient[a] and share of value added in the output of leading activities of the manufacturing specialization pattern,[b] 2008
(Percentages)



Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 classes de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000200002#ARBOL.

[a] The linkage coefficient is calculated as the fraction of the value of national raw materials and auxiliary inputs consumed in the total value of raw materials and auxiliary inputs consumed in production. This is an approximation to the share of local inputs in total inputs consumed in the productive process.

[b] To make the analysis consistent and use data obtained from sources under the North American Industry Classification System (NAICS), based on the activity classes of the CMAP classification, the following equivalences were defined: 384110 (Motor vehicle and truck manufacturing) corresponds to branch 3361 of the NAICS; 371001+371006 (Smelting and primary pressing of iron and steel and manufacture of steel sheets and other steel products) corresponds to Branch 3311; 372001 (Smelting, pressing, refining and extrusion of nonferrous metals) corresponds to activity class 331419; 352100 (Manufacture of pharmaceutical products) corresponds to Branch 3254; 313050 (Manufacture of soft drinks and other non-alcoholic drinks) corresponds to activity 312111; and 313041 (Production of beer) corresponds to activity class 312120.

The graphical representation also suggests that these activities engage with the wider domestic economy in different ways. The soft drink and other non-alcoholic beverage industry is highly integrated into the national economy, because it sells 99.6% of its products on the Mexican market, its share of value added in output is greater than the sector average, and it displays the highest linkage coefficient of the 200 classes of activity present in the database. At the other extreme, automobile and truck manufacture and assembly sector, which is fully engaged in international value chains, displays very low levels in all of these indicators. Among other factors, this reflects poor linkages with local suppliers and sales that are biased towards the global market.

Lastly, the data show the negligible weight of investment in the "dynamic" industries of Mexican manufacturing in 2008. For example, automobile and truck manufacturing and assembly invested just 5.8% of the value-added generated, whereas in none of the activity classes of the basic metal manufacturing considered is the percentage as high as 2.5%. Nonetheless, the two classes with the highest investment coefficients (pharmaceutical product manufacturing and breweries), are also the industries with the largest share of value added in output. A notable case is the pharmaceutical industry, controlled by large TNCs, which records the highest share of value-added in production among the sector's leading activity classes. This industry makes its products essentially for the domestic market (88.5% of its total sales), but uses mostly imported raw materials and inputs in its production processes, which means a low linkage coefficient: 33% (see table 6).

TABLE 6

Selected indicators of leading activity classes in the manufacturing specialization pattern, 2008
(Percentages)

Activity Classes	Value added/ production	Linkage coefficient	Share of national sales in total	Investment/ Value added
Motor vehicle and truck manufacturing and assembly	22.08	49.67	18.88	5.76
Smelting and primary pressing of iron and steel + manufacture of steel sheets and other steel products	26.48	79.37	72.93	0.22
Smelting, pressing, refining and extrusion of nonferrous metals	21.29	66.55	25.71	2.41
Pharmaceutical product manufacturing	48.11	33.01	88.54	6.31
Soft drink and other non-alcoholic beverage manufacturing	37.31	99.99	99.58	3.99
Brewing	40.20	73.10	67.87	15.30
Total manufacturing	*29.57*	*72.86*	*74.50*	*5.97*

Source: prepared by the author on the basis of National Institute of Statistics and Geography (INEG), "Encuesta industrial mensual (CMAP), 205 classes de actividad económica", 2011 [online] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVZ1012900090000020002#ARBOL.

Structural heterogeneity in Mexican manufacturing is also seen in the different modes of operation and business organization in the sector's dynamic activities, as a result of the wide range of expansion strategies deployed by GVCs worldwide (Gereffi, 1994; Gereffi, Humphrey and Sturgeon, 2005; Kaplinsky, 2000). This heterogeneity of dynamic activities and their trend reflects the specific business interests of TNCs in the different locations, which could broadly be identified with the determinants of foreign direct investment (FDI), commonly detected by the economics literature (namely the search for markets, resources and assets, or the pursuit of efficiency) (UNCTAD, 1998; Mallampally and Sauvant, 1999).

VI

Conclusions

In the tradition of Latin American thought, the pioneers of the concept of structural heterogeneity argued that the modernization of poorly integrated structures, which were technologically dependent on the exterior and unable to transmit and diversify technological progress, could foster imbalances within the productive apparatus. In the specific case of manufacturing industry in Mexico, the rapid trade liberalization and economic reforms implemented from the mid-1980s onwards fuelled a meagre modernization process, restricted to a very small number of activity classes generally engaged in global value chains. Although these "leading" activities in Mexico are governed by a very wide range of global corporate strategies that determine the type and level of relations they maintain with the domestic economy, among many other things, the fact is they tend to manufacture goods of low value-added and have weak linkages with the local economy.

In a context of extreme segmentation and dislocation of manufacturing processes worldwide, the characteristics of the leading activities of the Mexican manufacturing specialization model are explained by the proportion of temporary imports in the price of the goods produced, and by the undervaluation that GCV governance[9] makes of the activities undertaken by their subsidiaries in the

[9] Kaplinsky defines the concept of governance as the role of coordination and identification of dynamic income-earning opportunities, and the allocation of activities among the different participants in the productive process (Kaplinsky, 2000, p. 124).

country. By manipulating the transfer prices at which intra-enterprise transactions are undertaken,[10] that governance generally reflects the benefits of the overall productive process in external locations. As noted by Katz (2004) for Latin America, there are close correlations between the presence of the subsidiaries of large transnational groups in the productive fabric, their low degrees of linkage owing to the vertical disintegration of these firms in their local operations, and the reduction of innovation efforts in the domestic economy.

Owing to the predominance of these organizational patterns in the "leading" activities, general productivity levels have largely stagnated, and the structure of manufacturing industry has become more heterogeneous as a result of trade liberalization — particularly in the first decade of this century according to the results of the exercise described this study. On this point, traditional dispersion statistics reveal increasing heterogeneity in the sector, both horizontally and vertically, which not only confirms the results obtained in the few studies available on the subject, but also makes it possible to update them in terms of time coverage and scope, thanks to the higher level of disaggregation at which the statistical exercises are applied.

In this regard, one of the key findings makes it possible to distinguish different growth rates in the types of heterogeneity identified, and everything seems to suggest that the within-sector form has expanded more slowly. One plausible hypothesis that future studies could corroborate is that the phenomenon reflects the progressive weakening of interlinkages in Mexico's manufacturing structure, resulting from its highly specialized nature. The tendency for productive activity to become more concentrated arises from these trends, having developed out of the recessionary conditions caused by the external debt crisis and inherent in the economic model established since the 1980s. Based on the stratification and polarization of the sector's structure, the concentration of supply in a few large firms in nearly all markets led to a rapid shake-out of productive plant and laid the foundations for widening productivity gaps between the different activities.

Another result that is strongly consistent with the signs referred to in previous studies is the zero contribution made by the reallocation of labour, in other words structural change, to the trend of productivity in Mexican manufacturing in the period 1994-2008. This is of crucial importance since one of the main theoretical assumptions used to argue in favour of the trade liberalization and economic deregulation strategy of the 1980s, was that the destruction of jobs in inefficient industries would be more than compensated by the creation of jobs in the "new" dynamic activities linked to international markets. Nonetheless, the evidence shows that the enterprises engaged in GVCs have not yet been able to generate permanent jobs or to transmit technological and organizational capacities to the rest of the productive fabric.

In brief, the elements mentioned above point to the progressive isolation of globalized activities within the structure, and they highlight the absence of dynamic economies of scale at the sector level, which is typical of structural change characterized as shallow in the Ocampo (2005) classification.[11] In this context, the continuity and validity of the central concepts of the Latin American structuralist analysis would signal the need for growth planning that would reverse the trends observed, targeting the development of strategic industries with high potential for local integration, with a view to reconstructing domestic production chains.

[10] A technical term commonly used in economics to refer to the transactions/exchanges undertaken between different enterprises belonging to a single firm or company. Often these enterprises are located in different countries and are subsidiaries of a single parent company based in an advanced country.

[11] The characteristic shallow structural transformation involves the development of export enclaves. This type of transformation is generally distinguished by the weakness of its complementarities (agglomeration and specialization economies) and of its learning processes (induced technological innovations). These two factors are crucial for raising productivity levels.

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Mexico: Value added in exports of manufactures

Gerardo Fujii G. and Rosario Cervantes M.

ABSTRACT

In the last few decades, Mexico's export sector has seen extraordinarily robust growth and has undergone sweeping changes, with exports of manufactures, especially intermediate- and high-technology products, leading the way. At the same time, however, the gap between exports and GDP has been widening, which indicates that the export sector is underperforming as a driver of economic growth. This study is based on the idea that the ability of exports to galvanize the economy will be heightened if export activity leads to an expansion of the domestic market. Whether or not it will do so depends on the amount of national income that is incorporated into exports. The authors estimate how much national value added is contained in exports of manufactures, by sector and by category (direct income, i.e., income generated directly by export activity, and indirect income, i.e., income incorporated into the inputs used to produce export goods). This information is provided for total exports of manufactures, exports of the maquila industry and non-maquila exports.

KEY WORDS Manufacturers, exports, value, income, economic growth, statistics, Mexico

JEL CLASSIFICATION F14, F19, E01

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I

Introduction

A great deal of theoretical and empirical research has been conducted on the relationship between exports and economic growth. Four main vectors for the formation of that relationship have been identified. The first is competition in international markets, which creates an incentive for increasing the efficiency of the production system (Bhagwati and Srinivasan, 1979; Feder, 1983; Kohli and Singh, 1989; Krueger, 1980). The second is the effect that exports have in spurring specialization, which provides access to economies of scale (Helpman and Krugman, 1985). The third has to do with the fact that export firms tend to be more technologically advanced than others and that the technical progress they make diffuses into the rest of the economy (Grossman and Helpman, 1991). The fourth is that, by funnelling hard currency into the economy, exports help an economy to overcome external growth constraints (Thirlwall, 1979). This line of reasoning has underpinned the argument that countries with an export-led growth model will tend to grow faster than others. In addition, a number of research papers have posited that manufactured exports make the biggest contribution to growth because of the strength of global demand for those products, their price trends and the opportunities offered by a large manufacturing export sector for the incorporation of technical progress into its products.

These ideas were readily embraced in many countries in light of the strong growth of some Asian economies: growth which, according to proponents of this approach, was being driven primarily by exports of manufactures. This question has become even more relevant in recent times in view of the deep economic crisis that continues to trouble a large part of the world and that is prompting many countries to look to an increase in their exports as a means of pulling themselves out of that crisis.

These ideas took hold in Latin America in the 1980s and led the countries of the region to open up their economies and to give priority to their export sectors. Mexico has had one of the region's highest export growth rates in recent decades, and it has also witnessed a significant shift in the composition of its exports towards manufactures, particularly intermediate- and high-technology products. Nonetheless, the Mexican economy's long-term growth trends fall far short of what is needed. The primary focus of this study is to help to explain why that is happening.

One of the reasons for this –which ties in with the focus of this study– is the fact that export growth has spurred imports of inputs. As a result, the multiplier effect of exports on economic growth has been weak (Ruiz Nápoles, 2004; Moreno-Brid, Rivas and Santamaría, 2005; Cervantes, 2008). The point of departure for this analysis is the idea that export growth can drive the expansion of the domestic market. Traditionally, export-led growth has been seen as the converse of growth driven by domestic demand (Eatwell, 1998, pp. 737-738), and this belief has been reflected in recent calls for East Asia and China to reorient their growth towards the domestic market. The starting point here is the idea that export-led growth is not necessarily at odds with growth that is driven by domestic demand and that the export sector can be configured in a way whereby its growth will galvanize the domestic market (Palley, 2002; Razmi and Blecker, 2008). What is more, even when authors such as Felipe (2003, p. vii), in referring to the countries of South-East Asia, conclude that "in the end, it is about achieving a golden combination between export-led growth and domestic demand-led growth", or when they contend, as do Felipe and Lim (2005, p. 4), that: "…the best periods seem to be those when domestic demand and net exports exhibit significant and continuous growth or improvements…", they are placing enough emphasis, in our opinion, on the complementarity that can exist between the expansion of exports and the invigoration of the domestic market. This is why it is important to calculate the direct and indirect value-added content of exports.

The point of departure for this analysis, then, is the idea that, while export performance may certainly influence the dynamics of an economy, it is not necessarily a question of having either export growth *or* growth driven by domestic demand. Instead, external demand can help to spur domestic demand, with both the external and internal markets driving the economy's growth. As we will see in section II, this issue has been approached in the literature on the basis of growth estimates calculated

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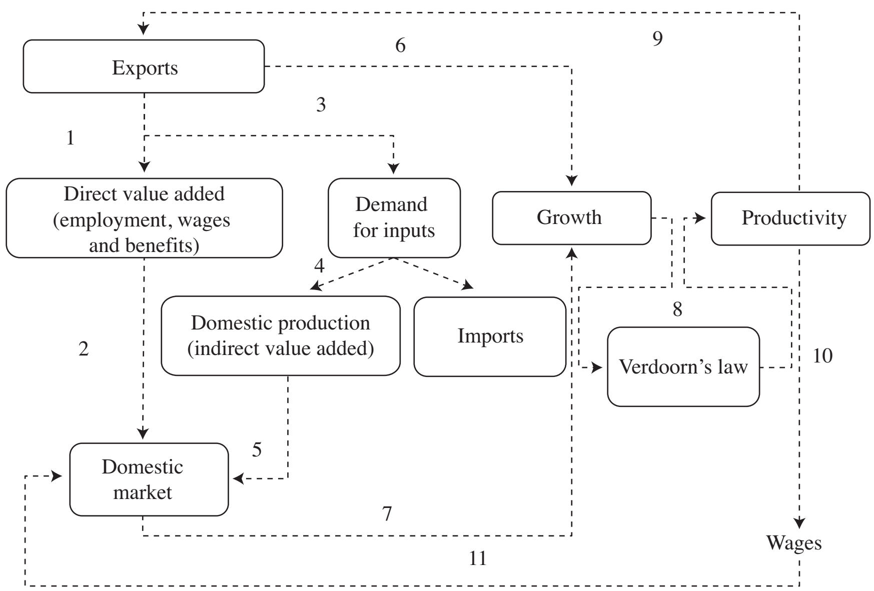
within a framework of external equilibrium. This study focuses on a different aspect of the question, which is explored by calculating the direct and indirect national value-added content of exports. The greater the amount of national income that is incorporated into exports, the stronger the effect that exports will have in terms of the growth of domestic demand. Since this will depend on the value-added profile of the export, this analysis will focus on Mexico's exports of manufactures as viewed from that vantage point. We believe that this approach can, on the one hand, help to explain why the Mexican economy has grown as slowly as it has during the last few decades and, on the other, help to pinpoint some of the traits of the export sector that can help to turn it into an engine of growth.

Figure 1 depicts the various paths by which exports can spur the domestic market and, hence, economic growth. On the one hand, exports translate directly into jobs, wages and benefits (1). The directly generated value added that is contained in exports fuels demand for consumer and capital goods, and the part of that demand that is met with domestically produced goods will help to expand the domestic market (2). On the other hand, inputs are needed in order to produce exports (3). The more of those intermediate goods that are supplied by local firms (4), the more jobs, wages and benefits will be generated indirectly by the export sector (5). In other words, exports help to boost total demand and GDP in two ways: because they are a component of total demand and because of the multiplier effect that an upswing in exports has on the other components of aggregate demand. An increase in exports entails the use of more inputs, and –so long as they are produced in the country— this boosts production in the sectors that are making those inputs as well as having a multiplier effect. GDP growth is therefore generated as a direct result of the expansion of exports (6) and of the growth of the domestic market that is an indirect result of exports via the directly generated income that they contain and the demand for intermediate products incorporated into exports (7). If the requirements of Verdoorn's Law (8) are also satisfied, then the rise in productivity makes prices and exports more competitive (9) and boosts wages (10). This, in turn, spurs the domestic market (11). The economy then enters into a virtuous circle of demand-led growth.

FIGURE 1

Exports and domestic demand



Source: prepared by the authors.

In this article, reference will be made only to those relationships shown in figure 1 that pertain to the measurement of the value added contained in exports. This is because the objective is to provide estimates of the domestically generated value added that is contained in Mexico's exports of manufactures, since that is what determines the level of the export sector's capacity to directly and indirectly generate income and, thus, to expand the domestic market and ultimately help to create the kind of demand that will spur growth.

This question has become particularly important because of the way in which the international division of labour within the manufacturing sector has been changing in recent decades. In particular, the fragmentation of the production process into stages that are completed in different countries has given rise to a new area of research focusing on the quantification of the contribution made by exports to economic growth. Since the imported content of the goods exported by many economies has increased and since some imported goods may incorporate products that had previously been exported by the importing economy, attention is being centred on calculating the national value added in exports and imports, which clearly differs from the value of those flows per se (Loschky and Ritter, 2006; Breda, Cappariello and Zizza, 2007; Kranendonk and Verbruggen, 2008; Breda and Cappariello, 2008; Koopman, Wang and Wei, 2008; Chen and others, 2008; Akyüz, 2010). This is an especially important issue in countries whose exporters are actively involved in international production sharing, since this results in exports that have a very large component of imported inputs. One of these countries is China, and this has recently prompted the development of methodological approaches to the estimation of the national value added in its exports, with the economy being broken down into those sectors that are actively engaged in international production sharing and those that are not (Chen and others, 2005; Koopman, Wang and Wei, 2008; Daudin, Rifflart and Schweisguth, 2009; He and Zhang, 2010).

Since Mexico is actively engaged in international production sharing, the estimation of the national value added contained in its manufactured exports is of particular interest, as it can help us to gauge how much of a contribution exports are actually making to the country's economic growth via their effect in driving the expansion of domestic demand.

This article is structured as follows. The line of reasoning followed in the literature concerning the ways in which exports can contribute to the expansion of domestic demand and, hence, to economic growth is outlined in section II. The new approach being taken to the issue in the light of the intensification of international production sharing is also discussed. Section III describes the methods used to estimate the national value added contained in Mexico's exports of manufactures. In section IV, we summarize the changes that have occurred in Mexico's export sector and look at the sharp differences between the growth trends of exports and production in recent decades. Estimates of the national value-added content of the country's exports –which determine the extent to which exports will stimulate the domestic market and thus the economy as a whole– are presented in section V. Section VI concludes.

II

Exports, domestic demand and growth

Adam Smith spoke about the process by which foreign trade spurs the growth of the home market and about the fact that, as a result, exports help to increase production, thereby deepening the division of labour, which he saw as of being of key importance in augmenting the wealth of nations. According to Smith, for trading nations, foreign trade: "…carries out the surplus part of the produce of their land and labour for which there is no demand among them, and brings back in return for it something else for which there is demand. By means of it, the narrowness of the home market does not hinder the division of labour in any particular branch of art or manufacture from being carried to the highest perfection. By opening a more extensive market for whatever part of the produce of their labour may exceed the home consumption, it encourages them to improve its productive powers, and to augment its annual produce to the utmost, and thereby to increase the real revenue and wealth of the society" (Smith, 1958).

The traditional view of the demand-side relationship between exports and growth has focused on the effect that exports have on total demand, both directly (because they are a component of total demand) and indirectly (because of the multiplier effect that they have on other components of total demand). This view informs the concept of the foreign trade multiplier (Harrod, 1933), as well as the Hicks "super-multiplier" (Hicks, 1950), which adds in the fact that increased exports allow other demand components to expand to the point where the increase in imports balances out the initial rise in exports. The work of Thirlwall (1979) and Kaldor (1989) follows along the same lines when they estimate the increase in GDP generated by a given export growth rate, as measured by import growth. In Kaldor's words: "from the point of view of any particular region, the 'autonomous component of demand' is the demand emanating from *outside* the region; and Hicks' notion of 'super-multiplier' can be applied so as to express the doctrine of the foreign trade multiplier in a dynamic setting. So expressed, the doctrine asserts that the rate of economic development of a region is fundamentally governed by the rate of growth of its exports." (Kaldor, 1989, p. 318) Kaldor also applies this principle to developing countries: "The spread of industrialisation in developing countries, if successful, involves following an 'outward strategy' which leads to the development of export potential and not just to import substitution…" (Kaldor, 1989, p. 341).

The estimates of the contribution of exports to growth that have been calculated on the above basis do not take the new stage-by-stage international division of labour into account. This is why it is so important to measure the national value-added content of trade flows.

III

A method for calculating the national value-added content of exports

An input-output analysis can be used to calculate how much national value added is contained in exports of manufactures, which can in turn be broken down into direct value added (the income generated during the process of transforming inputs into finished products for export) and indirect value added (income generated during the production of the domestically produced inputs incorporated into export products).

