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The impact of sectoral heterogeneities in economic growth and catching up: empirical evidence for Latin American manufacturing industries

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The Impact of Sectoral Heterogeneities in Economic Growth and Catching Up: Empirical Evidence for Latin American Manufacturing Industries[=]

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December 2011

Abstract

Building on different strands of literature this paper proposes an approach to characterize the structural patterns followed by the manufacturing sector of Latin American largest economies –Argentina, Brazil and Mexico– during the last decades. The main focus of this approach relies on the evolution of technological gaps with the world frontier. Measures of relative labour productivity with respect to the US (as a proxy for technological gaps) are used to identify industries with different degrees of modernity and to analyze their distribution in different points of time in order to establish stylized patterns in their structural trajectories.

The empirical analysis provides evidence supporting the hypothesis that the economies of the region are characterized by high and persistent sectoral heterogeneities. Moreover, it suggests that the manufacturing sector of these economies had followed a trajectory of partial catching-up with structural polarization. In short, these economies are lagging behind at the aggregate manufacturing level, but show very heterogeneous trends within their own structures. While a small fraction of industries seems to be using technologies close to the frontier or has managed to achieve fast reductions in the technological gap, the remaining industries are far away from the technological frontier and keep lagging further behind.

Keywords: Latin America; Manufacturing; Structural change; Catching-up

JEL Classification: L16 (Industrial Structure and Structural Change); O14 (Industrialization); N66 (Manufacturing and Construction in Latin America).

[=] This paper is a part of my Ph.D dissertation, which aims at studying Latin American industrial dynamics in the last half century. I sincerely thank Prof. Adam Szirmai for providing several useful comments and insights during the preparation of this paper.

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1 Introduction

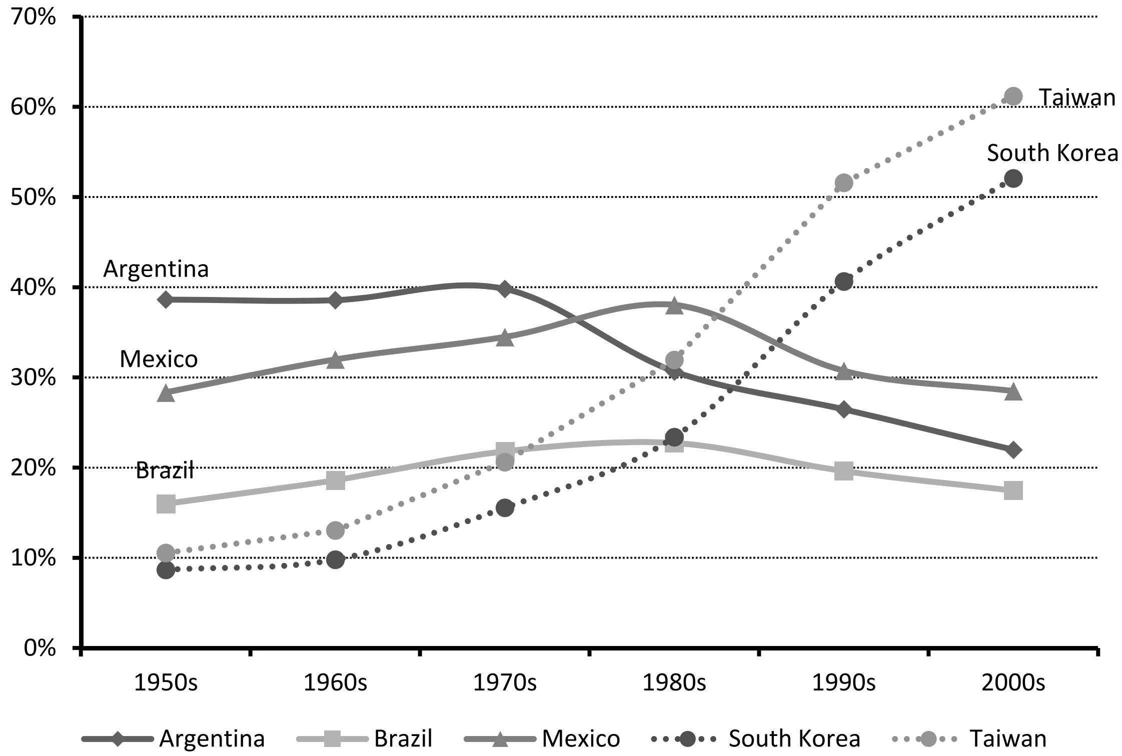
By the middle of the twentieth century Latin America was seen by many development scholars as the next emerging region of the world. Twenty years later, in the late 1970s, the three largest economies of the region –Argentina, Brazil and Mexico– were generally bracketed together with the East Asian Tigers –Hong Kong, Singapore, South Korea and Taiwan– as the newly industrialized countries (NICs).

In the subsequent decades, however, each group of countries followed an extremely different trajectory[2]. While the Latin American economies witnessed a sharp increase in their income gaps with the most developed nations, the Asian Tigers managed to achieve significant reductions in their own gaps, becoming –by the turn of the century– members of the *selected club* of advanced economies.

The evolution of GDP per capita relative to the US during the last six decades is illustrative in this respect. As it can be seen in Figure 1, until the 1970s, the three largest economies of Latin America had a relative GDP per capita that was higher than that of the largest Asian Tigers. In the following decades, however, this situation is reversed. While the relative income of the three Latin American economies drops dramatically, ending up at similar (or even lower, in the case of Argentina) levels than in the fifties, the relative GDP per capita in the Asian economies keeps expanding at a fast pace, reaching by the 2000s a level six times larger than in the fifties.

[2] This has been extensively documented by many authors. See for example, Amsden (1989), Dosi et al. (1994) and Gereffi and Wyman (1990).

Figure 1. Relative GDP per capita (US=100%). 10-years averages between 1950 and 2010. Argentina, Brazil, Mexico, South Korea and Taiwan.



Source: Own calculations based on The Conference Board Total Economy Database, September 2011. GDP per capita in 2010 US$ (converted to 2010 price levels with updated 2005 EKS PPPs)

The growing divergence in terms of per capita income levels with the developed world has been, therefore, one of the greatest sources of frustration regarding Latin American economic performance during the last decades. This aggregate performance, however, hides some important features of the development process followed by these economies. Recent contributions have remarked the increasing sectoral heterogeneity that characterize the countries of the region, where a small number of modern and highly productive sectors coexists alongside a set of very low productive activities (ECLAC, 2007b, Cimoli, 2005, Cimoli et al., 2005). In this context, the aforementioned divergence seems to reflect the failure of modern activities to either extend their share in GDP and become dominant or pull the rest of the economy into a process of generalized catching-up. A deep understanding of these structural trends and their implications in the long-run development of the region is the main concern of our research.

As an starting point to address this issue, this paper presents an empirical study of the industrial trajectories followed by the largest economies of the region during the last four decades with special focus on the evolution of technology gaps, both at the aggregate and disaggregate level. This study seeks to examine the extent and persistence of sectoral heterogeneities within manufacturing and their impact on productivity growth and catching-up.

2 Conceptual Framework

The conceptual framework of this paper combines two major strands of literature. On one hand, it follows the scholars embedded in the technology gap literature[3] and considers technological differences as the prime cause of disparity in per capita growth across countries. Hence, development is seen as the process by which countries manage to master frontier technologies at the domestic level and by doing so, reduce the technological gap with the leaders or, eventually, take over that position (Gerschenkron, 1962; Gomulka, 1971; Abramowitz, 1986). This, however, is not taken as a costless nor automatic process. On the contrary, there are specific features that lagging countries should have in order to benefit from its backwardness and achieve catching up. The literature has pointed out – among others– the notions of social capability (Ohkawa and Rosovsky, 1973), national absorptive capacity (Dahlman and Nelson, 1995) and technological congruence (Abramovitz, 1986) to designate those features.