The input-output matrix for Mexico developed by the National Institute of Statistics and Geography (INEGI) on the basis of data for 2003 (INEGI, 2008) can be used to arrive at separate estimates for maquila plants and for the other export activities that INEGI classifies as being part of the Mexican economy.

To arrive at these estimates, we used the methodology employed by Koopman, Wang and Wei (2008) and He and Zhang (2010) to calculate the national value-added content of China's exports of manufactures. They divided exports into regular exports and "processing exports", which are basically differentiated from one another on the basis of the percentage of imported inputs used in their production. These terms are equivalent to the "domestic-economy exports" (DE) and "maquila exports" (ME) used in the matrix for Mexico.

This methodology is used to estimate how much of an effect the exports of any given sector have on the value added of other sectors via the demand for intermediate goods for use as inputs.

The national value added that is contained in exports can be broken down, then, into its two components: domestic-economy exports (DE) and maquila exports (ME).

The direct and indirect value added contained in DE is estimated on the basis of the value-added multipliers shown in equation (1), while the direct and indirect value added generated by ME is estimated on the basis of equation (2).

$$M^{EI} = A_V^{EI}\left(I - A^{EI}\right)^{-1} \tag{1}$$

$$M^{IME} = \left[A_V^{EI}\left(I - A^{EI}\right)^{-1} A^{IME} + A_V^{IME}\right] \tag{2}$$

In (1), M^{EI} is the matrix for the coefficients of the value added contained in DE. In (2), M^{IME} is the matrix for the coefficients of the value added contained in ME. Both matrices are r x r, where r represents all subsectors of the economy.

A_V^{EI} is a diagonal matrix of coefficients of value added for DE, with the elements for the main diagonal being obtained by dividing the total value added by each subsector by the gross value of each subsector's output; $\left(I - A^{EI}\right)^{-1}$ is the Leontief inverse matrix, which, for the Mexican economy, is obtained from the DE input coefficients (i.e., by subtracting the ME intermediate consumption, since the firms in this sector use but do not produce intermediate inputs).

In equation (2), A_V^{IME} is a diagonal matrix for the coefficients of direct value added by ME activities and is obtained by dividing total value added for each subsector by the gross value of output. For ME firms, this is equal to the volume of their exports. A^{IME} is a matrix for the coefficients of the domestically produced intermediate inputs for which there is ME demand.

When the columns of the values obtained in M^{EI} are added up, this yields the multipliers for the export value added of the DE firms in each subsector. The sums of the figures in the columns for the M^{IME} matrix represent the multipliers for the value added by ME plants.

IV

Mexico: dynamics and change in the composition of slow-growing exports

Since the late 1980s, Mexico has been trying to implement a strategy in which economic growth is to be led by exports of manufactures. The level of these exports has, in fact, soared, but they have not become a driver of economic growth for the country.

1. Total exports

Mexico embarked on its trade liberalization process in 1987, when it became a party to the General Agreement on Tariffs and Trade (GATT). Between 1992 and 2008, in the space of just 16 years, the country's total exports jumped from US$ 46.2 billion to US$ 291 billion. The mean annual growth rate for exports was 9.6% in 1989-2006, 5.8% between 1989 and 1993, and 14.1% for 1994-2008. As a result, the country's export coefficient climbed from 13% to around 27 % between 1992 and 2008 (see figure 2).

2. The changing composition of exports

The buoyancy of the country's exports was coupled with a shift in the composition of its goods exports: in 2008, the value of exports of manufactures came to US$ 231 billion, which was equivalent to 79% of Mexico's total exports (see figure 3).

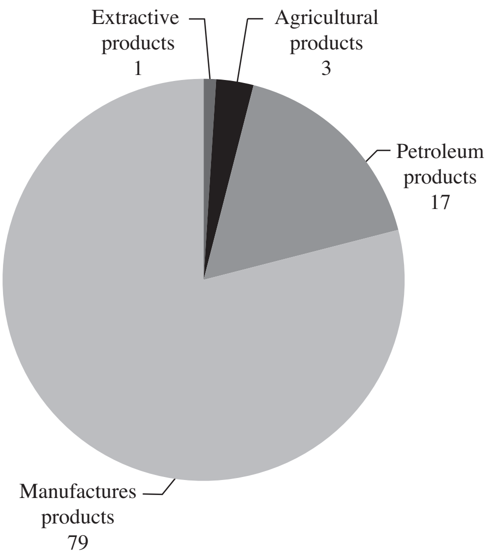
FIGURE 2

Mexico: total exports and export coefficients

Source: Banco de México, *Informe anual*, 2008, Mexico City, 2009.

FIGURE 3

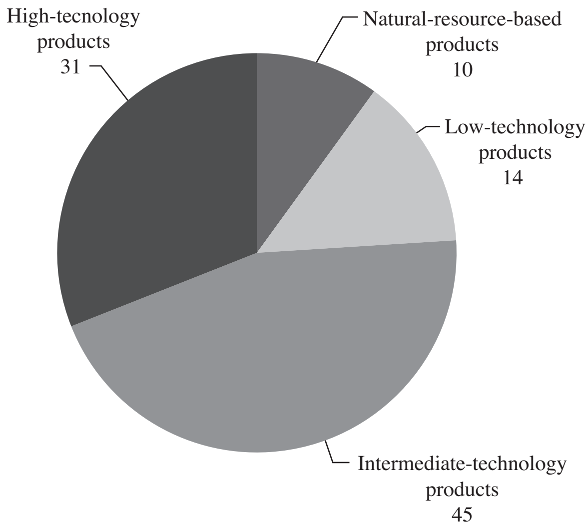
Mexico: exports, by type of product, 2008
(Percentages)



Source: Banco de México, *Informe anual*, 2008, Mexico City, 2009.

FIGURE 4

Mexico: industrial exports, by technological content, 2006
(Percentages of total industrial exports)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Latin America and the Caribbean in the World Economy 2007. Trends 2008* (LC7G.2383-P), Santiago, Chile, 2008. United Nations publication, Sales No. E.08.II.G.36.

3. Exports of manufactures, by factor-use intensity

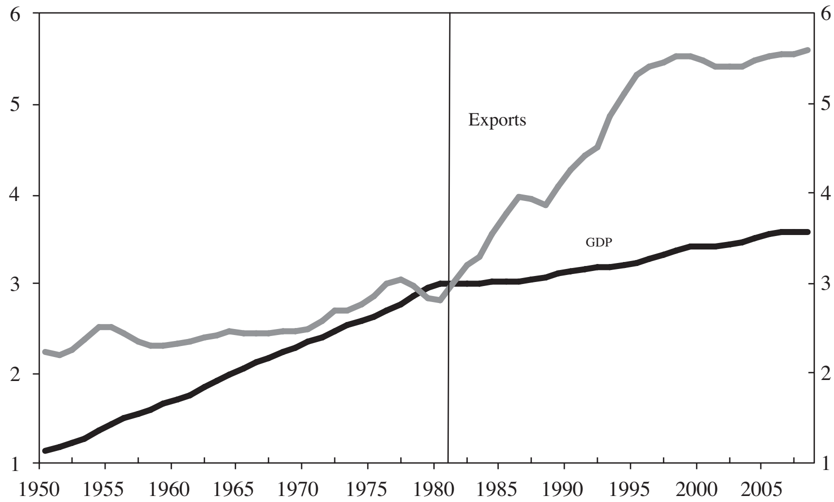
Figure 4 depicts the composition of industrial exports by factor-use intensity. Exports are also divided into natural-resource-intensive and (low, intermediate or high) technology-intensive goods. As the figure shows, manufactures that are intensive in intermediate and high technologies account for the lion's share of the export market (around 60% of the country's manufactured exports since the early 1990s). These figures should be viewed with caution, however, since they are derived from a technology-based classification of export products, and it is quite possible that a country may have specialized in technologically rudimentary stages in the production of a high-technology good. This is especially the case in countries where a large percentage of manufactured exports are produced as part of the system of international production sharing. And, as we will see now, Mexico has been an active participant in this system.

Failing to take into account the particular manufacturing-export profiles of countries actively engaged in international production sharing can yield misleading findings. For example, Myro and others (2008, pp. 38 and 40) divide the manufactured exports of member countries of the Organisation for Economic Cooperation and Development (OECD) into three categories (advanced, intermediate and traditional) and classify them on the basis of the growth of demand and technological intensity. They report that, as of 2005, 41% of Mexico's exports of manufactures were in the first category, 39% in the intermediate category and 25% in the category of traditional exports. The corresponding figures for Germany are 21%, 55% and 23%, while Japan's are 2%, 55% and 13%. In other words, these data are indicating that Mexico is more strongly positioned to meet the growing demand on the international market for high-technology manufactures than these two developed export powerhouses are. What is more, in terms of the sophistication of its exports (Hausmann, Hwang and Rodrik, 2007) and its adaptability index, the country's international position is expected to become even stronger because of the structure of its production specialization profile. These statements do not, however, appear to take into consideration the phase of the production process of high-technology goods in which Mexico has specialized.

Yet despite the fact that Mexican exporters of manufactures have performed so brilliantly since the 1980s, the gap between exports and GDP has continued to widen (see figure 5). This phenomenon, which has been highlighted by Palma (2005), was particularly marked in the 1990s, when exports jumped by an average annual rate of 12.5%, while GDP grew by a rate of 3.4% (World Bank, 2011).

FIGURE 5

Mexico: gross domestic product (GDP) and exports, 1950-2005[a]



Source: National Institute of Statistics and Geography (INEGI), "Banco de Información Económica" for the 1980-2010 series; "Estadísticas históricas de México" for the 1950-1979 GDP series; and Petróleos Mexicanos (PEMEX), *Anuario estadístico*, 1988, for the 1950-1979 oil exports series.

[a] The figures shown above were calculated as moving three-year averages and then converted into log-based index numbers. The base year 1981 = 20.1 was used both for the observed value of GDP and for the observed value of non-petroleum exports.

V

Estimation of the national value added contained in Mexico's exports of manufactures

Since the exports manufactured by the domestic economy and the maquila export economy differ greatly in terms of the value added that they contain (both in relation to the level of value added as such and the percentages of that value added that are generated directly and indirectly), we will start out by gauging the relative proportions of the country's manufactures supplied by each of these sectors, both at an overall level and in the different branches of the manufacturing sector.

1. Exports of manufactures generated by the domestic economyand by the maquila industry

Table 1 gives a breakdown of the country's exports of manufactures by subsector of economic activity. It also disaggregates the figures for the three sectors that account for two thirds of Mexico's exports (computers and electronics, transport equipment, and the electrical power industry) and for the maquila industry and domestic economy. (See table A1 of the statistical appendix for a breakdown of these data into 21 different sectors; tables 1 and 2 give the same information for the three major export sectors. More detailed information for all manufacturing sectors is given in the statistical appendix.) The results show that:

– The maquila industry accounts for the lion's share of manufactured exports (62% of the total).
– When the country's export sectors are divided up into three categories according to the extent of their integration with the Mexican economy as a whole, as measured by the contribution made by those exports to the domestic economy –high (over 70% of exports come from the domestic economy), intermediate (between 30% and 70% come from the domestic economy) and low (less than 30% do so)– it becomes clear that 52% of the country's exports of manufactures are produced by sectors that are not well integrated with the domestic economy. At the other extreme, just 10% of those exports come from sectors that are highly integrated with the domestic economy.
– The three sectors that account for the largest shares of exports of manufactures are the electronics industry (29% of the total), the transport equipment industry (28%) and the electrical equipment industry (9% of the total). Taken together, they account for 66% of the value of the country's exports of manufactures.
– These sectors differ a great deal from one another, however, in terms of the extent of their integration with the rest of the Mexican economy: whereas 88% of the exports of the electronics industry and 81% of those of the electrical equipment industry are produced by maquilas, 58% of the transport equipment that is exported is produced by the domestic economy.

2. National value added in exports of manufactures

Tables 2 and A2 show how much national value added is contained in the country's exports of manufactured goods. This information is given for the whole of the economy and for the two main categories within it (the domestic economy and the maquila industry) and is then broken down into the various branches of the manufacturing sector. The figures for national value added are also divided into the portions of that value that are generated directly and indirectly. Finally, the coefficients for the national value-added content of the country's exports are given. In order to provide a frame of reference, the corresponding figures for the Chinese economy are given where comparable statistics are available.

The most informative conclusions to be drawn from these tables are as follows:

(i) The domestic economy's exports (38% of total exports of manufactures) account for 67% of the domestic value-added content of the country's exports of manufactured goods. Maquila exporters (62% of total exports of manufactures) account for 33%. In other words, the bulk of the country's manufactured exports comes from the sector that makes less of a contribution to national income.

TABLE 1

Mexico: composition of manufacturing-sector exports, 2003
(Millions of pesos)

Subsector	Total		Domestic-economy exports (DE)		Maquila exports (ME)		Percentages	
	Exports	Percentages	Exports	Percentages	Exports	Percentages	Domestic economy	Maquila exports
Electronics	385 317	28.9	47 741	9.4	337 576	40.8	12.4	87.6
Transport equipment	366 969	27.5	211 203	41.6	155 766	18.8	57.6	42.4
Electrical equipment	122 366	9.2	23 135	4.6	99 231	12	18.9	81.1
Three-sector subtotal	874 651	65.5	282 078	55.6	592 573	71.6	32.3	67.7
Other manufactures	460 514	34.5	225 015	44.4	235 499	28.4	48.9	51.1
Total exports	*1 335 165*	*100*	*507 093*	*100*	*828 072*	*100*	*38*	*62*

Source: estimates calculated by the authors on the basis of Institute of Statistics and Geography (INEGI), "Matriz de insumo-producto 2003", Mexico City, 2008.

TABLE 2

Mexico: total national value-added content in exports of manufactures, 2003
(Millions of pesos)

	Total value added		Direct value added		Indirect value added		Percentages of national value added over value of exports				
	Pesos	Percentages	Pesos	Percentages	Pesos	Percentages	Total	Direct	Indirect	Indirect - manufacturing	Indirect - intra-industry
Manufacturing sector - total											
Transport equipment	182 741	32.4	100 446	33.4	82 294	31.1	49.8	27.4	22.4	5.7	2.7
Electronics	81 024	14.3	48 505	16.1	32 520	12.3	21	12.6	8.4	1.8	0.5
Electrical equipment	41 578	7.4	23 002	7.7	18 576	7	34	18.8	15.2	3.8	0.2
Three-sector total	305 343	54.1	171 953	57.2	133 390	50.5	34.9	19.7	15.3	3.7	1.5
Other manufactures	259 416	45.9	128 596	42.8	130 820	49.5	56.3	27.9	28.4	5.5	5.3
Total value added	*564 759*	*100*	*300 549*	*100*	*264 210*	*100*	*42.3*	*22.5*	*19.8*	*4.3*	
Domestic-economy exports (DE)											
Transport equipment	144 396	38.1	74 718	39.4	69 678	36.8	68.4	35.4	33	8.9	4.6
Electronics	33 812	8.9	20 878	11	12 934	6.8	70.8	43.7	27.1	7	2.8
Electrical equipment	17 551	4.6	9 398	5	8 153	4.3	75.9	40.6	35.2	10.4	0.5
Three-sector total	195 759	51.7	104 993	55.4	90 766	47.9	69.4	37.2	32.2	8.7	4.2
Other manufactures	183 185	48.3	84 452	44.6	98 734	52.1	81.4	37.5	43.9	8.5	8.2
Total value added	*378 945*	*100*	*189 445*	*100*	*189 499*	*100*	*74.7*	*37.4*	*37.4*	*8.6*	
Maquila exports (MEI)											
Transport equipment	38 344	20.6	25 728	23.2	12 616	16.9	24.6	16.5	8.1	1.2	0.1
Electronics	47 212	25.4	27 627	24.9	19 585	26.2	14	8.2	5.8	1.1	0.2
Electrical equipment	24 027	12.9	13 604	12.2	10 423	14	24.2	13.7	10.5	2.2	0.1
Three-sector total	109 584	59	66 960	60.3	42 624	57.1	18.5	11.3	7.2	1.3	0.2
Other manufactures	76 231	41	44 144	39.7	32 087	42.9	32.4	18.7	13.6	2.6	2.4
Total value added	*185 815*	*100*	*111 104*	*100*	*74 711*	*100*	*22.4*	*13.4*	*9*	*1.6*	

Source: estimates calculated by the authors on the basis of Institute of Statistics and Geography (INEGI), "Matriz de insumo-producto 2003", Mexico City, 2008.

(ii) The three biggest manufactures-exporting sectors (66% of the total) supply 54% of the national value added that is incorporated into exports. These figures also show how relatively small the main exporting sectors' contribution to national income is.

(iii) The contributions of these three sectors in terms of exports and domestic value added differ markedly: transport equipment represents 28% of exports of manufactured products and accounts for 32% of their value-added content; in the case of the production of computer hardware and electronics, the situation is just the opposite, as this sector produces 29% of exports of manufactures and accounts for 14% of the national value-added content of the country's total manufactured exports.

(iv) The domestic economy and the maquila industry differ markedly in terms of these three sectors' shares of exports and of their national value-added content. In the domestic economy, these sectors account for 52% of the value added and for 56% of that economy's exports, whereas the maquila industry accounts for 72% of exports, which incorporate 59% of the national value added contained in maquila exports.

(v) In the domestic economy, the largest difference between these indicators is found in the transport equipment sector (42% of exports and 38% of national value added), whereas, in the maquila sector, the sharpest contrast is seen in the electronics industry, which contributes 41% of total maquila exports and accounts for 25% of the national value added generated by this sector of the economy.

(vi) Other manufacturing sectors make relatively small contributions to exports and to their national value-added content. For the most part, however, their share of value added is larger than their share of exports. The gap between the two is especially wide in manufacturing activities that process natural resources, such as the food industry (3.3% of value added versus 1.8% of exports), the chemicals industry (6.4% versus 3.5%) and the basic metals industry (4.6% versus 2.6%).

(vii) The national value-added content of all of the country's exports amounts to 55% of the total (authors' calculation), which is significantly higher than the corresponding coefficient for exports of manufactures, since agricultural, mining and petroleum products all contribute more value added relative to their levels of exports than the manufacturing sector does. The corresponding coefficient for China is 47% (Chen and others, 2008, p. 14). The difference is largely explained by the fact that natural-resource-based exports account for a bigger share of total exports in Mexico's case than they do in China's.

(viii) National value added represents 42% of the value of exports of manufactures. This coefficient is considerably higher for exports from the domestic economy (75%) than for the maquila industry's exports (22%).

(ix) In China, as of 2002, national value added as a proportion of the value of exports of manufactures amounted to 51% for such exports as a whole; the figure for the domestic economy's exports was 88% while, for export processors, it was 25% (Koopman, Wang and Wei, 2008, p. 24). This means that the share of national value added that is contained in exports of manufactures from China is larger than it is in the case of Mexico; this is especially true for total exports and for the domestic economy's exports.

(x) In Mexico's three largest manufacturing export sectors, the corresponding coefficients are 50% for transport equipment production, 21% for the electronics industry and 34% for the electrical equipment sector. In all these cases, there is substantially more national value-added content in the domestic economy's exports than in those of the maquila industry. For transport equipment, the coefficient is 68% in the domestic economy and 25% in the maquila industry. For electronics, the percentages are 71% (domestic economy) and 14% (maquila industry). Finally, for electrical equipment, the figures are 76% (domestic economy) and 24% (maquila industry). The corresponding percentages for these three branches of activity in China's export-processing sector are 27%, 20% and 26% (Chen and others, 2008, p. 14).

(xi) As noted earlier, the value added by a given sector can be divided into the value generated directly (the factor income paid out directly by that sector) and the value generated indirectly (the income incorporated into the inputs required by that sector). Indirect value added can, in turn, either be national (Mexican, in this case) –when the inputs come from the export-producing country in question– or imported, in which case they constitute income for the countries that they were imported from. If export activities have strong linkages with input suppliers in the rest of the economy, then exports generate more national income. In Mexico's case, 53% of the national value-added content of exports of manufactures is generated directly. The breakdown of this figure shows that the percentage is lower for domestic-economy exports (50%) than it is for maquila exports (60%).

(xii) The proportion of indirect national value added relative to the value of manufactured exports is 20% in Mexico but is 32% in China (see paragraph ix above and Koopman, Wang and Wei, 2008, p. 24; the data, both for total national value added and direct value added, are for 2002). This indicates that China's exports are more effective in indirectly generating income in other sectors of its economy.

(xiii) In Mexico's three largest manufacturing export sectors, a majority of the national value-added content of exports is generated directly: in the transport equipment and electrical equipment industries, the percentage is 55% and, in the electronics industry, it is 60%. The fact that the level of indirect value added is lower is a sign that the linkages between export sectors and the industries that produce inputs for those sectors are weak. As a result, these exports do not generate as much income in other sectors of the Mexican economy as they otherwise would.

(xiv) In view of the importance of the level of indirect value added as an indicator of the strength of the linkages between export sectors and the rest of the economy, the last two columns of table 2 show the breakdown of the proportion of the indirect value added in these sectors' exports that comes from the manufacturing sector at large and the proportion that is generated by manufacturing industries within the export sector (the column headed "indirect intra-industry"). As shown in the table, the indirect value added originating in the manufacturing sector represents 4.3% for exports of manufactures overall, while the corresponding figure for the maquila industry is just 1.6%. The weakness of the linkages between exporters of manufactured goods and the rest of the manufacturing sector is mirrored within each branch of export activity as well, and it is particularly marked in the maquila industry. For example, in the computer and electronics industry, which accounts for such a large share of the country's exports, the indirect value added originating in other branches of manufacturing activity amounts to just 0.2% of the value of the manufacturing sector's exports.

VI
Conclusions

The objective of this study has been to help to explain why, even though Mexico's export sector has displayed extraordinarily robust growth and has become much more mature in recent decades, it has contributed so little to the overall economy's growth.

In the authors' view, the main reason for this is the weakness of the linkages existing between manufacturing exporters and the domestic market. As a result, the national value-added content of Mexico's exports is relatively small. This is especially true of the exports of the maquila industry, which produces more than 60% of the country's manufactured exports.

The national value added that is contained in exports can be divided into its direct and indirect components. The greater the linkages between export activities and domestic suppliers of parts and inputs, the higher the level of indirect value added, measured as a proportion of total national value-added content. This analysis has demonstrated that there is more direct value added than indirect value added in Mexican exports of manufactured goods, which is indicative of the export sector's relative isolation from the rest of the country's economy.

STATISTICAL APPENDIX

TABLE A1

Mexico: composition of manufacturing-sector exports, 2003
(Millions of pesos)

Subsector	Total		Domestic-economy exports (DE)		Maquila exports (ME)		Percentages	
	Exports	Percentages	Exports	Percentages	Exports	Percentages	Domestic economy	Maquila exports
Food products	24 186	1.8	18 873	3.7	5 312	0.6	78	22
Beverages and tobacco	14 795	1.1	13 981	2.8	814	0.1	94.5	5.5
Textile inputs	16 804	1.3	6 631	1.3	10 174	1.2	39.5	60.5
Textile products	11 103	0.8	2 549	0.5	8 554	1	23	77
Wearing apparel	73 418	5.5	15 323	3	58 096	7	20.9	79.1
Leather products	7 511	0.6	2 944	0.6	4 567	0.6	39.2	60.8
Wood products	2 363	0.2	1 061	0.2	1 302	0.2	44.9	55.1
Paper products	9 240	0.7	4 030	0.8	5 211	0.6	43.6	56.4
Printing and related products	3 977	0.3	1 196	0.2	2 781	0.3	30.1	69.9
Coke and petroleum products	14 794	1.1	14 791	2.9	4	0	100	0
Chemicals	46 117	3.5	40 792	8	5 325	0.6	88.5	11.5
Rubber and plastics products	37 055	2.8	10 100	2	26 954	3.3	27.3	72.7
Non-metallic mineral products	18 523	1.4	11 309	2.2	7 214	0.9	61.1	38.9
Basic metals	34 172	2.6	27 346	5.4	6 825	0.8	80	20
Metal products	42 803	3.2	19 137	3.8	23 666	2.9	44.7	55.3
Machinery and equipment	43 406	3.3	24 048	4.7	19 358	2.3	55.4	44.6
Electronics	385 317	28.9	47 741	9.4	337 576	40.8	12.4	87.6
Electrical equipment	122 366	9.2	23 135	4.6	99 231	12	18.9	81.1
Transport equipment	366 969	27.5	211 203	41.6	155 766	18.8	57.6	42.4
Furniture	18 256	1.4	4 415	0.9	13 841	1.7	24.2	75.8
Other manufactures	41 990	3.1	6 488	1.3	35 501	4.3	15.5	84.5
Total exports	*1 335 165*	*100*	*507 093*	*100*	*828 072*	*100*	*38*	*62*

Source: estimates calculated by the authors on the basis of Institute of Statistics and Geography (INEGI), "Matriz de insumo-producto 2003", Mexico City, 2008.

TABLE A 2

Mexico: total national value-added content in exports of manufactures, 2003
(Millions of pesos)

	Manufacturing sector - total										
	Total value added		Direct value added		Indirect value added		Percentages of national value added over value of exports				
	Pesos	Percentages	Pesos	Percentages	Pesos	Percentages	Total	Direct	Indirect	Indirect - manufacturing	Indirect – intra-industry
Food products	18 845	3.3	8 476	2.8	10 369	3.9	77.9	35.0	42.9	7.1	4.5
Beverages and tobacco	12 738	2.3	6 045	2.0	6 693	2.5	86.1	40.9	45.2	12.6	0.5
Textile inputs	9 184	1.6	4 195	1.4	4 990	1.9	54.7	25.0	29.7	4.9	2.2
Textile products	4 235	0.7	2 573	0.9	1 662	0.6	38.1	23.2	15.0	2.9	0.3
Wearing apparel	31 952	5.7	19 804	6.6	12 148	4.6	43.5	27.0	16.5	4.0	1.2
Leather products	3 606	0.6	1 889	0.6	1 717	0.6	48.0	25.1	22.9	8.0	4.2
Wood products	1 515	0.3	774	0.3	741	0.3	64.1	32.8	31.3	4.8	2.2
Paper products	4 645	0.8	2 365	0.8	2 281	0.9	50.3	25.6	24.7	5.6	2.9
Printing and related products	1 917	0.3	1 025	0.3	892	0.3	48.2	25.8	22.4	3.9	0.5
Coke and petroleum products	13 527	2.4	2 068	0.7	11 459	4.3	91.4	14.0	77.5	2.7	0.3
Chemicals	35 961	6.4	13 311	4.4	22 651	8.6	78.0	28.9	49.1	5.8	3.9
Rubber and plastics products	16 349	2.9	8 603	2.9	7 746	2.9	44.1	23.2	20.9	3.8	0.7
Non-metallic mineral products	12 686	2.2	7 566	2.5	5 120	1.9	68.5	40.8	27.6	5.3	2.2
Basic metals	24 174	4.3	11 157	3.7	13 017	4.9	70.7	32.7	38.1	10.0	7.5
Metal products	21 605	3.8	11 414	3.8	10 191	3.9	50.5	26.7	23.8	6.5	0.6
Machinery and equipment	22 852	4.0	12 711	4.2	10 142	3.8	52.6	29.3	23.4	5.6	0.7
Electronics	81 024	14.3	48 505	16.1	32 520	12.3	21.0	12.6	8.4	1.8	0.5
Electrical equipment	41 578	7.4	23 002	7.7	18 576	7.0	34.0	18.8	15.2	3.8	0.2
Transport equipment	182 741	32.4	100 446	33.4	82 294	31.1	49.8	27.4	22.4	5.7	2.7
Furniture	8 200	1.5	4 700	1.6	3 501	1.3	44.9	25.7	19.2	4.7	0.2
Other manufactures	15 423	2.7	9 921	3.3	5 503	2.1	36.7	23.6	13.1	2.7	0.4
Total manufactures	*564 759*	*100.0*	*300 549*	*100.0*	*264 210*	*100.0*	*42.3*	*22.5*	*19.8*	*4.3*	*1.6*
	Domestic-economy exports (DE)										
Food products	16 302	4.3	7 240	3.8	9 062	4.8	86.4	38.4	48.0	8.0	5.4
Beverages and tobacco	12 087	3.2	5 889	3.1	6 198	3.3	86.5	42.1	44.3	12.0	0.5
Textile inputs	4 606	1.2	2 265	1.2	2 341	1.2	69.5	34.2	35.3	4.8	1.8
Textile products	1 888	0.5	985	0.5	903	0.5	74.1	38.6	35.4	8.3	1.1
Wearing apparel	11 853	3.1	7 317	3.9	4 536	2.4	77.4	47.8	29.6	8.6	2.2
Leather products	2 335	0.6	1 092	0.6	1 244	0.7	79.3	37.1	42.2	17.1	9.9
Wood products	971	0.3	461	0.2	510	0.3	91.5	43.4	48.1	6.2	4.4
Paper products	2 944	0.8	1 325	0.7	1 618	0.9	73.0	32.9	40.2	9.9	5.7
Printing and related products	943	0.2	479	0.3	463	0.2	78.8	40.1	38.7	9.2	1.3
Coke and petroleum products	13 526	3.6	2 068	1.1	11 459	6.0	91.5	14.0	77.5	2.7	0.3
Chemicals	34 176	9.0	12 354	6.5	21 822	11.5	83.8	30.3	53.5	6.2	4.3
Rubber and plastics products	7 261	1.9	3 473	1.8	3 788	2.0	71.9	34.4	37.5	7.0	0.6

Non-metallic mineral products	10 118	2.7	6 098	3.2	4 020	2.1	89.5	53.9	35.5	6.7	3.2
Basic metals	21 751	5.7	9 939	5.2	11 812	6.2	79.5	36.3	43.2	11.5	8.9
Metal products	15 016	4.0	7 536	4.0	7 480	3.9	78.5	39.4	39.1	12.2	0.9
Machinery and equipment	18 345	4.8	10 408	5.5	7 938	4.2	76.3	43.3	33.0	8.8	1.1
Electronics	33 812	8.9	20 878	11.0	12 934	6.8	70.8	43.7	27.1	7.0	2.8
Electrical equipment	17 551	4.6	9 398	5.0	8 153	4.3	75.9	40.6	35.2	10.4	0.5
Transport equipment	144 396	38.1	74 718	39.4	69 678	36.8	68.4	35.4	33.0	8.9	4.6
Furniture	3 670	1.0	2 151	1.1	1 519	0.8	83.1	48.7	34.4	10.9	0.6
Other manufactures	5 393	1.4	3 371	1.8	2 023	1.1	83.1	51.9	31.2	7.8	0.5
Total manufactures	*378 944*	*100.0*	*189 445*	*100.0*	*189 499*	*100.0*	*74.7*	*37.4*	*37.4*	*8.6*	*3.6*
Maquila exports (ME)											
Food products	2 543	1.4	1 236	1.1	1 307	1.7	47.9	23.3	24.6	3.9	1.2
Beverages and tobacco	651	0.4	156	0.1	495	0.7	80.0	19.2	60.9	22.9	0.0
Textile inputs	4 578	2.5	1 929	1.7	2 649	3.5	45.0	19.0	26.0	5.0	2.4
Textile products	2 347	1.3	1 588	1.4	759	1.0	27.4	18.6	8.9	1.3	0.0
Wearing apparel	20 099	10.8	12 487	11.2	7 612	10.2	34.6	21.5	13.1	2.7	0.9
Leather products	1 270	0.7	797	0.7	473	0.6	27.8	17.5	10.4	2.1	0.5
Wood products	544	0.3	313	0.3	231	0.3	41.8	24.1	17.7	3.7	0.5
Paper products	1 702	0.9	1 039	0.9	663	0.9	32.7	19.9	12.7	2.3	0.6
Printing and related products	974	0.5	545	0.5	429	0.6	35.0	19.6	15.4	1.7	0.1
Coke and petroleum products	1	0.0	1	0.0	0	0.0	20.8	14.6	6.3	0.9	0.2
Chemicals	1 785	1.0	957	0.9	829	1.1	33.5	18.0	15.6	2.9	1.1
Rubber and plastics products	9 088	4.9	5 130	4.6	3 957	5.3	33.7	19.0	14.7	2.6	0.8
Non-metallic mineral products	2 568	1.4	1 467	1.3	1 101	1.5	35.6	20.3	15.3	3.1	0.5
Basic metals	2 423	1.3	1 218	1.1	1 205	1.6	35.5	17.8	17.7	3.9	1.8
Metal products	6 589	3.5	3 878	3.5	2 711	3.6	27.8	16.4	11.5	1.9	0.3
Machinery and equipment	4 507	2.4	2 303	2.1	2 204	2.9	23.3	11.9	11.4	1.7	0.2
Electronics	47 212	25.4	27 627	24.9	19 585	26.2	14.0	8.2	5.8	1.1	0.2
Electrical equipment	24 027	12.9	13 604	12.2	10 423	14.0	24.2	13.7	10.5	2.2	0.1
Transport equipment	38 344	20.6	25 728	23.2	12 616	16.9	24.6	16.5	8.1	1.2	0.1
Furniture	4 531	2.4	2 549	2.3	1 982	2.7	32.7	18.4	14.3	2.8	0.0
Other manufactures	10 030	5.4	6 550	5.9	3 480	4.7	28.3	18.5	9.8	1.7	0.3
Total manufactures	*185 815*		*111 104*		*74 711*		*22.4*	*13.4*	*9.0*	*1.6*	*0.3*

Source: estimates calculated by the authors on the basis of Institute of Statistics and Geography (INEGI), "Matriz de insumo-producto 2003", Mexico City, 2008.

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The political economy of regional grants in Peru

Leonardo E. Letelier S. and Gonzalo Neyra A.

ABSTRACT

This paper explores the regional allocation pattern of general resources (*recursos ordinarios*) in Peru, which are distributed to regional governments through a discretionary grant by the national government. We estimate an empirical model based on a panel of annual data between 2004 and 2010. Although national transfers are significantly biased towards regions where the national government received the lowest electoral support, the data suggest that this effect is strongest at the beginning of the administration's period in office. In the long run, however, opposition regions appear to host more volatile constituencies, which is compatible with the swing-voter hypothesis. Interestingly, regions that strongly supported the president receive the fewest benefits. Finally, the role of regional conflicts, the effect of lobbying by organized regionally based civil groups and the size of the regional constituency, among others variables, are statistically significant in the estimations.

KEYWORDS Local government, revenues, regional development, political aspects, econometric models, Peru

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I
Introduction

This article explores the dynamics of grants to regional governments in Peru. It provides empirical support to the hypothesis that the central government's decisions about transfers to regional governments respond, at least partially, to political opportunism. Following similar studies for other countries, we examine the territorial distribution of general resources (called *recursos ordinarios* in Peru), which account for more than 70% of all transfers to regions. Since this fund is allocated on a discretionary basis, the national government has considerable leeway to use the grants to generate political returns.

The theoretical background on the subject is twofold. On the one hand, a normative set of policy recommendations conceive intergovernmental transfers as a way of correcting the potential resource misallocation caused by interjurisdictional externalities, the response to the need for national standards in public goods and the way to address interjurisdictional equity goals and a number of other national welfare goals. On the other, the political economy approach stresses potential deviations from national welfare targets as a result of the central government's use of grants as a pork barrel political device. The literature is divided, however, regarding the most likely strategy to be used by governments when allocating grants. The two most common views are the swing-voter approach (Lindbeck and Weibull, 1987 and 1993) and the aligned-region hypothesis (Cox and McCubbins, 1986).

This article argues that Peru provides a fertile ground for machine politics. As in other Latin American countries, the political scenario is difficult to predict over time, and the mechanisms for social monitoring of the government's behaviour are relatively weak, which facilitates taking larger spoils from office. Moreover, the clear dissociation between national versus regional political parties in Peru makes it difficult to link the two tiers of government through a mutually rewarding strategy. This has two implications. First, short-term motives are likely to carry the most weight in decisions about which regions and functionaries are to receive discretionary grants. This situation promotes giving larger transfers to more risky and politically profitable regions, where the local constituency is highly volatile. Second, the national government's predominant strategy minimizes the potential danger of giving support to rising regional leaders and thereby maximizes the benefit in terms of votes from less supportive regional constituencies. To explore these issues, we build an empirical model of the national government's transfer allocation strategy, using a panel data set covering the period from 2004 to 2010, to identify the main factors in the regional distribution of general resources. While a set of normative considerations are properly accounted for in the empirical model, the results are generally in line with the aforementioned hypotheses.

The rest of the article is organized as follows. Section II examines the theoretical and empirical literature. Section III describes political institutions and the existing regional funding mechanism in Peru. The empirical model, the estimation approach and the data description are reported in section IV. Our econometric results are shown in section V, and section VI presents the main conclusions.

II
Theory and existing empirical evidence

The "public economics" explanation of the behaviour of intergovernmental grants clearly distinguishes two approaches. One is purely normative, as it stresses the view that the donor tier of government follows some kind of national utility function (Musgrave, 1958). Just as typical market failures impede competitive markets from achieving an efficient resource allocation for private goods, subnational governments can make suboptimal decisions about which type and how much of specific public goods are to be provided. Externalities between jurisdictions place a wedge between national and jurisdictional marginal benefits (or costs) (Oates, 1972). The need for national standards, the implicit (or explicit) principal-agent relationship between central and subnational governments, the aim of having a more equitable revenue distribution across the national territory and the achievement of an efficient country-based resource allocation, are all normative justifications for grants (Buchanan, 1950; Inman, 1988; King, 1991; Letelier, 2012). The second explanation, based on the "public choice" approach, states that national fiscal decisions will be shaped by the preferences of what is known as the median voter. This implies that any grant allocation has to follow the demands and geographical distribution of the median voter (Boex and Martínez-Vásquez, 2010).

Grants can also be analysed from a political economy perspective. A number of studies of the New Deal experience in the United States, where significant grants were allocated to jurisdictions hit hard by the Great Depression, question the assumption that federal grants really targeted jurisdictions in need (Arrington,1970; Reading, 1973). Wright (1974) finds a systematic correlation between federal expenditures per capita and states' votes during the New Deal period. Similar results are found by Inman (1988) and Couch and Shughart (1998), among others. These studies generally show that normative arguments for justifying federal grants to states fall short of the facts, suggesting that redistributive politics played a significant role. This last behaviour is commonly known as a "pork barrel" policy, and it raises the potential for misallocation of public funds when government grants are allocated on a discretionary basis.[1]

If we assume that national grants to regions respond at least partially to political economy considerations and that voter preferences are self-motivated, then the key issue to be addressed hinges on the type of regional voters who are more likely to be given larger allocations. Two competing views have been put forwards in the literature (Cox, 2010). First, the swing-voter hypothesis states that regions where a significant number of voters are undecided are the most politically attractive areas (Lindbeck and Weibull, 1987 and1993). Case (2001) finds evidence of such a pattern in federal grants to local governments in Albania. Milligan and Smart (2005) show similar evidence for federal grants to the five poorest Canadian provinces. Castells and Solé-Ollé (2005) conclude that swing voters matter when it comes to the allocation of central government grants to regional governments for infrastructure in Spain. Additional evidence is provided by Wallis (1998) and Gamkhar and Ali (2007) for the United States, Dahlberg and Johansson (2002) and Johansson (2003) for Sweden and Gonçalves (2010) for Portugal. For Peru, Schady (2000) provides some weak (albeit consistent) evidence in favour of the swing-voter hypothesis in a study of the National Social and Development Compensation Fund (FONCODES), which was discretionally allocated to provinces in the early1990s.

The second view is that transfers will be allocated mostly to regions where the national government has the highest support. This is the aligned-region hypothesis, which suggests that no clear-cut political economy rationale can be found to explain why central governments would be equally generous with aligned and non-aligned regions. Cox and McCubbins (1986) contend that candidates' promises to their constituencies are made in the context of the classic trade-off between political returns and risk. If politicians are risk-averse (as they probably are) and swing voters are riskier than aligned voters in terms of political return, then grants are more likely to be given to aligned voters. Supporting evidence is provided by Solé-Ollé and Sorribas (2008) in the case of Spanish municipalities. For the United States, the cases of federal grants to states (Grossman, 1994) and federal grants to local governments (Ansolabehere and Snyder, 2006) appear to favour this hypothesis. Similar results were obtained by Biswas, Marjit and Marimoutou (2010) for federal grants to states in India. Interestingly, Hanes (2007) finds that only socialist central government coalitions (as opposed to conservative ones) appear to be more sensitive to vote purchasing among municipalities with a high socialist share of voters in Sweden. Gonçalves (2010) concludes that European funds geared to Portuguese local governments are skewed to municipalities where the local ruling political coalition is more strongly supported. For Peru, Schady (2000) concludes that more resources were given to aligned provinces and to those where political support for the government in office declined relative to the last presidential elections. In opposition to the aligned-region hypothesis, Segura-Ubiergo (2007) and Graham and Kane (1998) show clear stylized facts suggesting that throughout the term in office of President Fujimori (1990–2001), social grants were discretionally directed to areas where the ruling government won the least support in the 1993 referendum.