Since our main concern is on sectoral heterogeneities within and between countries, the technology gap approach is complemented with insights from other strand of literature that have stressed the importance of structural differences in the process of economic growth. On one hand, we follow the literature rooted in the Post-Keynesian tradition that states that structural differences across countries may lead to long-run differences in growth rates. In this view, the prospects for technological progress are more favourable in manufacturing than elsewhere, and thus, this sector emerge as the principal engine of growth (Kaldor, 1967; Cornwall, 1977; Szirmai, 2009).

At this point, we will take into consideration the vein opened by those studies which stress the importance of using a disaggregated approach, distinguishing different subsectors within manufacturing (Fagerberg and Verspagen, 1999; Fagerberg, 2000). This paper contributes to this debate by analyzing in detail the different industries that compose manufacturing and the important heterogeneities that arise inside this sector in developing countries. In doing so, we incorporate insights from different contributions that have emphasized the dual character of developing economies, ranging from development pioneers (Chenery, Hirschman, Lewis and Prebisch, among others) to more recent literature on growth accounting (Ranis, 2003; Temple, 2004 and 2005; Vollrath, 2009). We share with these authors the idea that in developing economies potential productivity gains arise from the reallocation of resources from backward to modern sectors.

[3] For an extensive review of this literature, see Fagerberg (1994) and Fagerberg and Godinho (2005).

In our analysis, however, we depart from the traditional concept of duality between rural-agriculture and urban-manufacturing. Instead, we follow some authors rooted in the Neo-Structuralist tradition who, studying the particular case of Latin America, have pointed out that the classic rural-urban duality has been replaced by a new form of structural heterogeneity in which an export-oriented and highly productive group of sectors coexist together with a set of low-productive activities operating mainly for domestic markets (ECLAC, 2007b). Latin America then appears as a sort of polarized economy, where two different sectors with contrasting dynamics of accumulation, production and output growth coexist, and where the leading modern sector emerges as an enclave (Cimoli, et al., 2005). Case studies for different Latin American countries seem to confirm this stylized picture (Cimoli, 2005).

Following this line of argumentation, we claim that the development path followed by Latin American economies during the last decades cannot be fully characterized by the convergence/divergence dichotomy, even though it is clear that these economies have lagged-behind at the aggregate level. Focusing on certain structural characteristics of the manufacturing sector[4], we argue that behind this aggregate trend lies a more complex picture in which sectoral heterogeneities play a fundamental role. In our view, this sort of heterogeneities are reinforced by processes of "partial catching up" in which only a small fraction of the economy manages to narrow the technological gap while the rest of the economy lags further behind.

In the next section, we describe the approach that will guide our analysis in addressing this issue.

3 Approach

Building on the elements detailed on the previous section, we propose an approach to characterize the structural patterns followed by Latin American economies during the last decades. The main focus of this approach relies on the evolution of technological gaps between the countries of the region and the world frontier. By analyzing the technological gaps at sectoral levels we identify the different layers of technological sophistication that can be found within a particular economy. Sectors close to the technological frontier are associated with the technological modernity of the economy while sectors far from it represent the backwardness.

---

[4] Although the empirical part of this paper focuses exclusively on manufacturing industries, the theoretical approach that we propose is described in broader terms so it can be applied for the whole economy as well. In future work we intend to extend our empirical approximation to include the remaining sectors of the economy (primary activities and services).

In this sense, we try to capture the kind of dualities or sectoral heterogeneities that, according to the literature previously reviewed, characterize Latin American countries. Our approach, however, departs from the traditional studies on dual economies because we do not concentrate in productivity differentials across sectors but on the differentials in the distance to the world frontier. In our view, this is a more appropriate way of dealing with this issue. Concentrating exclusively on labour productivity differentials may be misleading given the differences that arise from the very nature of sectors (according, among other elements, to their factor intensity)[5].

The proposed approach is constituted by three consecutive steps of research.

In the first step, we broadly characterize the productive structures of the countries under analysis by focusing in the distribution of sectors according to their distance to the world technological frontier. Moreover, we analyze the movements of these distributions in different points of time and we try to identify stylized patterns in their "structural trajectories".

In the second step, we undertake a more detailed analysis of the sectoral dynamics behind these structural trends. In this sense, we carry out a battery of econometric regressions aimed at testing the catching-up hypothesis at sectoral level. By means of this econometric exercise, we attempt to analyze what empirical evidence there is for the kind of partial catching up phenomenon described before.