[1] As Grossman (1994) correctly points out, formula-driven grants may also be politically motivated insofar as the formula itself is defined by the national government. Nevertheless, while this may occur over long periods of time, if the formula can be actually changed, it becomes more likely that purely discretion-based allocations will be especially responsive to pork barrel political considerations.

Some efforts have been made to bridge the gap between these approaches. Dixit and Londregan (1996) state that if parties are equally able to levy taxes on all groups but are more efficient in benefiting their own constituency, then machine politics will dominate, and more money will be channelled to supportive groups. Swing regions will be given higher benefits when parties are equally efficient in benefiting all groups, so that parties' vote-maximizing behaviour is consistent with targeting moderate groups with loose ideological attachments. In a follow-up paper, Dixit and Londregan (1998) show that in a world of equity-concerned voters, middle-class groups become more politically attractive, given their higher concentration of flexible voters. Another brand of theoretical research uses the traditional portfolio theory to explore how politicians allocate money across regions so as to maximize rents subject to varying degrees of risk from various assets (Díaz-Cayeros, Estévez and Magaloni, 2008; Díaz-Cayeros, 2008).

Another strand of literature stresses the potential impact of interest groups in making the national government more sensitive to their demands (Olson, 1965). While economic redistribution is involved in almost every aspect of the political process, singling out specific groups can be construed as a tactical (or pork barrel) redistribution or even as an attempt to buy votes from those most likely to sell them (Anderson and Tollison, 1988). Support for this hypothesis in the context of the national government's allocation of transfers has been found by Grossman (1994) and Gamkhar and Ali (2007) for the United States, Porto and Sanguinetti (2001) for Argentina and Biswas, and Marjit and Marimoutou (2010) for India.

The dynamic implications of pork barrel politics may also be relevant. Political business cycle theory (Rogoff and Sibert, 1988; Rogoff, 1990) suggests that the magnitude of grants being used as a tactical device will increase in the years leading up to a national election to raise the chances of the incumbent's re-election. Numerous studies support the existence of such a cycle (for example, Drazen, 2000). The Peruvian case, in particular, seems to conform to this pattern. Schady (2000) finds that expenditures under FONCODES increased significantly before elections. Carranza, Chávez and Valderrama (2007) look at the period from 1970 to 1995; they conclude that the combination of strong presidentialism and a fragmented political scenario in Peru have favoured the use of government expenditure as a re-election device.

III
Political institutions and regional funding in Peru

1. The political map in Peru

Peru has a multi-party political system in which different parties often form alliances to improve their electoral chances. One of the most important parties during our sample period (2004–2010) was the Revolutionary Popular Alliance (APRA), which promotes a social democratic ideology with a clear-cut pro-decentralization discourse. In contrast to other political forces, APRA is a well-organized party, and it is the only national party with strong roots at the regional and municipal levels. Three other parties were also important during this period: Possible Peru, a centre-left party founded in 1994 by Alejandro Toledo; the Christian People's Party, a centre-right party dating back to the 1960s (which has some congressional representation, but has never won a presidential election); and the Alliance for the Future, which was formed by the merger of two pro-Fujimori parties (Change 90 and New Majority). After the end of our sample period, the formerly small Peruvian Nationalist Party had become a strong force by winning the 2011 presidential election.

The decentralization process in Peru received a major boost in 1989, when Alan García —an APRA-supported president— created 12 regions with elected regional presidents. However significant, this important step was temporarily reversed by García's successor, Alberto Fujimori, who carried out a military-supported presidential coup in 1992, in which he suspended the constitution, shut down the national Congress and blocked political regional autonomy. A new constitution was adopted in 1993, wherein former regional governments were supplanted by administrative branches of the presidency called Transitory Councils of Regional Administration (Bensa, 2002). After Fujimori's downfall in 2000, the Congress itself elected a new transitory government which called for presidential and congressional elections. The new national Congress was to be composed of regionally represented members.

Fujimori was succeeded by Alejandro Toledo, a Possible Peru candidate who came into power in 2001 following a very tight election. In an attempt to dampen APRA leadership, Toledo launched a pro-decentralization constitutional reform in April 2002. Regional presidential elections were held in November of that year, in which 24 regional governments were appointed (Tanaka, 2002). Although no Possible Peru candidates were elected, 12 APRA-supported regional governments came into power. In July 2006, Alan García was elected national president for a second term, and regional elections were held in November of that year. APRA lost 12 regional governments in that election, ending up with only two representatives. Understandably, budget-approved transfers to regions by García's government were sharply cut from 2006 to 2007.

Political representation at the regional level is based on the simultaneous appointment of the regional president, vice-president and regional council for a four-year period. A similar system holds at the municipal level. Peru is currently divided into 25 regional governments, including the El Callao Constitutional Province (which has regional status) and 1,828 municipal governments. Twelve regions were in opposition to the national government between 2003 and 2006.[2] Only two of them kept the same regional government and ruling political party after the 2006 national election. This shows a highly volatile constituency among these regions, which provides relevant information as to where the swing voters are located.

2. Regional funding

With the exception of some minor income from regionally provided services, regions in Peru have very few revenues of their own (Vega, 2008). Most resources come from two main fiscal transfers from the national government: earmarked resources (*recursos determinados*) and general resources (*recursos ordinarios*). The first source is fed by taxes on the extractive industry, of which the mining canon is the most important. A small share of import taxes is also given to regions under this grant, but only Callao receives any. A distinguishing feature of earmarked resources is that they are allocated according to a well-specified formula that benefits only natural-resource-producing regions. Given that natural resources are very unevenly distributed across the territory, this tax-sharing scheme results in a very inequitable regional allocation. About 80% of the State's mining revenues is absorbed by one third of all regions (Vega, 2008). Moreover, not all transfers in this category are given to regional governments, but rather are shared with municipalities and local universities.

In contrast to the earmarked resources, general resources are assigned on a discretionary basis. They originate from national general tax revenues and have no link to specific public entities. At the beginning of the decentralization process, regional governments were made automatically responsible for a much larger share of national public revenues. This led the Ministry of Economy and Finance to introduce regional transfers as a new budget item in 2003, although general resources are not formally included under the existing institutional framework. A feasible interpretation of the Fiscal Decentralization Law suggests that general resources should be conceived as a transitory device for supporting the regions, until some specific taxes are legally committed to regional control. For now, no specific rule precludes general resources from being assigned discretionally across regions, which then use the funds to finance both their staff and local investment. In recent years, an increasing share of regional investment is being funded through earmarked resources, leaving general resources to cover most current expenditures.

Total transfers to all subnational governments (including municipalities) rose from 27% of the general government's budget in 2005 to 37% in 2011 (see table 1). There were three main reasons for this sharp rise. First, some new functions were delegated to the regions over the period under analysis. Second, non-discretional transfers grew considerably as a result of a surge in the price of gold, copper and oil over the sample period. Third, the robust growth of the Peruvian economy over the period further contributed. Although the Ministry of Economy and Finance is involved in decision-making on the distribution of regional grants, a large share of general resources comes from the general government budget. This, together with the regions' lack of funding, has tended to reinforce the use of political negotiations as a major factor in allocating this money.

[2] That is, they had less than 50% support for the national government.

TABLE 1

Transfers to subnational governments in Peru

Type of transfer	2005	2006	2007	2008	2009	2010	2011
Total general government budget (billions of dollars)	17.64	19.45	22.51	27.69	27.70	31.76	33.63
Transfers to all subnational governments (billions of dollars)	4.80	5.47	6.79	9.97	11.03	11.48	12.30
Transfers as a percentage of general government budget	27.00	28.00	30.00	36.00	40.00	36.00	37.00
Total transfers to regional governments(billions of dollars)	1.67	2.04	2.94	4.543	4.97	5.581	5.35
General resources (billions of dollars)	1.46	1.67	2.171	3.41	3.66	4.06	4.03
General resources as a percentage of regional transfers	87.00	82.00	74.00	75.00	74.00	73.00	75.00
Earmarked resources (billions of dollars)	0.21	0.37	0.77	1.13	1.31	1.52	1.32
Earmarked resources as a percentage of regional transfers	13.00	18.00	26.00	25.00	26.00	27.00	25.00

Source: authors' elaboration, on the basis of the annual General Budget Law of the Republic of Peru.

IV

Hypothesis testing

1. The empirical model

Our hypothesis is that the national incumbent's behaviour as far as grant allocation is concerned is generally determined by a combination of sociodemographic (*SD*), economic (*EC*) and political (*POL*) factors. We assume that the government's potential opportunistic bias is restricted by various environmental factors. First, there is an institutional framework that limits the chance of grants being used for electoral purposes. Second, all political coalitions respond, at least partially, to the will of the median voter. Third, ideology usually matters. Thus, our empirical panel model is expected to be represented by equation (1), where *r* represents the region and *t* time:

$$grant_{rt} = \alpha + \beta_1 \times POL_{rt} + \beta_2 \times ECON_{rt} + \beta_3 \times SDEM_{rt} + {}_{rt} + \varepsilon_{rt} \qquad (1)$$

A key variable to discriminate between the swing-voter and aligned-region hypotheses is the degree of regional political support for the national government in office. As in most empirical papers on this topic, we explore two related variables. The first is the share of each regional constituency that voted for the national government in office (*ng.votes*). A positive effect indicates that aligned regions are being favoured. Second, some studies identify swing regions as being close to 51% in support of the national government. This share of votes is called marginal votes (*mar.votes*). Both variables are timed by the regional constituency.

The following outcomes may be expected: (i) if $[\partial grant/\ \partial ng.votes] > 0$ and $[\partial grant\ /\ \partial mar.votes] = 0$, aligned voters are assumed to predominate when deciding the assignment of grants; (ii) if $[\partial grant/\ \partial ng.votes] = 0$ and $[\partial grant/\ \partial mar.votes] < 0$, it follows that swing regions are being favoured; and (iii) if $[\partial grant/\ \partial ng.votes] < 0$ and $[\partial grant/\ \partial mar.votes] \geq 0$, the answer depends on the composition of the region's voters. A volatile constituency among low *ng.votes* regions (which are the most favoured in this case) indicates that swing voters are being targeted. Even if this were not the case, option (iii) is compatible with the national government having a special skill for reaching beneficiaries from low *ng.votes* regions and a similar capacity to tax all regions (Dixit and Londregan, 1996). In Peru, option (iii) is the most likely situation, given that in a rapidly evolving political setting, voters are usually short-sighted in their capacity to penalize the incumbent when it results in lower transfers to their region. In this regard, we expect that the traditional political cycle as conceived by Rogoff and Sibert (1988) may be contaminated by the opportunity to withdraw benefits from supporters and give them to political opponents immediately after the national government is elected.

Another point to consider is whether the degree of regional government support is relevant from the view point of the national government's strategy for staying in power. We hypothesize that political loyalty to regional parties (*rg.votes*) represents a threat to the national government as regional leaders become more popular. For example, Dickovick (2006) argues that municipal decentralization in Peru and other countries in Latin America is implicitly intended to weaken the intermediate level of government. Just as we expect that highly supported regional governments are given fewer transfers, we also expect that regional governments who hold the same party as the national president are likely to be particularly benefited. A dummy variable (*D.REGNAT*) for this case is included.

Among political variables, we assume that national authorities are sensitive to lobbying and pressure groups, but this channel of local demands is not easily observable. We distinguish lobbying (*lobby*), which expresses in the form of both organized and non-organized individuals who manage to represent their demands, from more radical ways to pressure the national government that result in visible political conflict at the regional level (*conflict*). Both forms of pressure may become a threat to the central government's ability to stay in power, so grants are likely to be sensitive to them. Additionally, regression models include time fixed effects that are expected to capture elements of the political cycle and a dummy variable to capture the effect of regions where the national government got more than 50% of the votes in the last presidential elections (*D.50*).

Regarding non-opportunistic reasons to assign grants, we expect that cost push and demand factors may affect the government's willingness to support more urbanized or densely populated regions (*urban* and *dens*). Similarly, the potential role of grants in compensating poor regions explains why the poverty rate (*pov*) might be relevant. A fair distribution of public tax revenues calls for more transfers to regions in which taxes per head are lower. Thus, high per capita regionally generated taxes (*tax*) and high per capita earmarked resources (*canon*) are likely to diminish financial support from the central government.

2. Estimation approach

The estimation strategy considers two econometric specifications of the general model. The first follows similar studies in using per capita transfers as the endogenous variable. Deviations from an equal per capita allocation arguably respond to factors cited above (see equation 1). Countries like Spain and Canada are explicit in equalizing per capita fiscal capacity across regions, which accounts for the local cost of public goods, fiscal equalization targets, some measurements of local needs, the jurisdictional tax base and a number of other indicators (Dahlby, 2008; Bosch, 2009).

The second specification focuses on the level of grants being allocated (designated using capital letters). All variables are presented in natural logs (ln). In contrast to the per capita model, this approach assumes that each year's allocation is based on the amount assigned the year before. An obvious challenge with this model is the potential correlation between the lagged level of our dependent variable, ln (GRANT_I), and the error term. The simple ordinary least squares (OLS) estimation of this model leads to biased and inconsistent parameter estimates (see Greene, 2003).To deal with that, we use a generalized method of moments (GMM) estimation approach, which under reasonable assumptions results in consistent, asymptotically normal and asymptotically efficient estimators (Hansen, 1982). Both the remaining (non-endogenous) variables and the regions' fixed effects are all accounted for as instruments.

3. The data

The appendix provides a full list of the variables, with their definitions and sources. *GRANT* represents discretionary transfers from the central government to the regional governments (*OR*). These are assigned annually by the Ministry of Economy and Finance. Data on this variable were taken from the corresponding annual budget, which is published on the Ministry's economic transparency website. The political discussion of the budget is based on a proposal from the national government, which becomes law on approval by the Congress. All data are expressed in the Peruvian currency, *nuevos soles*, at constant 2006 prices. The same source was used for the variable *canon*, which captures all regional transfers of earmarked resources. Budget items under this category were not available before 2007, so for 2004–2006 the variable was constructed by summing up all revenues (*canon*) from the exploitation of natural resources in each region. The variable *tax* was taken from the Office of the National Superintendent of Tax Administration, which is the administrative division responsible for collecting taxes. Formally, these data are collected regionally on the basis of taxpayers' fiscal address.

With regard to political variables, *conflicts* accounts for the number of regionally rooted initiatives intended to pressure the government to increase funding for specific areas. This variable was constructed from information provided by the Office of the Ombudsman, which classifies such conflicts regionally. The most common sources of lobbying include local (municipal) and regional authorities and public officers' unions, in particular teachers. Electoral variables were obtained from the National Elections Board, which manages electoral processes and records their results.

Sociodemographic variables were provided by the National Institute of Statistics and Informatics. Two basic data sets are collected by this bureau: the national census, whose last version dates to 2007, and the national household survey, which is carried out continuously. The bureau has published a poverty rate report annually since 1997 based on the household survey.

Finally, some caveats on the data are in order. First, despite our choice to use budget-based general resources, the figures are likely to overestimate actual regional expenditures. The budget itself, however, is assumed to capture political pressures fairly accurately. Second, the data used for the *lobby* variable are potentially biased downwards, as some lobby-related episodes may go unrecorded if they are not reported through an official note to the authorities in charge. The same holds for *conflicts*. Third, since some related series being considered are only available with a lag, the reported regressions only cover up to 2010.

V

Econometric results

1. Economic variables

We expect transfers to be negatively affected by *tax* and *canon* in the per capita regression (see table 2). Although this is precisely the case, only *canon* appears to be significant. A feasible explanation is that grants from general resources are used as a compensatory device, whereby regions with poor natural endowments are given more transfers. The negative —albeit non-significant— sign of the estimated coefficient for *tax* probably reflects a similar role being played by general resources with respect to the general regional tax base. Nevertheless, this latter compensatory effect appears to be weaker. The regressions in levels provide slightly different results (see table 3). One important difference is that ln(*CANON*) appears to have a positive effect on the level of grants. This may reflect the fact that regions in which earmarked resource transfers are important (that is, a large value of *CANON*) also have larger demands on public infrastructure. Since the regions are responsible for this area of government, they should be given more resources to manage it. Nevertheless, demand for infrastructure is not necessarily related to the value of *canon* per capita, which explains why the signs of the estimated coefficients differ between tables 2 and 3. In contrast to grants per capita, the level of taxes has a significant negative effect on the level of grants. This shows that regardless of the population, regions with a rich tax base receive fewer transfers.

2. Sociodemographic variables

The reported estimates show that *pov* is not significant in any of the regressions except GMM3 (see table 3). This is in line with the legal assignment of regional functions as defined in the constitutional reform on decentralization (Law 27680), the Decentralization Basis Law (Law 27783), and the Organic Law on Regional Governments (Law 27867), all passed in 2002. Regions are meant to promote regional economic development, regional investment and all services and activities related to regional responsibilities. Although these functions are ample, they do not explicitly make regions responsible for poverty alleviation programmes; this should be taken into account when interpreting the above results. While shared responsibilities are acknowledged in the provision of basic education, health services and employment promotion, the national government handles both the funding and the administration of poverty reduction programmes.

With regard to *density*, the positive coefficient in per capita estimates suggests that more densely populated regions probably have larger inter-jurisdictional externalities and congestion costs. This raises the per capita cost of regional public goods (the FE2 and FE3 regressions in table 2), but not the level of transfers (Litvack and Oates, 1971).This also explains the sign of *urban*. This variable records the extent to which the national population is unevenly distributed across regions. As this exacerbates the externality and congestion problems, more grants are likely to be allocated to highly urbanized regions. Results consistent with this argument are reported in both tables.

The variable *pop* captures a pure demand effect on regional public goods, and in so doing it affects grants positively. Since grants are divided by population in table 2, this variable is omitted from these regressions, whereas it is included in table 3. The results show that a 1% increase in population leads to a rise in grants between 0.63% and 0.52% (the GMM2 and GMM3 regressions in table 3).

3. Political economy variables

With regard to political economy considerations, the variable *lobby* is significant only in the regressions in levels. Exactly the opposite occurs with *conflicts*. This is consistent with the nature of both variables. Since *conflicts* originate in pressure from well-identified groups that represent a permanent threat to national political stability, they are likely to lead to permanently higher transfers per capita over time (see table 2). Alternatively, the variable *lobby* is built on demands expressed to regional representatives by a variety of groups and people. Given its less specific origin, this variable poses no visible threat to national authorities. This is also in line with *lobby* being significant in the regressions in levels only, which implicitly means that increased lobbying does not necessarily lead to higher grants per capita.

We explore several measurements of voters' support for national and regional governments. As expected, the results in table 2 show that highly supported regional governments (large *rg.votes*) appear to receive fewer transfers per capita. This is in line with the national government's attempt to dampen potential political competition in a rather non-ideological context. A similar result is found with the regressions in levels (see table 3). Consistently with this finding, econometric evidence also suggests that more gains (in terms of new votes) are expected to be achieved by sending money to non-aligned regions. We find support for this assertion when we use D50+ instead of the government support variables (FE2 in table 2 and GMM2 in table 3). This dummy variable appears to be particularly significant for explaining grants per capita (see table 2), in which case the results are the same even when *ng.votes*, *rg.votes* and *D50+* are included together in the regression (FE3, FE4 and FE5). Moreover, grants are positively correlated with the regional constituency (GMM1 in table 3). Due to the high correlation between constituency and population, these regressors are not used together. A direct reading of GMM1 says that a 1% rise in *constituency* leads to almost a 0.4% increase in grants. We ran an additional regression to include the marginal voter variable (*mar. votes*) in FE4 and GMM4. This is done jointly with *50+* included in the regression. In both cases, *mar.votes* is significant and has a positive coefficient in FE4, which runs counter to some of the evidence in favour of the swing-voter hypothesis. The interpretation of this is twofold. First, it suggests that swing voters are not located in regions where political support for the national government is close to 50%, as some empirical studies point out. Second, it reveals that the national government attributes the highest political return to giving transfers to opposition regions. One feasible explanation is that taxing support groups, which in this case must be redefined as groups receiving lower transfers, does not lead to a significant loss of voters relative to the votes being gained by favouring opposition groups (Dixit and Londregan, 1998). While difficult to maintain in the long term, such a strategy can be given some credit at the beginning of the government's ruling period, as the relatively higher value of the 2007 time effect suggests (see table 2). A more time-consistent pattern can be observed by looking at how voters from opposition regions behave relative to those from supporting regions. Among the 12 opposition regions[3] during the 2003–2006 period, only two kept the same regional government and ruling political party after the 2006 national election. This shows a highly volatile constituency, which suggests that opposition regions are the most likely to include indecisive voters, which in turn supports the swing-voter hypothesis.

Evidence of a classic political cycle may also be detected. During the period when President Toledo was in office (2004–2006), the first sample year (2004) records a lower value than the remaining time effects, which is also true for 2009. That is, years that are distant from presidential elections show smaller and less significant coefficients (see table 2).

4. Hypotheses versus empirical evidence: a summary view

Table 4 highlights our main findings by providing a summary of the hypotheses tested and the corresponding econometric results. The variables intended to detect opportunistic behaviour on the part of the national government are generally significant and exhibit theoretically sound effects. First, discretionary grants

[3] Those with less than 50% support for the national government.

TABLE 2

Per capita variables: OLS and time fixed effects

Explanatory variable	FE1		FE2		FE3		FE4		FE5	
	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
lobby	–0.009	–0.99	–0.008	–0.91	–0.009	-1.02	–0.007	–0.80	–0.008	–1.00
conflicts	0.025	**3.43	0.021	**2.74	0.023	** 3.10	0.018	**2.22	0.025	**3.41
ng.votes	–0.001	** –2.70			–0.001	–1.20	–0.0004	–0.54	–0.001	**–2.61
rg.votes	–0.003	**–2.05			–0.002	*–1.92	–0.002	*–1.84	–0.002	**–2.04
D.50+			–0.030	**–2.58	–0.005	–0.23	–0.011	–0.51		
D.REGNAT									–0.002	–0.13
mar.votes							0.004	**2.70		
canon	–0.026	–0.80	–0.040	–1.21	–0.030	–0.83	–0.034	–0.97	–0.026	–0.79
tax	–80.28	*–1.69	–68.71	–1.43	–81.79	*–1.70	–58.32	–1.22	–78.16	–1.55
pov	0.0005	0.52	0.001	0.59	0.001	0.55	0.0003	0.33	0.001	0.53
density	0.010	**2.15	0.011	**2.36	0.010	**2.17	0.005	1.05	0.01	**2.13
urban	3.894	**5.06	4.110	**5.27	3.92	**5.04	3.91	**5.15	3.90	**5.03
D. 2004	0.063	1.21	0.071	1.39	0.061	1.15	0.054	1.04	0.063	1.21
D. 2005	0.077	*1.74	0.085	*1.97	0.076	*1.67	0.072	1.63	0.078	*1.73
D. 2006	0.063	*1.63	0.070	*1.89	0.062	1.58	0.062	1.61	0.063	1.63
D. 2007	0.105	**3.39	0.111	**3.71	0.105	**3.29	0.104	** 3.36	0.106	**3.37
D. 2008	0.074	**3.42	0.074	** 3.43	0.073	**3.35	0.068	**3.18	0.074	**3.39
D. 2009	0.042	**2.49	0.041	**2.43	0.042	** 2.48	0.039	** 2.33	0.042	**2.48
Constant	–2.21	**–3.97	–2.49	**–4.47	–2.239	**–3.96	–2.11	**–3.80	–2.21	**–3.96
R^2										
Within	0.67		0.66		0.67		0.68		0.67	
Between	0.12		0.13		0.12		0.06		0.13	
Overall	0.08		0.09		0.08		0.04		0.09	
F statistic	**17.36		**17.57		**15.91		**16.15		**16.16	
Hausman (Chi^2)	**34.63		**48.19		**34.14		**36.50		**34.00	

Source: prepared by the authors.

* Statistically significant at the 10% level.
** Statistically significant at the 5% level.

TABLE 3

Variables in levels: Generalized method of moments (GMM)

Explanatory variable	GMM1		GMM2		GMM3		GMM4		GMM5	
	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
ln(*GRANT_1*)	0.45	**4.65	0.495	**3.84	0.353	**3.07	0.486	** 4.85	0.423	**4.43
ln(*lobby*)	0.226	**2.00	0.174	1.49	0.271	**2.47	0.177	1.52	0.279	**2.66
ln(*conflicts*)	–0.013	–0.57	0.020	0.68	0.022	0.88	0.012	0.46	0.017	0.67
ln(*CANON*)	0.009	**2.35	0.009	*1.94	0.006	1.17	0.010	**1.97	0.007	* 1.76
ln(*TAX*)	–0.070	**–3.49	–0.051	**–2.51	–0.075	**–3.84	–0.058	**–3.09	–0.070	**–4.01
ln(*pov*)	–0.024	–0.77	–0.041	–1.01	–0.104	**–2.37	–0.020	–0.61	–0.031	–1.00
ln(*dens*)	0.001	0.06	0.002	0.15	–0.002	–0.16	–0.001	–0.06	0.001	0.100
ln(*urban*)	0.092	** 2.00	0.035	0.92	0.067	1.38	0.050	1.23	0.060	1.52
ln(*constituency*)	0.381	** 6.95					0.263	**4.34	0.243	**3.95
ln(*pop*)			0.263	**2.83	0.514	**4.67				
mar.votes x constituency							3.3e–16	0.28	6.8e–16	0.58
Ln(*ng.votes*)	–0.086	**–4.25			–0.140	**–3.56				
ln(*rg.votes*)	–0.067	**–2.05			–0.064	*–1.79				
D.50(+)			–0.038	*–1.75	0.027	0.86	–0.018	–0.89		
D.50(+) x constituency			2.6e–08	1.12	2.3e–08	1.11				
D.REGPRES									0.038	0.86
D.2004	–0.141	**–2.06	–0.175	**–2.29	–0.123	*–1.84	–0.164	** –2.41	–0.121	*–1.75
D.2005	0.128	** 4.65	0.135	** 4.56	0.124	**4.08	0.133	**4.65	0.137	**4.91
D.2006	0.092	**3.13	0.090	**3.19	0.098	** 3.42	0.087	**3.09	0.093	**3.32
D.2007	0.150	**4.43	0.159	**5.11	0.165	**4.87	0.157	**5.12	0.147	** 4.75
D.2008	0.082	** 2.99	0.076	** 2.86	0.076	**3.30	0.078	**2.70	0.073	**2.54
D.2009	0.028	1.21	.023	1.52	0.038	*1.75	0.028	1.13	0.037	1.48
Constant	3.370	**3.04	2.414	**2.26	4.012	**3.63	2.44	**2.25	3.333	**3.36
Wald (Chi^2)	**5 884		**9 378		**5 888		**5 494		**5 842	
R^2	0.94		0.93		0.95		0,93		0.94	

Source: prepared by the authors.

* Statistically significant at the 10% level.
**Statistically significant at the 5% level.

appear to be driven by swing voters. On the one hand, the aligned-region hypothesis is clearly rejected on account of the negative coefficients of *ng.votes* and *D.50+*, which indicate that non-aligned regions receive the most benefits. On the other, the composition of regional constituencies seems to be highly volatile (see above), which reinforces the assertion that opposition regions host the most indecisive voters in our sample. A second political economy finding is that regions in which the president in office is strongly supported by the local constituency receive fewer discretionary grants. The negative and significant *rg.votes* coefficient supports this, providing evidence that popular regional leaders are likely to be seen as a political threat to the national government. A third piece of evidence confirms that lobbying (*lobby*) and interest groups (*conflicts*) matter. Fourth, we also find evidence of a political business cycle, as years close to presidential elections record higher and more significant time effects. Lastly, the lack of statistical significance of *D.REGNAT*, which stands as a proxy for the extent of ideological interaction between the national and regional tiers of government, may be interpreted as a sign that ideology does not rank high in the grant allocation criteria.

Normative considerations also play a significant role. As expected, population (*pop*), population density (*density*) and urbanization (*urban*) all affect grants positively. Nonetheless, poverty (*pov*) does not appear to be a factor in grant allocation, which is in line with the institutional role of the regions in Peru. Similarly, per capita mining taxes (*canon*) affect per head assignments negatively, as do taxes in the ln(*GRANT*) regressions. As stated above, the positive effect of *canon* on ln(*GRANT*) may reflect the fact that regions receiving a high level of earmarked resources are likely to require more public investment.

Finally, some other feasible hypotheses are potentially testable beyond the scope of our database. A municipal-based empirical study on the subject matter would be a major contribution. Local governments in Peru are also given general resources, which are basically used to fund social programmes executed by the municipalities to fulfil a central government mandate. While they are smaller than regional grants, there is plenty of space for their allocation to be politically motivated. Another potentially interesting extension of this research hinges on how municipalities determine property tax collection, including who is to be charged and how intensive the tax collection effort is.

TABLE 4

Expected effects and econometric results

Variable	Effect on *grcap*		Effect on ln(*GRANT*)	
	Expected	Estimated	Expected	Estimated
lobby	+	NS	+	+
conflicts	+	+	+	NS
ng.votes	?	–	?	–
rg.votes	–	–	–	–
Constituency			+	+
D.50+	?	–	?	–
D.50+× constituency			?	NS
mar.votes	?	+	?	NS
mar.votes ×constituency			+	NS
canon	–	–	?	+
tax	–	NS	?	–
pov	?	NS	?	–
density	+	+	+	NS
pop	+	+		
urban	?	+	?	+
D.REGNAT	+	NS	+	NS

Source: prepared by the authors.

Grcap: grants per capita.
NS: Not significant.

VI
Conclusions

This research sheds light on the political economy of the regional allocation of discretionary grants in Peru. In contrast to similar empirical studies for other countries, we found that regions in which the national government has the lowest support generally receive the largest benefits. One feasible explanation for this trend, following Dixit and Londregan (1996), is that the national government may have a comparative advantage in targeting opposition groups, while shifting the cost of this political manoeuvre to supporting groups. This scenario is more likely to hold at the beginning of the government's ruling period, which is compatible with regression results. Nevertheless, the positive association between opposition regions and more volatile constituencies suggests than in the long term, the swing-voter hypothesis is valid.

Our results also indicate that the national government is sensitive to the size of the regional constituency and the potential danger of competition from powerful regional leaders, which is reflected in the low level of transfers to politically strong regional governments. When allocating transfers, the national government also appears to be sensitive to lobbying from private organized groups and regional conflicts. Normative considerations are also relevant. More discretionary funds are given to densely populated and urbanized regions and to regions with a lower tax base and fewer mining-related resources.

APPENDIX

Variable definitions and sources

Variable	Definition	Source
GRANT	Discretionary transfers to regions	Economic transparency website of the Ministry of Economy and Finance
lobby	Complaints sent by organized regional residents to the national Congress	Congress of the Republic of Peru and Ministry of Economy and Finance
conflicts	Number of regionally rooted regional conflicts	Office of the Ombudsman
ng.votes	[percentage of regional votes for the ruling national government] x [regional constituency]	National Elections Board
rg.votes	[percentage of regional votes for the ruling regional government] x [regional constituency]	National Elections Board
Constituency	Regional constituency	National Elections Board
D.50+	Dummy variable for regions with more than 50% support for the national government	National Elections Board
mar.votes	Marginal voter: Absolute value of [percentage of regional support for the national government]– 50	National Elections Board
D.REGNAT	Dummy variable for the case in which the national and the regional presidents belong to the same political party	National Elections Board
canon	Earmarked resources per capita	Economic transparency website of the Ministry of Economy and Finance
tax	Regionally generated taxes per capita	Office of the National Superintendent of Tax Administration
pov	Regional population below the poverty line	National Institute of Statistics and Informatics
density	Population density	National Institute of Statistics and Informatics
pop	Regional population	National Institute of Statistics and Informatics
urban	Degree of urbanization	National Institute of Statistics and Informatics

Source: prepared by the authors.

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Chile: is the fee for non-use of water rights effective?

Christian Valenzuela, Rodrigo Fuster and Alejandro León

ABSTRACT

This paper examines whether the fees for non-use of water rights implemented in Chile in 2005 have provided an incentive for the exploitation of unused water. Two comparisons are made and descriptively analysed: between fees charged and paid, and between fees and the market price of water rights. In the successive fee charging rounds, payment levels increased from 67% of the total charged in 2007 to 81.4% in 2009. It was also found that several years of fee payment would be required to match the market price of water rights. The conclusion is that the fee has not been effective in discouraging non-use, since owners tend to pay it rather than forfeit rights whose market price exceeds the fee. Some improvements to the legal design of the instrument are also suggested.

KEYWORDS

Water, fees, water rights, water law, prices, revenues, legal aspects, Chile

JEL CLASSIFICATION

Q25, Q28, H21

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I
Introduction

The Water Code enacted in Chile in 1981 allowed the State to grant water rights to private users free of charge[1] and in perpetuity, with no obligation to justify the flow applied for, state the field of production involved or actually use the rights. The result was that a substantial proportion of these rights were left unused and unavailable for projects that might have made effective use of them, once water rights to the source concerned had been fully allocated for the purposes of law. In 2005, the Code was reformed with the introduction of a non-use fee to discourage certain market agents from accumulating rights.[2] Now in 2011, with four fee charging rounds completed and a fifth in progress, this study sets out to determine whether the fee has effectively discouraged ownership of rights without effective use, by analysing the results of its implementation.

International practice is for water rights to be made conditional on specific uses, since granting rights for effective and beneficial uses prevents speculation and the creation of monopolies, as indicated, for example, by United States law (ECLAC, 1995). No provision was made for this in the Chilean legislation, and "the decision not to make rights conditional upon effective and beneficial uses or to adopt alternative measures has encouraged speculation and hoarding, facilitating the manipulation of water rights as an instrument of unfair economic competition, and meant that they can be used to exercise market power" (Dourojeanni and Jouravlev, 1999). In comparative law, charging a fee for water rights, as is currently done in Chile, is unusual in that it entails an approach radically different to the "charging for use (or possession) of water" that predominates both in developed countries (Barde and Braathen, 2002) and in developing ones (Jouravlev, 2000) where charges exist. Thus, the Chilean non-use fee is an exception to the rule that charges apply to natural (untreated and non-potable) continental waters, making it an interesting subject for analysis.

While speculators usually look to profit under conditions of uncertainty, the situation was different in Chile's water markets, since having water rights without effective use entailed no risk whatsoever given that:

(i) until 2006, owners were not obliged to invest in facilities[3] to make effective use of their rights;
(ii) many of the water rights used for speculation were granted free of charge by the State; and
(iii) even if speculation took place with rights purchased in the marketplace, the risk remained close to zero as demand has grown steadily and the prices of water rights have shown a steady upward trend (Dourojeanni and Jouravlev, 1999).

These arguments meant that the opportunity cost of keeping rights unused or unsold was less than the profits from rising prices (Dourojeanni and Jouravlev, 1999). The result was a situation that was strategically problematic for the country, considering that water is a vital natural resource and an irreplaceable production input.

Consequently, in 1992 the Government of Chile decided on a core amendment to the Water Code requiring unused water rights to be surrendered, which meant that they would lapse after a period of non-use (Aylwin, 1992). However, this amendment, entailing the application of a command and control type instrument, did not enjoy a consensus among users or in Parliament; indeed, "there was a major debate within the Government" (Lagos, cited by Comisión Especial sobre Régimen Jurídico de las Aguas, 1997). The outcome was that the idea of charging for unused rights was implemented (Comisión Especial sobre Régimen Jurídico de las Aguas, 1997), although it took 13 years of parliamentary debate for agreement to be reached on the application of this economic instrument.

The diagnosis by the executive branch found that there were about 50,000 cubic metres per second (m^3/s) in outstanding applications to the State from hydroelectric companies for non-consumptive water

[1] The exception are the auctions carried out by the State authority in situations where two or more applications cannot be met from the water available for the creation of new water rights, in which case payment does take place.

[2] Rights awarded before 1981 were (theoretically) in use, since the *merced de agua*, as water rights were called before that year, only became definitive once water extraction facilities were in place (Peña, 2003).

[3] These are extraction facilities in the case of consumptive water rights and extraction and return facilities in the case of non-consumptive water rights. Chilean water law distinguishes between consumptive and non-consumptive rights. The former are defined as those that entitle their owner to fully consume the water concerned in any activity, while the latter are defined as those that allow water to be used but not consumed, with a requirement to return it in the manner determined when the right is acquired or constituted (Ministry of Justice, 1981).

rights, which if granted would prevent rights from being constituted for a range of other uses and would consequently hinder economic development. In 1996, the Department of Water (DGA) of the Ministry of Public Works (MOP) estimated that the country's effectively usable hydroelectric resources (non-consumptive water rights) from the Aysén Region to the north totalled no more than about 30,000 m³/s. At that time, non-consumptive rights in current use represented a total flow of 1,699 m³/s (5.7% of the estimated effectively usable total), while constituted but unused rights represented 11,203 m³/s (37.3%) and rights applied for and pending approval totalled 38,509 m³/s (128%), with most being accounted for by just one hydroelectric company (Comisión Especial sobre Régimen Jurídico de las Aguas, 1997). The potential for monopolization, for control of hydroelectric generation and for closure of basins to other uses was obvious (Comisión Preventiva Central, 1996). At that time, the Central Preventive Commission (Comisión Preventiva Central, 1996) advised the Department of Water not to approve any new non-consumptive rights pending implementation of a legal amendment designed to ensure proper water usage, unless the projects concerned were of general interest.

The charge was thus designed as an annual fee, payable to the State, on the proportion of flows left unused because the owners of the rights had not constructed the necessary facilities. If the fee was not paid, the water right would be put up for auction. It was established that fee revenues (whether from payment or from auctions for non-payment) would be divided between the National Fund for Regional Development of the regional government concerned (65%), municipalities in proportion to the surface area of their communes intersecting with the basin and the registration area concerned (10%) and the general central Government treasury (25%).

At the same time, the reform made provision for a number of exceptional situations in which rights are exempted from payment of the non-use fee even in the absence of facilities,[4] these situations having been included for the "peace of mind" of those who viewed the reform as threatening (Peña, 2009). The Act also established that, once the necessary facilities had been built, the owner would be reimbursed (via tax deduction) for up to the last six non-use fee payments in the case of consumptive rights and up to the last eight in that of non-consumptive rights (MOP, 2005).

Thus, the goals in establishing the non-use fee for water rights were (Riestra, 2009a):

(i) to keep water available for those who needed it and had plans for it, encourage rational use and do away with hoarding and speculation so as to favour competition;
(ii) to constitute water rights for flows that were actually in use; and
(iii) to redistribute rights that were not in use.

Given the goals detailed above, the optimum take from the non-use fee is nil (Pérez, cited in Comisión de Hacienda del Senado, 2004), i.e., a situation in which all owners are making use of their water rights.

Following this Introduction, the present study is organized as follows: section II contains the methodology and the data collected for the research, section III expounds and discusses the empirical results, and section IV offers conclusions.

[4] These exceptional situations are provided for in article 129 bis 4, point 4; 129 bis 5, fifth paragraph; 129 bis 6, second, third and fourth paragraphs; and 129 bis 9 of Act No. 20017 (MOP, 2005).

II

Methodology and data

One mechanism for measuring the effectiveness of the non-use fee is to compare the amount charged with the actual take from it. The closer the take is to zero, the more successful the fee is being, as water rights with fee arrears are auctioned by the State and acquired by new owners. Conversely, the closer the take is to the amount charged, the less successful the non-use fee is being, as paying the fee allows owners to retain rights without effective use.

Another mechanism for measuring the effectiveness of the fee is to contrast the market price of rights with the non-use fee amount, since a pure speculator who owned water rights could select the most profitable (or least costly) option: using or selling the water rights, or paying the fee while waiting to transfer the rights at the best possible price.

Given the above, and to determine how effective the non-use fee has been in its purpose of discouraging ownership of rights without effective use, a descriptive analysis was carried out by way of two comparisons.

1. Fees charged and paid

This first comparison was carried out for the charging rounds from 2007 (the first year the non-use fee was charged) to 2009[5] at the region and macrozone level for the whole of Chile, distinguishing between consumptive and non-consumptive water rights. Three macrozones were established, coinciding with the geographical breakdown of the non-use fee levied for consumptive rights[6] (see figure 1). Fees were also linked to the number of rights and the flows of water involved. Data were taken from the official listing of water rights liable to payment of a non-use fee and databases showing the take[7] from fees on the rights listed (DGA, 2010a). This was complemented by reviewing the 2010 charging round to analyse the number of rights owners leaving and remaining on the list of rights liable to the 30 largest fee payments, for both consumptive and non-consumptive water rights, on the assumption that there is a particularly strong incentive for this group of rights to start being used.

The following criteria were then used to gauge the effectiveness of the non-use fee:

(i) "Percentage of fees charged that are actually paid and number of rights and water flow liable" (criterion A). This percentage is inversely proportional to the likelihood of rights being redistributed, since the closer it is to 100%, the greater the preference it reveals on the part of owners for paying the non-use fee and keeping rights unused instead of employing or selling them or waiting for the State auction.

(ii) "Differences in the fees charged and in the number of rights and water flow liable for them between successive charging rounds" (criterion B). In other words, if in any given year the list contains fewer rights liable to the fee (or fewer fees charged or a smaller chargeable flow) than the year before, this means that water rights have come off the payment list because they have started to be used, so that the purpose of the non-use fee has been met. If the opposite happens, i.e., if in a given year there are more rights on the list (or more fees charged or a greater chargeable flow) than the year before, this will be because new rights have been incorporated into the oversight process, and not necessarily because no rights have come off the list. Consequently, no precise conclusions can be drawn from this situation.

2. The market price of rights relative to the fee

This second comparison was carried out separately for consumptive and non-consumptive water rights. For the former, the comparison was carried out on a regional scale for the whole of Chile, while for the latter it was carried out case by case, owing to the scarcity of data.

The comparisons only covered transactions from 2005, when the non-use fee came into force, until 2009, the latest year with information available for this study. The transaction data were obtained from the records of property registries (DGA, 2009), the auction section of the Department of Water website (DGA, 2010b) and a private business, Remates Fernando Zañartu Rozas y Cía. Ltda. (Gallo, 2010).

For consumptive rights, average regional market prices per 50 litres per second (l/s) of permanent and continuous use were estimated.[8] The estimation was carried out on a regional scale because the bulk of the data, obtained from the Department of Water (DGA, 2009), were not suitable for compiling a list at the basin or aquifer level, these being the geographical units in which water markets operate.[9]

In the case of non-consumptive rights, use was made of all available market transaction records that provided

[5] At the time this study was carried out, the 2010 non-use fee charging round was under way, while the 2011 round had yet to begin, which is why these two rounds were not included in this first part of the analysis.

[6] Although the geographical breakdown of charges for the non-use fee on non-consumptive rights is different, the data were tabulated for both types of rights with the breakdown described to facilitate comparison.

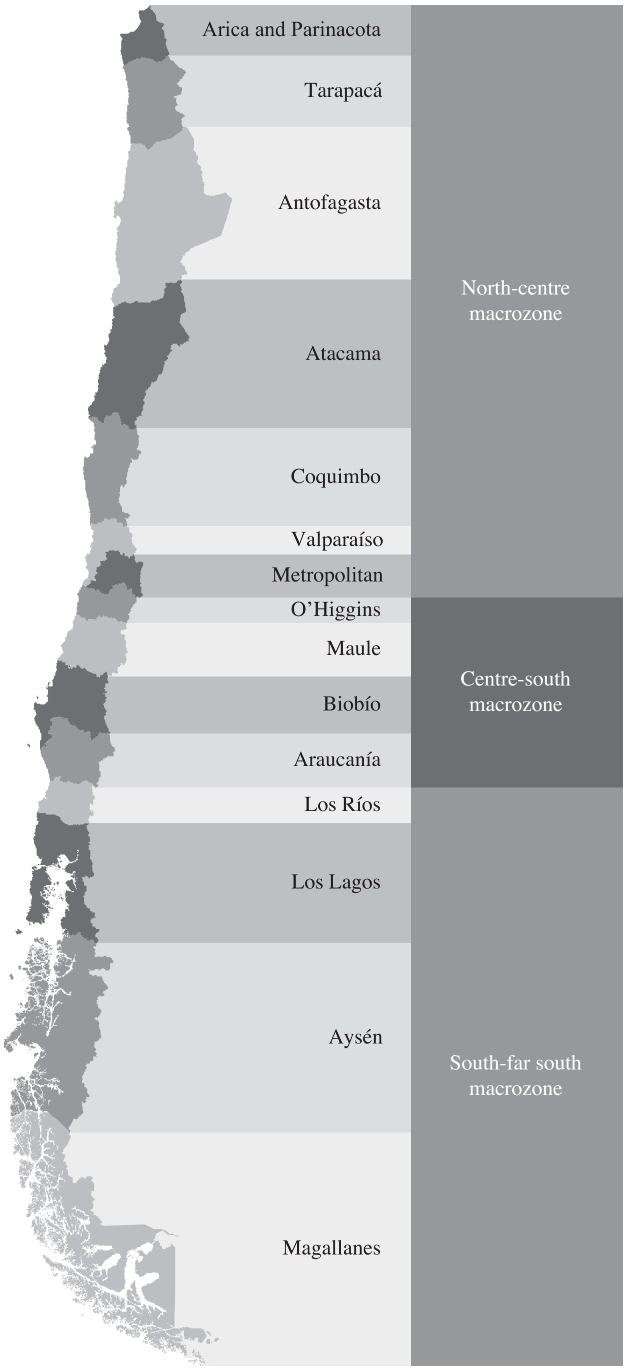
[7] The list includes partial fee payments in very isolated cases, representing a percentage close to zero of the total fee take. For the purposes of the analysis, only fees paid in full were considered, as rights with partial payments are meant to go to auction for non-payment.

[8] As well as being classified as consumptive and non-consumptive, water rights may be exercised permanently or contingently, and may be continuous or discontinuous or alternate between different users. Details of this typology can be found in articles 16 to 19 of legislative decree 1122, which fixes the text of the Water Code (Ministry of Justice, 1981).

[9] In Chile, the boundaries of political and administrative regions coincide only sometimes with basins and never with aquifers.

FIGURE 1

Regions of Chile and macrozones for applying the non-use fee to consumptive water rights



Source: prepared by the authors.

enough detail for the fee to be calculated[10] and case-by-case comparisons made. This procedure is justified because non-consumptive water rights transactions:

(i) are few in number compared with consumptive water rights transactions, and little in the way of data is available on them;
(ii) mainly take place between the Maule and Los Lagos regions;
(iii) cannot be averaged out, since one variable they include is the height difference between the extraction and return points, which is important to the price because it affects hydroelectric power; and
(iv) are less influenced in their pricing by latitude and climate variability (a consequence of Chile's geographical distribution) than are consumptive water rights transactions, with local variables having a greater influence on the value of each litre per second, such as proximity to the power distribution system or the geological conditions of the flow, which affect the type of hydroelectric installation used.[11]

Act. No. 20017 amending the 1981 Water Code (MOP, 2005) yielded equations (1) and (2), which calculate the non-use fee to be paid for consumptive and non-consumptive rights, respectively:

$$F_C = \gamma_C \cdot Q_C \cdot f \qquad (1)$$

$$F_{NC} = \gamma_{NC} \cdot Q_{NC} \cdot H \cdot f \qquad (2)$$

where:

F_C: fee for consumptive water rights in monthly tax units (UTM).[12]

F_{NC}: fee for non-consumptive water rights in UTM.

γ_C: macrozonal constant for consumptive water rights (north-centre 1.6; centre-south 0.2; south-far south 0.1).

γ_{NC}: macrozonal constant for non-consumptive water rights (0.33 from Chiloé northward and 0.22 from Palena southward, these both being provinces in the Los Lagos Region).

Q_C: mean unused flow for consumptive water rights (in litres per second).

Q_{NC}: mean unused flow for non-consumptive water rights (in cubic metres per second).

H: height difference between the extraction and return points (in metres).[13]

f: progressiveness factor (1 from the first to the fifth year of charging, 2 from the sixth to the tenth and 4 from the eleventh onward).

Both equations are designed for permanently and continuously exercised rights. Notwithstanding this, the design of the fee establishes the following:

(i) Contingent rights are liable to one third of the fee payable for an equivalent permanently exercised right.
(ii) For rights with differentiated flow distribution over the year, the annual average is taken.
(iii) For discontinuously exercised rights, any months with a positive flow are added together and the result is divided by 12.
(iv) No difference is made between fees for surface water and groundwater.
(v) Provisional rights are also liable to fee payment.

Lastly, the effectiveness of the non-use fee was determined using the criterion "Difference between the non-use fee charged and the market price of a right" (criterion C); the larger this gap is, with the market price representing the upper bound, the greater the likelihood of owners paying the fee and retaining their unused rights. Conversely, the smaller this gap (and whenever the market price is the lower bound), the smaller the likelihood of owners choosing to retain their unused rights.

[10] Most of the few records available on non-consumptive rights transactions fail to report the height difference between the water extraction and return points, or the geographical coordinates of these points, from which it would be possible to ascertain the altitude and estimate the height difference, a variable that needs to be known for the fee to be calculated.

[11] No information is available on other non-consumptive uses, such as fish farming or industrial refrigeration, as they amount to only a tiny fraction of hydroelectricity use.

[12] Monthly tax unit: a unit of account, adjusted monthly for inflation, that is used in Chile for tax purposes and fines.

[13] This variable cannot be less than 10 m, so this value is used for smaller height differences.

III

Empirical findings and discussion

1. Fees charged and paid

The payment percentage rose over the successive fee charging rounds, from 67% of the fee amount charged in 2007 to 81.4% in 2009. Nonetheless, the percentage of all rights on which the fee was paid fell from 63.4% in 2007 to 50.9% in 2009 (see table 1). This situation arose because:

(i) some rights have been surrendered,[14] some have been redistributed to new owners and some unused rights have started to be used;

(ii) the highest fees for non-consumptive water rights have usually continued to be paid; and

(iii) in the 2008 and 2009 charging rounds, new rights liable to lower fees (colloquially known as "smaller rights") were incorporated into the list, the result being a progressive drop in the average fee per chargeable right and a low level of variability in the average fee per right charged for (see table 1).

Again, the value of fees charged was US$ 2,943,626 less in 2009 than in 2008 (see table 1), a figure that reflects the removal of a number of rights from the list because they were surrendered, sold or brought into use. For this group of water rights, in other words, the non-use fee succeeded in its purpose, except in the case of rights that came off the list because their owners found a way of avoiding the fee, as will be discussed further on.

A more specific breakdown of the data (see figure 2) reveals that the fee total charged for consumptive rights was similar in 2007 and 2008, before diminishing in 2009, while in the case of non-consumptive rights the opposite happened, even as the number of rights liable for the fee, both consumptive and non-consumptive, increased (see figure 3). Regarding the proportion of fees actually paid, this has always exceeded 95% in the case of non-consumptive rights, whereas payment of consumptive rights did not reach 50% until 2009. This indicates at least that the non-use fee is proving successful for consumptive water rights, while the data available do not yet allow a trend to be established for non-consumptive rights.

Similarly, consumptive water rights have been exiting the list of rights liable to the highest fees (see table 2), but this is not so with non-consumptive rights, which tend to crop up in the list year after year (see table 3). This can be corroborated by examining the ranking for 2010 (the last column of tables 2 and 3), since only 2 out of 30 consumptive rights are listed for earlier rounds, while a further 2 did come up in earlier rounds but under different ownership, meaning that they were sold or transferred and will presumably soon begin to be used. Conversely, only three non-consumptive rights appeared in the list for the first time in the 2010 round, and just two exited the list that year. The rest were rights that had previously been in the list, either as the

[14] Surrender of water rights was provided for in Act No. 20017 and, as the name indicates, it consists in a person surrendering ownership of a right. When this happens, the right is extinguished and the water associated with it becomes available; non-payment of the non-use fee creates a different situation, as then the water right is auctioned off.

TABLE 1

Non-use fees charged and paid, national total, 2007-2009

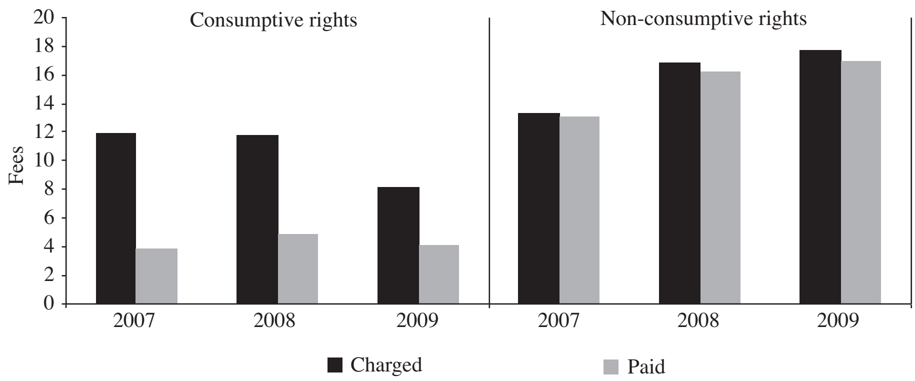
Charging round	Fees *(dollars)*			Number of rights *(units)*			Average fee per right *(dollars)*	
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid
2007	25 349 632	16 971 827	67.0	1 302	826	63.4	19 470	20 547
2008	28 767 544	21 097 355	73.3	1 554	959	61.7	18 512	21 999
2009	25 823 918	21 017 428	81.4	2 006	1 021	50.9	12 873	20 585

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

property of a single owner or as the property of two or even three different owners. An example can be found in the fourth, fifth and sixth records of table 3, with the owner changing over the years ("Beatriz Cortés Torres" in 2007 and 2008, "Inversiones Arlequín Ltda." in 2009 and "Hidroeléctrica Centinela Ltda." in 2010), indicating that the same right had been kept unused for four years by different owners.

FIGURE 2

Revenues from non-use fees charged and paid, 2007-2009
(Millions of dollars)



Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

FIGURE 3

Number of rights liable to non-use fees and number paying, 2007-2009
(Units)

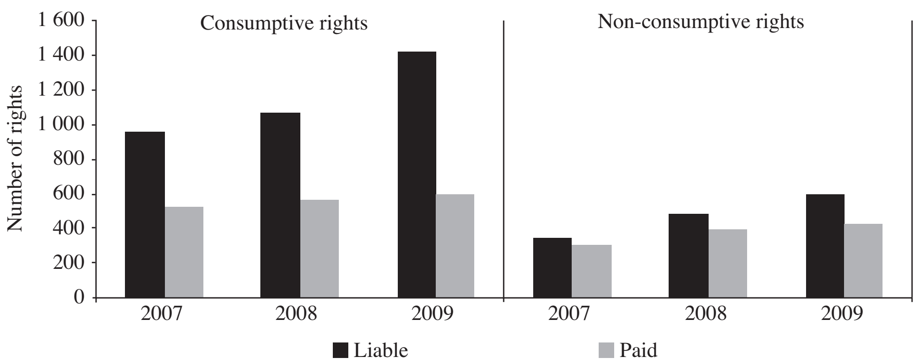


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TABLE 2

Largest non-use fees charged, consumptive rights, 2007-2010

Owner	Region	Fee *(dollars)*	Flow *(l/s)*	Ranking			
				2007	2008	2009	2010
María Estela García Constans	Valparaíso	4 498 101	37 787	1	—	—	—
Valle Rapel S.A.	Valparaíso	3 594 988	30 200	—	1	—	—
Valle Central S.A.	Valparaíso	904 699	7 600	—	2	—	—
State. Department of Waterworks	Biobío	644 797	43 333	2	—	—	—
State. Department of Waterworks	Biobío	644 797	43 333	3	—	—	—
State. Department of Waterworks	Biobío	644 797	43 333	4	—	—	—
Usuarios del Canal Biobío Sur	Biobío	578 313	38 865	5	—	—	—
Agrícola y Comercial Los Lleuques Ltda.	Metropolitan	553 533	4 650	6	—	—	—
Inversiones El Álamo S.A.	Metropolitan	462 765	3 888	—	3	1	—
Alberto Acuña Puchi y Otros	Araucanía	446 398	30 000	7	4	2	1
Proyectos de Aysén S.A.	Aysén	446 398	60 000	8	5	3	—
Energía Austral Ltda.				—	—	—	2
Exploraciones, Inversiones y Asesorías Manantiales S.A.	Metropolitan	404 920	3 402	—	—	—	3
Proyectos de Aysén S.A.	Aysén	371 998	5 000	9	6	4	—
Energía Austral Ltda.				—	—	—	4
State. Department of Irrigation	Araucanía	314 586	21 142	10	—	—	—
María Estela García Constans	Valparaíso	312 677	7 880	11	—	—	—
Juan Landerretche Díaz y Otros	Biobío	295 366	19 850	—	7	—	—
Comercial San Alberto Ltda.	Metropolitan	273 791	2 300	—	8	—	—
Valle Rapel S.A.	Valparaíso	249 983	6 300	—	9	—	—
Inversiones Quintay S.A.	Metropolitan	231 383	1 944	—	—	—	5
Agrícola Las Acacias del Aconcagua S.A.	Metropolitan	231 383	1 944	—	—	—	6
Inversiones Quintay S.A.	Metropolitan	219 479	1 844	—	10	5	—
Inversiones Arlequín Ltda.	Coquimbo	158 719	4 000	—	—	—	7
Inversiones Arlequín Ltda.	Valparaíso	148 799	1 250	12	11	6	8
Gonzalo Donato Quezada Pressac	Metropolitan	140 109	1 177	—	—	7	—
Hidroeléctrica Guardia Vieja S.A.	Valparaíso	134 068	1 126	13	—	—	—
Agrícola Los Retoños S.A.	Valparaíso	122 015	1 025	14	12	—	—
Jorge Schmidt y Cía. Ltda.				—	—	8	—
Humberto Einar y Otro	Valparaíso	119 039	1 000	—	—	9	—

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

Note: Records shaded in grey are water rights whose owners changed between non-use fee payment rounds.

TABLE 3

Largest non-use fees charged, non-consumptive rights, 2007-2010

Owner	Region	Fee *(dollars)*	Flow *(l/s)*	Ranking 2007	Ranking 2008	Ranking 2009	Ranking 2010
ENDESA S.A.	Los Lagos	3 526 876	850	1	1	1	1
Juan Wenke Williams	Valparaíso	2 393 807	2	—	2	—	—
ENDESA S.A.	Biobío	1 189 538	255	—	—	—	2
Beatriz Cortés Torres	Maule	618 707	60	2	3	—	—
Inversiones Arlequín Ltda.				—	—	2	—
Hidroeléctrica Centinela Ltda.				—	—	—	3
ENDESA S.A.	Los Ríos	478 276	48	—	4	3	4
ENDESA S.A.	Maule	472 623	25	3	5	4	5
ENDESA S.A.	Los Lagos	438 251	255	4	6	5	6
AES Gener S.A.	Metropolitan	407 365	61	—	7	—	—
AES Gener S.A.	Metropolitan	405 106	15	—	8	6	7
ENDESA S.A.	Maule	392 830	80	5	—	—	—
Colbún S.A.				—	9	7	8
AES Gener S.A.	Metropolitan	353 915	31	—	10	8	9
Hernán Lacalle Soza y Otros	Los Lagos	318 192	270	6	—	—	—
Colbún S.A.				—	11	9	10
Chilgener S.A.	Maule	285 784	19	7	—	—	—
AES Gener S.A.				—	12	10	11
Mediterráneo S.A.	Los Lagos	257 034	75	—	—	—	12
Jorge Wachholtz Buchholtz	O'Higgins	243 063	30	—	—	—	13
CGE Generación S.A.	Maule	239 994	23	8	13	11	14
ENDESA S.A.	Los Ríos	223 717	68	—	14	12	15
AES Gener S.A.	Metropolitan	205 622	25	—	15	13	16
CGE Generación S.A.	Biobío	204 272	52	—	16	14	17
AES Gener S.A.	Metropolitan	200 343	30	—	—	15	18
CGE Generación S.A.	Maule	190 031	18	9	17	16	19
AES Gener S.A.	Metropolitan	183 651	36	—	18	—	20
Compañía Forestal Chiloé	Los Lagos	178 861	47	10	19	17	—
Inversiones y Desarrollo Sur S.A.				—	—	—	21
Forestal Cholguán S.A.	Biobío	172 354	130	—	—	18	22

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

Note: Records shaded in grey are water rights whose owners changed between non-use fee payment rounds.

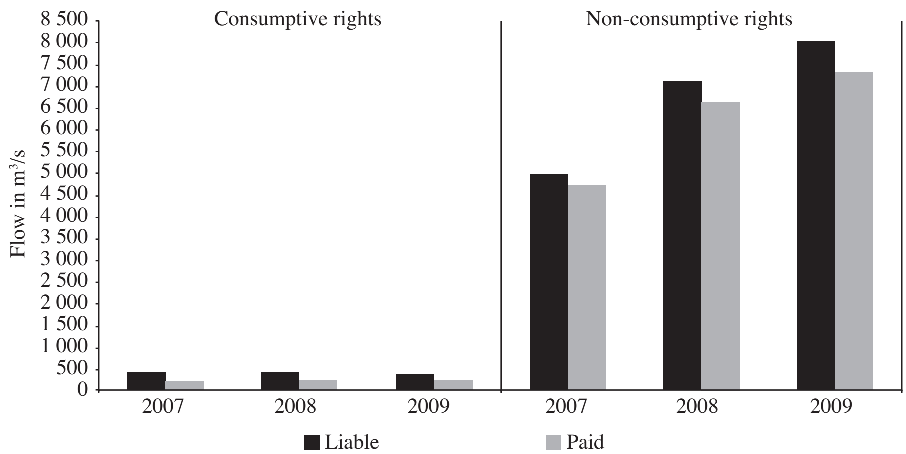
Although the total fees charged for consumptive water rights have been less than the total for non-consumptive rights (see figure 2), it is important to consider flows (see figure 4), as there are large differences between the two types of rights. These differences are not accurately reflected in the fees charged, since fees for consumptive rights are calculated by the flow in litres per second, whereas for non-consumptive rights they are calculated in cubic metres per second (see equations (1) and (2)), a ratio of 1,000 to 1.

As expected, only rights liable to the fee were surrendered, and there was further confirmation that the non-use fee was being more successful for consumptive rights than for non-consumptive ones, with figures of US$ 4,365,908 and 58.4 m^3/s (see table 4) and US$ 28,476 and 11.1 m^3/s (see table 5), respectively.

FIGURE 4

Flows liable to non-use fees and flows paid out on, 2007-2009

(Cubic metres per second: m^3/s)



Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 4

Consumptive water rights surrendered, 2007-2010

Owner	Region	Source	Flow *(l/s)*	Equivalent fee *(dollars)*
Valle Rapel S.A.	Valparaíso	Rapel river	28 527	3 395 836
Humberto Benedetti Rosenqvist	Valparaíso	Unnamed	4 570	544 010
Valle Rapel S.A.	Valparaíso	Rapel river	5 579	221 376
Bosques Cautín	Araucanía	Toltén river	3 500	52 080
Corpora Agrícola S.A.	Valparaíso	Aconcagua river	213	25 296
Dora Elena Oelckers	Los Lagos	Pilmaiquén river	10 000	24 797
Agrícola Paiquén	Valparaíso	Aconcagua river	208	24 760
Bosques Cautín	Araucanía	Imperial river	1 500	22 320
Ganadera Río Caleta Ltda.	Magallanes	La Caleta river	1 951	14 515
Corpora Agrícola S.A.	Valparaíso	Aconcagua river	255	10 118
Agrícola Paiquén	Valparaíso	Aconcagua river	250	9 920
Bosques Cautín	Araucanía	Cholchol river	667	9 917
Margarita Yutronich	Magallanes	Blanco river	841	6 257
José Irarrázaval Larraín	Araucanía	La Gaviota river	219	3 255
Rolando Hott Marquard	Araucanía	Huilío river	88	1 302
Domingo Couso	Los Lagos	Lake Llanquihue	20	149
Total			*58 386*	*4 365 908*

Source: Department of Water (DGA), *Informe sobre patente por no uso de derechos de aprovechamiento de aguas*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 5

Non-consumptive water rights surrendered, 2007-2010

Owner	Region	Source	Flow *(l/s)*	Equivalent fee *(dollars)*
Soc. Agrícola y Forestal Degenfield	Los Lagos	Cahulnalhue river	4 259	26 144
Rolando Polh Marquard	Araucanía	Palguín river	2 000	982
Soc. Agrícola y Forestal Degenfield	Los Lagos	Cahulnalhue river	1 752	513
Bosques Cautín	Araucanía	Imperial river	1 500	368
Bosques Cautín	Araucanía	Cholchol river	1 083	346
Bosques Cautín	Araucanía	Toltén river	500	123
Total			*11 094*	*28 476*

Source: Department of Water (DGA), *Informe sobre patente por no uso de derechos de aprovechamiento de aguas*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

Up and down the country, there are substantial differences in the total macrozonal fees charged for consumptive rights (see tables 6, 7 and 8). In the different rounds, the largest portion of the total charged has been in the north-centre macrozone (arid and semiarid zone), as in this part of Chile the equation for calculating the non-use fee is weighted by a constant of 1.6, whereas in the centre-south and south-far south macrozones it is weighted by constants of 0.2 and 0.1, respectively (see equation (1)), the result being that total fees charged are less in these latter two macrozones.

Where fee revenue is concerned, the differing availability of water by latitude within Chile (with scarcity diminishing from north to south) and the macrozonal constants for calculating fees on consumptive water rights have resulted in payment percentages varying between regions in the same macrozone. One effect of this difference can be exemplified by the case of two neighbouring regions

TABLE 6

Total regional non-use fees charged and paid, consumptive rights, 2007

Region	Fees *(dollars)*			Number of rights *(units)*			Flow *(m³/s)*		
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid	Percentage
Arica y Parinacota	3 333	3 333	100.0	1	1	100.0	0 028	0 028	100.0
Tarapacá	117 992	116 682	98.9	23	21	91.3	0 991	0 980	98.9
Antofagasta	437 185	428 674	98.1	59	55	93.2	3 673	3 601	98.1
Atacama	594 777	406 575	68.4	97	63	64.9	4 996	3 415	68.4
Coquimbo	475 872	396 580	83.3	47	38	80.9	3 998	3 332	83.3
Valparaíso	6 367 626	777 629	12.2	116	53	45.7	62 240	7 917	12.7
Metropolitan	1 312 339	309 098	23.6	115	47	40.9	11 687	2 577	22.0
North-centre macrozone	9 309 123	2 438 571	26.2	458	278	60.7	87 612	21 850	24.9
O'Higgins	38 744	14 515	37.5	31	14	45.2	2 681	0 976	36.4
Maule	125 102	34 489	27.6	65	19	29.2	11 171	3 159	28.3
Biobío	86 364	13 612	15.8	14	5	35.7	5 923	0 915	15.4
Araucanía	879 953	236 726	26.9	135	64	47.4	65 644	20 327	31.0
Centre-south macrozone	1 130 163	299 343	26.5	245	102	41.6	85 418	25 376	29.7
Los Ríos	150 911	101 582	67.3	104	72	69.2	23 335	14 810	63.5
Los Lagos	159 532	82 670	51.8	45	31	68.9	28 585	11 588	40.5
Aysén	932 360	895 497	96.0	21	8	38.1	145 498	140 208	96.4
Magallanes	299 019	53 402	17.9	85	30	35.3	50 607	10 592	20.9
South-far south macrozone	1 541 822	1 133 152	73.5	255	141	55.3	248 025	177 197	71.4
Total	*11 981 107*	*3 871 065*	*32.3*	*958*	*521*	*54.4*	*421 055*	*224 423*	*53.3*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

with similar hydrological conditions: the Metropolitan and O'Higgins regions. In the 2009 round (see table 8), the flow liable to payment of a non-use fee was found to be similar (15.39 and 11.42 m³/s, respectively), but the sum total of fees charged was very different (US$ 1,688,064 and US$ 153,158, respectively) as, predictably, were the ratios between the amounts paid and the amounts charged (31.2% and 87.2%, respectively).

TABLE 7

Total regional non-use fees charged and paid, consumptive rights, 2008

Region	Fees (*dollars*)			Number of rights (*units*)			Flow (*m³/s*)		
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid	Percentage
Arica y Parinacota	3 333	3 333	100.0	1	1	100.0	0 028	0 028	100.0
Tarapacá	117 992	115 016	97.5	23	22	95.7	0 991	0 966	97.5
Antofagasta	644 254	642 111	99.7	83	82	98.8	5 412	5 394	99.7
Atacama	586 801	351 654	59.9	95	53	55.8	4 929	2 954	59.9
Coquimbo	607 703	447 298	73.6	68	41	60.3	5 105	3 758	73.6
Valparaíso	5 376 561	835 488	15.5	137	67	48.9	53 000	9 797	18.5
Metropolitan	1 752 758	1 034 532	59.0	148	51	34.5	15 934	8 803	55.2
North-centre macrozone	9 089 402	3 429 432	37.7	555	317	57.1	85 400	31 700	37.1
O'Higgins	168 148	155 314	92.4	41	29	70.7	12 444	11 582	93.1
Maule	138 425	31 158	22.5	62	13	21.0	12 013	3 135	26.1
Biobío	85 472	14 729	17.2	16	9	56.3	5 863	0 990	16.9
Araucanía	862 022	122 876	14.3	134	54	40.3	64 439	12 576	19.5
Centre-south macrozone	1 254 067	324 076	25.8	253	105	41.5	94 758	28 282	29.8
Los Ríos	146 136	111 672	76.4	101	71	70.3	22 026	16 630	75.5
Los Lagos	161 090	82 664	51.3	52	34	65.4	28 795	11 466	39.8
Aysén	932 360	893 332	95.8	21	7	33.3	145 498	139 917	96.2
Magallanes	284 504	53 105	18.7	86	31	36.0	48 656	10 552	21.7
South-far south macrozone	1 524 089	1 140 772	74.8	260	143	55.0	244 975	178 565	72.9
Total	*11 867 558*	*4 894 280*	*41.2*	*1 068*	*565*	*52.9*	*425 133*	*238 547*	*56.1*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 8

Total regional non-use fees charged and paid, consumptive rights, 2009

Region	Fees (*dollars*)			Number of rights (*units*)			Flow (*m³/s*)		
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid	Percentage
Arica y Parinacota	35 871	13 253	36.9	6	4	66.7	0 508	0 198	39.0
Tarapacá	129 646	115 123	88.8	27	24	88.9	1 089	0 967	88.8
Antofagasta	726 190	724 047	99.7	84	83	98.8	6 125	6 107	99.7
Atacama	606 220	346 881	57.2	109	51	46.8	5 359	2 914	54.4
Coquimbo	516 455	241 057	46.7	58	33	56.9	4 339	2 025	46.7
Valparaíso	1 421 693	644 577	45.3	181	72	39.8	14 852	6 784	45.7
Metropolitan	1 688 064	525 992	31.2	163	46	28.2	15 390	4 461	29.0
North-centre macrozone	5 124 138	2 610 930	51.0	628	313	49.8	47 663	23 457	49.2
O'Higgins	153 158	133 483	87.2	44	26	59.1	11 421	10 021	87.7
Maule	191 522	81 816	42.7	60	13	21.7	23 815	14 896	62.5
Biobío	152 559	29 969	19.6	27	14	51.9	10 371	2 133	20.6
Araucanía	851 927	102 654	12.0	187	41	21.9	63 266	9 499	15.0
Centre-south macrozone	1 349 166	347 922	25.8	318	94	29.6	108 873	36 548	33.6
Los Ríos	254 224	173 932	68.4	214	121	56.5	38 196	26 275	68.8
Los Lagos	204 346	48 331	23.7	151	46	30.5	28 965	6 629	22.9
Aysén	933 759	891 431	95.5	25	5	20.0	146 024	139 150	95.3
Magallanes	276 200	18 379	6.7	79	16	20.3	47 175	3 114	6.6
South-far south macrozone	1 668 529	1 132 073	67.8	469	188	40.1	260 360	175 169	67.3
Total	*8 141 833*	*4 090 926*	*50.2*	*1 415*	*595*	*42.0*	*416 895*	*235 174*	*56.4*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

Where non-consumptive water rights are concerned, the percentage of fees charged that is actually paid is high in all regions, and the fee calculation constants (see equation (2)) are not a determining factor. With non-consumptive rights, furthermore, unlike consumptive ones, the largest fee amounts are charged in the centre-south and south-far south macrozones (see tables 9, 10 and 11), for two reasons:

(i) whereas consumptive and non-consumptive rights that were originally less than 10 and 100 l/s, respectively, are exempt from fee payment in the north-centre macrozone, in the other macrozones these values are 50 and 500 l/s, so that a larger number of rights are excluded from the payment list from the O'Higgins Region southward; and

(ii) non-consumptive rights, predominantly used for hydroelectricity, are concentrated in southern Chile, where the conditions for generating this type of power are better than in the north.

Lastly, one thing that might explain the almost 100% take from fees on non-consumptive rights (see tables 9, 10 and 11) is the considerable economic power of the owners of rights of this type (mainly hydroelectric companies and their investors), whereas the owners of consumptive rights operate in different sectors and have differing levels of financial capacity (see tables 12 and 13).

TABLE 9

Total regional non-use fees charged and paid, non-consumptive rights, 2007

Region	Fees *(dollars)*			Number of rights *(units)*			Flow *(m³/s)*		
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid	Percentage
Arica y Parinacota	–	–	–	–	–	–	–	–	–
Tarapacá	–	–	–	–	–	–	–	–	–
Antofagasta	–	–	–	–	–	–	–	–	–
Atacama	–	–	–	–	–	–	–	–	–
Coquimbo	6 064	6 064	100.0	1	1	100.0	19 000	19 000	100.0
Valparaíso	185 813	185 813	100.0	6	6	100.0	19 525	19 525	100.0
Metropolitan	1 324 214	1 317 923	99.5	41	38	92.7	329 632	326 223	99.0
North-centre macrozone	1 516 091	1 509 800	99.6	48	45	93.8	368 157	364 748	99.1
O'Higgins	637 869	522 966	82.0	22	20	90.9	178 766	126 766	70.9
Maule	3 328 385	3 295 027	99.0	29	24	82.8	695 142	675 225	97.1
Biobío	223 422	223 422	100.0	14	14	100.0	262 997	262 997	100.0
Araucanía	687 409	618 827	90.0	56	48	85.7	481 729	362 929	75.3
Centre-south macrozone	4 877 084	4 660 241	95.6	121	106	87.6	1 618 634	1 427 918	88.2
Los Ríos	2 643 369	2 637 565	99.8	85	83	97.6	1 197 965	1 195 969	99.8
Los Lagos	4 209 094	4 173 071	99.1	67	55	82.1	1 548 904	1 518 253	98.0
Aysén	116 026	114 771	98.9	8	6	75.0	219 623	209 064	95.2
Magallanes	6 861	5 313	77.4	15	10	66.7	20 754	16 251	78.3
South-far south macrozone	6 975 349	6 930 720	99.4	175	154	88.0	2 987 246	2 939 537	98.4
Total	*13 368 525*	*13 100 762*	*98.0*	*344*	*305*	*88.7*	*4 974 037*	*4 732 202*	*95.1*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 10

Total regional non-use fees charged and paid, non-consumptive rights, 2008

Region	Fees (dollars)			Number of rights (units)			Flow (m^3/s)		
	Charged	Paid	Percentage	Liable	Paid	Percentage	Liable	Paid	Percentage
Arica y Parinacota	–	–	–	–	–	–	–	–	–
Tarapacá	–	–	–	–	–	–	–	–	–
Antofagasta	–	–	–	–	–	–	–	–	–
Atacama	–	–	–	–	–	–	–	–	–
Coquimbo	6 064	6 064	100.0	1	1	100.0	19 000	19 000	100.0
Valparaíso	186 917	93 252	49.9	7	6	85.7	19 710	12 710	64.5
Metropolitan	2 276 787	2 267 453	99.6	50	45	90.0	458 745	454 507	99.1
North-centre macrozone	2 469 768	2 366 769	95.8	58	52	89.7	497 455	486 216	97.7
O'Higgins	1 170 448	1 169 585	99.9	38	37	97.4	281 608	280 906	99.8
Maule	3 347 907	3 327 924	99.4	32	26	81.3	699 550	678 134	96.9
Biobío	1 455 336	1 041 819	71.6	32	27	84.4	634 520	500 707	78.9
Araucanía	1 145 818	1 049 429	91.6	82	60	73.2	1 157 908	998 526	86.2
Centre-south macrozone	7 119 510	6 588 757	92.5	184	150	81.5	2 773 587	2 458 272	88.6
Los Ríos	2 951 593	2 915 768	98.8	125	103	82.4	1 995 057	1 948 879	97.7
Los Lagos	4 235 675	4 212 171	99.4	104	77	74.0	1 608 296	1 550 983	96.4
Aysén	122 739	118 909	96.9	9	6	66.7	223 793	208 515	93.2
Magallanes	701	701	100.0	6	6	100.0	6 171	6 171	100.0
South-far south macrozone	7 310 708	7 247 548	99.1	244	192	78.7	3 833 317	3 714 549	96.9
Total	*16 899 986*	*16 203 075*	*95.9*	*486*	*394*	*81.1*	*7 104 360*	*6 659 038*	*93.7*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 11

Total regional non-use fees charged and paid, non-consumptive rights, 2009

Region	Fees (dollars)			Number of rights (units)			Flow (m^3/s)		
	Charged	Paid	Percentage	Charged	Paid	Percentage	Charged	Paid	Percentage
Arica y Parinacota	–	–	–	–	–	–	–	–	–
Tarapacá	1 107	–	–	1	–	–	0 150	–	–
Antofagasta	–	–	–	–	–	–	–	–	–
Atacama	–	–	–	–	–	–	–	–	–
Coquimbo	6 064	6 064	100.0	1	1	100.0	19 000	19 000	100.0
Valparaíso	100 022	99 967	99.9	5	4	80.0	7 932	7 710	97.2
Metropolitan	2 327 341	2 319 171	99.6	55	51	92.7	467 745	464 447	99.3
North-centre macrozone	2 434 534	2 425 203	99.6	62	56	90.3	494 828	491 156	99.3
O'Higgins	1 083 655	1 073 045	99.0	37	35	94.6	279 956	277 268	99.0
Maule	3 369 928	3 369 069	100.0	31	29	93.5	700 510	697 010	99.5
Biobío	1 740 568	1 519 655	87.3	49	41	83.7	1 273 248	1 132 618	89.0
Araucanía	1 610 266	1 181 803	73.4	129	72	55.8	1 433 868	1 061 545	74.0
Centre-south macrozone	7 804 416	7 143 573	91.5	246	177	72.0	3 687 582	3 168 441	85.9
Los Ríos	3 026 896	3 005 939	99.3	132	111	84.1	2 007 726	1 947 329	97.0
Los Lagos	4 293 016	4 229 998	98.5	139	73	52.5	1 609 799	1 508 401	93.7
Aysén	122 834	121 484	98.9	10	8	80.0	223 793	213 235	95.3
Magallanes	389	306	78.8	2	1	50.0	3 383	1 870	55.3
South-far south macrozone	7 443 134	7 357 727	98.9	283	193	68.2	3 844 702	3 670 836	95.5
Total	*17 682 085*	*16 926 502*	*95.7*	*591*	*426*	*72.1*	*8 027 112*	*7 330 434*	*91.3*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 12

Owners of water rights liable to the highest non-use fees, 2010

Ranking	Owner	Sector	Fees *(dollars)*	Number of rights *(units)*	Flow *(m³/s)*
1	ENDESA S.A.	Hydroelectricity	6 478 281	17	1 575 05
2	AES Gener S.A.	Hydroelectricity	3 549 024	58	1 156 32
3	Colbún S.A.	Hydroelectricity	1 771 140	22	1 514 02
4	CGE Generación S.A.	Hydroelectricity	1 183 343	16	495 53
5	Hidroeléctrica Trayenko S.A.	Hydroelectricity	1 085 390	46	259 52
6	Inversiones Arlequín Ltda.	Investment	549 584	11	13 51
7	CODELCO	Mining	378 603	22	7 55
8	Hidroeléctrica La Higuera S.A.	Hydroelectricity	286 177	13	65 60
9	Exploraciones, Inversiones y Asesorías Huturi S.A.	Investment	274 127	29	120 19
10	Hidroeléctrica La Confluencia S.A.	Hydroelectricity	233 485	8	59 20
11	Exploraciones, Inversiones y Asesorías Mundo S.A.	Investment	121 658	15	1 02
12	Forestal Valdivia S.A.	Forestry	118 157	10	14 75
13	Álvaro Flaño García	Natural person	77 252	10	66 12
14	Maderera Panguipulli S.A.	Forestry	49 119	12	50 41
15	Eléctrica Panguipulli S.A.	Hydroelectricity	38 565	11	94 85
Total			*16 193 906*	*300*	*5 493 66*
Share of total			52.0%	10.0%	51.6%

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

TABLE 13

Total non-use fees charged by sector, 2010

Sector	Fees *(dollars)*	Percentage	Number of rights *(units)*	Percentage	Flow *(m³/s)*	Percentage
Natural persons	4 068 945	13.1	1 329	44.3	1 345.3	12.6
Agriculture	1 583 207	5.1	376	12.5	904.6	8.5
Fishing and aquaculture	78 534	0.3	90	3.0	157.3	1.5
Mining	897 647	2.9	163	5.4	15.3	0.1
Forestry	561 805	1.8	78	2.6	239.3	2.2
Hydroelectricity	18 187 182	58.4	279	9.3	7 544.7	70.9
Sanitary services	712 931	2.3	98	3.3	14.8	0.1
Real estate	319 953	1.0	83	2.8	19.5	0.2
Non-profit organizations	60 870	0.2	40	1.3	6.5	0.1
Other legal entities	4 650 271	14.9	466	15.5	396.2	3.7
Total	*31 121 345*	*100.0*	*3 002*	*100.0*	*10 643.5*	*100.0*

Source: prepared by the authors on the basis of Department of Water (DGA), *Bases de datos del listado de derechos de aprovechamiento de aguas afectos a pago de patente por no uso, procesos 2007 a 2010*, Santiago, Chile, Ministry of Public Works (MOP), 2010.

2. The market price of rights relative to non-use fees

Estimates of average market prices for consumptive rights yield very varied results in the different regions. When these figures are compared with a non-use fee differentiated into three macrozones of application, disparities are found in the number of years of fee payment that would be required to exceed the average market price of rights. Whereas in the Arica y Parinacota, Coquimbo, Valparaíso, Metropolitan, Los Lagos and Magallanes regions the number of years of cumulative fee payment needed to exceed the average market price ranges from 18 to 22, in Antofagasta and Atacama the period is about 100 years (see table 14). This situation is ultimately reflected in differences in willingness to pay, since the non-use fee will be a smaller burden for owners who are being charged a fee representing only a tiny fraction of the price their rights could command in the marketplace than for those who are having to pay a fee representing a substantial percentage of the price of their rights, something that can be observed by contrasting the payment percentages in tables 6, 7 and 8 with the data in table 14.

For non-consumptive rights, data were obtained on just eight transactions that could be used to calculate the equivalent fee. Although there are considerable price differences, it is difficult to make a comparison on this basis, as the rights traded differ in a number of respects such as flow, exercise and height difference between the extraction and return points. Nonetheless, the number of years of fee payment needed to exceed the transaction price allows the differences to be contrasted (see table 15). Having isolated market prices rather than average ones as with consumptive rights makes it difficult to use criterion C to assess whether the fee for non-consumptive rights is sufficient to discourage non-use. However, it would take over two centuries of fee payment to match the prices that some rights of this kind would go for in the market, which appears to support the idea that the design of the non-use fee has been lax where non-consumptive rights are concerned.

TABLE 14

Estimated market price and cumulative regional non-use fees for permanent, continuous consumptive rights of 50 l/s

Region	Estimated average market price *(dollars)*	Cumulative fees *(dollars)*								Years of fee payment needed to exceed price
		Year 1	Percentage	Year 5	Percentage	Year 10	Percentage	Year 15	Percentage	
Arica y Parinacota	262 177	5 952	2.3	29 760	11.4	89 280	34.1	208 319	79.5	18
Tarapacá	1 472 769	5 952	0.4	29 760	2.0	89 280	6.1	208 319	14.1	69
Antofagasta	2 182 564	5 952	0.3	29 760	1.4	89 280	4.1	208 319	9.5	98
Atacama	2 481 823	5 952	0.2	29 760	1.2	89 280	3.6	208 319	8.4	111
Coquimbo	337 036	5 952	1.8	29 760	8.8	89 280	26.5	208 319	61.8	21
Valparaíso	307 981	5 952	1.9	29 760	9.7	89 280	29.0	208 319	67.6	20
Metropolitan	274 622	5 952	2.2	29 760	10.8	89 280	32.5	208 319	75.9	18
O'Higgins	145 904	744	0.5	3 720	2.5	11 160	7.6	26 040	17.8	56
Maule	115 638	744	0.6	3 720	3.2	11 160	9.7	26 040	22.5	46
Biobío	85 880	744	0.9	3 720	4.3	11 160	13.0	26 040	30.3	36
Araucanía	50 095	744	1.5	3 720	7.4	11 160	22.3	26 040	52.0	24
Los Ríos	43 091	372	0.9	1 860	4.3	5 580	12.9	13 020	30.2	36
Los Lagos	22 485	372	1.7	1 860	8.3	5 580	24.8	13 020	57.9	22
Aysén	54 264	372	0.7	1 860	3.4	5 580	10.3	13 020	24.0	43
Magallanes	19 182	372	1.9	1 860	9.7	5 580	29.1	13 020	67.9	20

Source: prepared by the authors on the basis of Department of Water (DGA), *Base de datos de transacciones de derechos de aprovechamiento a diciembre de 2009 informadas por los Conservadores de Bienes Raíces*, Santiago, Chile, Ministry of Public Works (MOP), 2009 [online] http://www.dga.cl/administracionrecursoshidricos/cbr/Documents/2registrosmodificadoscbr.xls and *Listado de remates de derechos de aprovechamiento de aguas realizados para situaciones en que dos o más solicitudes se contraponen*, Santiago, Chile, Ministry of Public Works (MOP), 2010; José Pedro Gallo, *Listado de remates de derechos de aprovechamiento de aguas realizados*, Santiago, Chile, Remates Fernando Zañartu Rozas y Cía. Ltda., 2010; and Ministry of Public Works (MOP), *Ley N° 20.017: Modifica el Código de Aguas*, Santiago, Chile, 2005 [online] http://www.leychile.cl/Navegar?idNorma=239221.

TABLE 15

Market transactions and cumulative non-use fees for non-consumptive rights

Transaction type	Flow *(m^3/s)*	Head height *(metres)*	Price *(thousands of dollars)*	Cumulative fees *(thousands of dollars)*								Years of fee payment needed to exceed price
				Year 1	Percentage	Year 5	Percentage	Year 10	Percentage	Year 15	Percentage	
Auction 6 participants	3 P/CS; 11 CT/CS	200	34 340	34	0.1	168	0.5	503	1.5	1 174	3.4	263
Auction 8 participants	75 P/CS; 81 CT/CS	139	47 630	349	0.7	1 747	3.7	5 240	11.0	12 226	25.7	41
Auction 1 participant	29 P/D; 72 CT/CS	37	625	48	7.7	241	38.5	722	115.5	1 685	269.4	9
Auction 0 participants	130 P/CS	54	1 383	172	12.5	862	62.3	2 585	187.0	6 032	436.3	7
Contract of sale	5 P/CS	10	1 259	1	0.1	6	0.4	17	1.3	39	3.1	292
Contract of sale	2 P/CS	14	699	1	0.1	3	0.5	10	1.5	24	3.4	261
Contract of sale	2 P/CS	10	165	0	0.2	2	1.1	6	3.4	13	7.8	118
Contract of sale	80 P/CS	200	3 448	393	11.4	1 964	57.0	5 892	170.9	13 749	398.8	7

Source: prepared by the authors on the basis of Department of Water (DGA), *Base de datos de transacciones de derechos de aprovechamiento a diciembre de 2009 informadas por los Conservadores de Bienes Raíces*, Santiago, Chile, Ministry of Public Works (MOP), 2009 [online] http://www.dga.cl/administracionrecursoshidricos/cbr/Documents/2registrosmodificadoscbr.xls and *Listado de remates de derechos de aprovechamiento de aguas realizados para situaciones en que dos o más solicitudes se contraponen*, Santiago, Chile, Ministry of Public Works (MOP), 2010; José Pedro Gallo, *Listado de remates de derechos de aprovechamiento de aguas realizados*, Santiago, Chile, Remates Fernando Zañartu Rozas y Cía. Ltda., 2010; and Ministry of Public Works (MOP), *Ley N° 20.017: Modifica el Código de Aguas*, Santiago, Chile, 2005 [online] http://www.leychile.cl/Navegar?idNorma=239221.

Note: Right exercised: P = permanently; CT = contingently; CS = continuously; D = discontinuously.

As the Introduction explains, the goal of the non-use fee is not to raise revenue but to ensure that water is actually used. This means that in Chile the State prefers the owners of unused water rights to take up one of the following five options instead of paying the non-use fee: not pay the fee and lose the right at a public auction, or surrender, sell, rent or make effective use of the right (or, strictly, build extraction and return facilities as appropriate). It is reasonable to think that, with each year that passes, owners of unused water rights will be less willing to pay the fee than they were the year before. That said, something that is helpful for the analysis is to know the years in the fee charging process when owners ought to become more willing to take one of the five courses described in order to exit the list. Given the design of the non-use fee, these should be:

(i) the first year, as the owner might simply be unwilling to pay a fee;
(ii) the sixth, as it is the first year in which the value of the fee doubles, increasing the likelihood that the owner of an unused right will be unwilling to pay. Furthermore, where consumptive water rights are concerned, all fees paid are recovered if extraction facilities are built that year, which is not the case in the seventh, eighth and subsequent years, when fees paid during the first, second and subsequent years, respectively, will be forfeited for good if these facilities are constructed, since for rights of this type only fees paid in the previous five years are refunded once the facilities are built;
(iii) the ninth year for non-consumptive rights, as for this type of rights only payments made in the previous eight years are refunded once extraction and return facilities have been built; and
(iv) the eleventh year, as this is the first time the fee quadruples relative to the first year it is charged, once again increasing the likelihood that the owner of an unused water right will be unwilling to pay.

Although these years mark milestones in the charging process that increase the incentive for the effective water use promoted by the non-use fee, it can be seen that the number of years of payment needed to exceed the average market price for consumptive rights (see table 14) is over 11 (the last year that represents a milestone in the charging process) in all regions, albeit with striking differences, which means that the fee cannot be expected to disincentivize ownership of unused consumptive rights in the short run. Nonetheless, as discussed earlier, some very substantial water rights have exited the list, which is a reason to think that the fee could improve its short-term performance for rights of this type.

For non-consumptive water rights, by contrast, there are cases where the number of years of fee payment needed to exceed transaction prices is less than 11, but there are others where it is a multiple of this, with centuries of payment sometimes being required to exceed the transaction price (see table 15). In the light of the early tendencies observed in the level of fee payment, these latter cases indicate that the non-use fee will not meet its objective in the short run where rights of this kind are concerned.

3. Fee evasion mechanisms

Fee evasion mechanisms have their origins in the very design of the non-use fee and in the original 1981 Water Code, which does not allow the work of promoting effective and beneficial use to be carried out by way of a straightforward correction that can be implemented via a non-use fee, this being in reality a fee for non-construction of facilities. There are two main mechanisms: non-registration of water rights with the property registry, and the building of facilities without effective use.

(a) Non-registration of water rights with the property registry (Conservador de Bienes Raíces—CBR)

There are cases in which it has not been possible to carry out auctions for non-payment of the fee because many rights are not duly registered with the CBR, making it legally impossible to conduct the auction (Vásquez, 2010). The number of water rights liable to the non-use fee that are not registered with the CBR is estimated at about 1,000, or some 30% of all rights liable to the non-use fee in 2010 (Riestra, 2010). The impossibility of auctioning off a substantial portion of water rights stands in the way of the objectives the fee was meant to achieve, for while the Code makes CBR registration compulsory, it does not establish any penalties for non-registration (Riestra, 2009b) and, furthermore, it recognizes the existence of unregistered rights both in its article 181 and in its provisional article 2. This unresolved situation has led some specialists to suggest that there ought to be a property right guarantee involving an administrative process whereby rights expire or are extinguished or terminated if not registered with the CBR (Schulbach, 2010).

Perversely, rights that cannot be auctioned because they are not registered with the CBR have sometimes prevented rights that are registered from being auctioned, as some judges prefer to auction off the whole list of rights at once (Riestra, 2009b).

(b) *Construction of facilities without effective use*

The State water authority knows of cases in which water extraction facilities have been built for consumptive rights with the sole object of avoiding fee payment, without any effective and beneficial use existing, a situation much like the one predicted by some authors before the 2005 reform to the 1981 Water Code was passed (Paredes and Gómez-Lobo, 2000; Domper, 2003).

It is actually easy to set up installations that simulate groundwater extraction, with rights owners installing diesel engines so that they can give inspectors an explanation for the lack of electricity at the time of the inspection while claiming that they are using the water, when in fact these are dummy installations set up only to avoid paying the fee (Proschle, 2010).

As regards surface water, Riestra (2010) states that cases of intakes leading nowhere have been discovered; since these works were approved by the Department of Water, no fee could be charged on them for the first two years (2007 and 2008). There is a Supreme Court ruling (2010) covering these groundwater situations, but the reinspection process is currently slow.

The kind of dummy installations described have not been detected in the case of non-consumptive rights. As predicted by Jara and Melo (2003), it is unlikely that superfluous works would be built to emulate the exercise of water rights of this kind, since they are subject to the regulatory oversight of the State in the case of hydroelectric installations. Furthermore, the extraction and return installations needed to exercise non-consumptive rights are usually much costlier than extraction facilities for the exercise of consumptive water rights.

Lastly, the operation of this fee evasion mechanism, which is almost exclusive to consumptive rights, could be one of the factors explaining why more rights of this type than non-consumptive rights have exited the fee payment list.

IV
Conclusions

Following this analysis of the results of applying the non-use fee in its first four years, the conclusion is that the disincentive to ownership of water rights without effective use is still not working well, for several reasons. One is that all fee charging rounds have seen payment levels of over 67%, and rising. Nonetheless, this could change if owners begin to make effective use of their rights, with the fees they have paid being refunded to them so that the take falls closer to zero. Furthermore, the effort to do away with hoarding and speculation looks weak in the initial stage because non-use fees would have to be paid for a number of years before the market price of water rights was exceeded, a consideration which suggests that fee payment percentages will remain high in the short run.

Another consideration is that, in practice, water is being kept available for the benefit of those who have the economic power to pay the fee and not exactly those who need the water and have plans for effective and beneficial use. This means that the competition for water use is favouring those who are in a position to delay their investments by paying the non-use fee, i.e., a subset of the universe of potential water users.

As for rights being surrendered, while there have been cases of this, they have been few (22) compared to the total number of water rights on the list, and only three have been substantial in terms of the fees they represent. The infrequency with which this happens may be due to the fact that the owners being charged would in theory be willing to accept any price higher than the non-use fee rather than just give up their rights, and indeed it is never in their interests to surrender a water right, as it will always be better to wait for it to be auctioned and then receive any surplus from the selling price.

Fees for consumptive rights present substantial geographical differences. The constants that were set to differentiate fees by macrozone within the country have proven to be insensitive to local realities, with equal treatment being given to basins that differ in their hydrological conditions and optimum use, the result being that owners' behaviour differs by latitude and, in consequence, that fees are giving better results within a single macrozone in regions where water rights are cheaper (or water is more abundant).

Again, fees are much less burdensome for non-consumptive rights than for consumptive rights. This is demonstrated by the fact that fee payment percentages for the former have been in excess of 95% in all rounds. Furthermore, there is empirical evidence that rights of this type are drifting towards hydroelectric companies, which have no financial difficulty in paying the fee. While it might be thought that the unused water rights which still exist remain unused because they are valued by their respective owners and will soon be put to use, it is also possible to infer, particularly in the case of non-consumptive rights, that it may suit some groups to keep these rights unused in order to prevent new actors from moving into their markets and maintain oligopolies.

This suggests that the efficiency of the non-use fee is likely to improve over time in the case of consumptive rights, the fees for which have proved harder to afford than fees for non-consumptive rights.

The aim of favouring rational use of water resources is coming up against owners' fear of losing their water rights, an apprehension that in some cases has led to facilities being constructed purely to avoid paying the fee. This is an ambiguity that could be resolved by court rulings. Regarding non-registration of water rights with the CBR, the conclusion is that this is a severe enough problem to warrant legal amendments to the Water Code.

The path of "charging for non-use of water" that was taken in Chile is a remarkable one, an approach based on water abundance that contrasts with an international context where the scarcity approach predominates in the form of "charging for water use (or possession)". The fact that the path chosen is unusual makes ex post evaluation of the legislation particularly important since without it, in the absence of comparable international experience, future amendments to the law will only be justified once any undesirable effects have actually arisen.

It is relevant to ask if any politically feasible alternative to charging for non-use might have been better. The requirement of effective and beneficial use, a universal criterion in water regulations, was a better option than the non-use fee; however, the only direct method of applying it in Chile would be for unused water rights to be voided, and this was not politically feasible. Charging for use or ownership of water is not exactly an alternative to the non-use fee, but rather a compatible and complementary instrument; furthermore, it is a long-term initiative that is very hard to design and does not meet the core objective of the non-use fee (Comisión de Hacienda del Senado, 2000; Comisión de Obras Públicas del Senado, 2004, both cited by Valenzuela, 2009). Efforts to improve water legislation are controversial and are confined to the small sphere of action in which public policy can operate. This can be put down to the conflicts of interests in which water resources are embroiled, with disputes between the different actors often being a "dialogue of the deaf" that is not conducive to consensus. Again, among other reasons, what some consider to be errors in the legislation are a source of opportunity for others. Given this logic, establishing the non-use fee was an imaginative response to a problem that had no easy solutions (Valenzuela, 2009).

(i) A more obvious politically feasible alternative is to improve the non-use fee now that it has been established. Its design could be improved by applying it to basins and aquifers instead of political and administrative regions, thus avoiding situations in which changes in extraction points or the transfer of water rights from one region to another (i.e., when a water source straddles a boundary and is in two regions at once) lead to fees lower than those originally charged.

(ii) The value of the macrozonal constants used to calculate fees should be determined on the basis of the market price of water rights given that, under the methodologies originally employed, use was made of information from just one production sector per type of water right, namely sanitary service firms for consumptive rights (Peña, 1999, cited by Valenzuela, 2009) and hydroelectric firms for non-consumptive rights (CNE, 1997, cited by Valenzuela, 2009), which skewed the analysis and the subsequent calculation of the amounts to be charged.

(iii) The progressiveness of the non-use fee for non-consumptive rights should be as originally proposed in the parliamentary debate, i.e., the fee should be multiplied by 5 in the sixth to tenth years and by 25 from the eleventh year onward, as the measure appears to have had little effect for rights of this kind.

(iv) The values of exempt flows should be applied as a discount to non-exempt flows. Under the present system, for example, a permanent, continuous consumptive right of 10.1 l/s in the north-centre macrozone is liable to the non-use fee, while a right with the same characteristics but a flow of 9.9 l/s is exempt.

(v) The calculation equation should include a flat amount to cover the administration costs to the State of applying the non-use fee, given that the inclusion of some rights on the lists entails large costs for the public sector relative to their importance for economic development.

(vi) Any water rights belonging to any State agency should be exempt from fee payment, but if they pass to a private owner then the arrears of fees for all the years in which the right was left unused should become payable by the State agency. This would prevent the State from charging itself fees when it held rights for strategic purposes and had no intention of transferring them, as with rights belonging to the Chilean army (military purposes) and the Municipality of Pucón (for the purposes of conservation to encourage tourism). Although the Water Code provides for such situations with its categories of reserve flows and ecological flows, it is on condition that these do not affect the rights of third parties, and they have to be approved by the President of the Republic. Furthermore, ecological flows are limited to a set amount.

(vii) Any right that is inalienable, and thus cannot be the object of speculation, should be exempted from fee payment, examples being those acquired in the name of indigenous communities through the Indigenous Land and Water Fund of the National Indigenous Development Corporation (CONADI). This is in consideration of the fact that if these fees are charged but not paid, the water rights associated with them can still not be auctioned or redistributed, so that it is arguably pointless to incur all the costs of these proceedings.

(viii) Rights subject to the non-use fee that are not registered with the Public Water Registry held by the Department of Water should expire within a set time period following notification of this measure. This would prevent evasion of the non-use fee. Likewise, even leaving the matter of the fee aside, it would be advisable for any water rights not so registered to be liable to a fine unless the registration procedure is carried out within a set time; this would solve a recurrent problem with the Public Water Register, whose picture of water rights tends to be out of date.

Lastly, it is worth considering whether the non-use fee has meant greater pressure on water resources. In theory it has, because the fee promotes water use, something that may be a problem in drier areas, where measures ought to aim at reducing extraction. In practice, however, what has happened to date is that fees on less abundant aquifers have usually been paid so that the pressure implied by the non-use fee has yet to be explicitly manifested, although this could change as time passes and fees progressively rise. The ideal outcome would be for organizations of users who take water from less abundant aquifers (which in many cases have yet to be formed) to take the steps necessary to meet two fee payment exemption conditions specially designed for situations of this type: alternation or proportional sharing of water rights, and the absence of circumstances, acts or agreements that prevent, restrict or hinder free competition in their area. Success in doing so will necessarily depend on the support and management capacity these organizations acquire.

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Desde 2013 el Observatorio aparece una vez al año. Valor por ejemplar: US$ 15.

Bilingual publication (Spanish and English) proving up-to-date estimates and projections of the populations of the Latin American and Caribbean countries. Also includes various demographic indicators of interest such as fertility and mortality rates, life expectancy, measures of population distribution, etc.

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Specialized journal which publishes articles and reports on recent studies of demographic dynamics in the region, in Spanish with abstracts in Spanish and English. Also includes information on scientific and professional activities in the field of population.

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