Finally, in our last step, by means of shift-and-share methods we study the contribution of each sector to the aggregate productivity growth, with the intention of measuring how concentrated or disperse this growth has been.

These steps are oriented at testing a particular set of hypothesis regarding the structural trends followed by Latin American economies in the last decades. At the end of this section we will specify these hypotheses.

1.1. Structural characterization

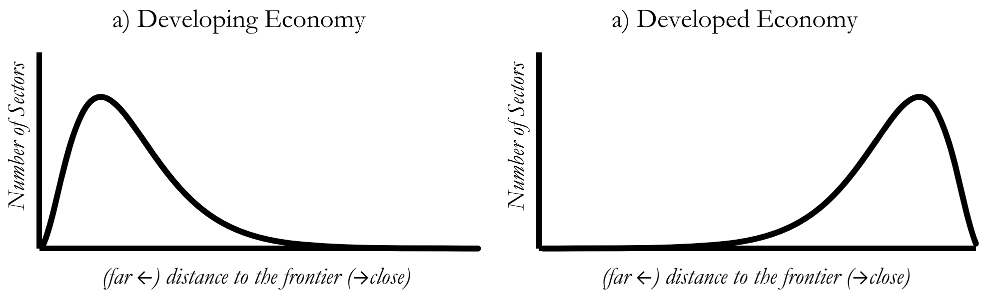
Our starting point consists in characterizing the distribution of sectors in terms of their technological gap with the world frontier. Presumably, for a given country in a particular point in time, there are a wide array of cases, ranging from sectors which are very close (or at) the technological frontier to sectors that are far away from it. At the risk of some oversimplification, however, we may state certain stylized patterns of sectoral distribution according to the country's levels of economic development.

[5] By looking only at labor productivity levels we may, for example, unequivocally associate capital intensive-industries with the modernity of the economy even if these industries are using obsolete techniques according to international standards. From a long run-development perspective, these industries could hardly constitute a sustainable engine for economic progress since sooner or later they will have to face foreign competition and – unless they have managed to catch up with the world frontier– they will lose ground or, eventually, disappear.

To begin with, we may distinguish between two extreme cases: a poor-developing economy and a rich-developed one. Following the definition of development previously stated, in a developed economy we would expect most sectors using state-of-art technologies and thus, the sectoral distribution should tend to cluster close to the technological frontier. In a developing economy, on the other hand, we would expect most sectors working with low levels of technological sophistication and thus, the sectoral distribution should be concentrated far from the technological frontier. Figure 2 illustrates this point plotting the stylized distribution for the two polar cases[6].

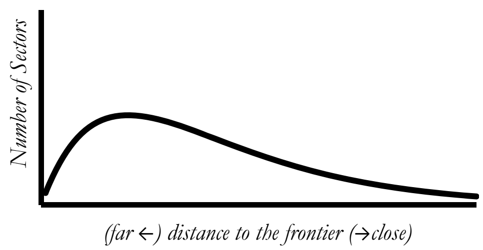
[6] Since we will empirically approximate the distance to the technological frontier with measures of relative labor productivity with respect to the US (e.g., sectors with low relative productivity will be assumed to have larger gaps than sectors with high relative productivity), the theoretical distributions presented in this section are plotted against an "inverse" measure of distance to the frontier. Thus, the closer a sector is to the origin, the farther it is from the frontier. This facilitates the interpretation of our empirical results on the light of our theoretical approach.

Figure 2. Distribution of sectors according to their technological gap.



The picture of the developing economy presented in Figure 2, however, is a quite extreme representation of this kind of economies. If true, it will only represent economies at the very first stages of development. As we have stressed in our previous discussion, many developing economies have, at least, a small fraction of their sectors using technologies that are relative close to the frontier. Then, we would expect to find a small number of sectors in the right hand side of the distribution as well. In Figure 3 we take this fact into consideration and we present the stylized picture for a middle-income developing economy.

Figure 3. Distribution of sectors according to their technological gap in a Middle-Income Developing Economy.

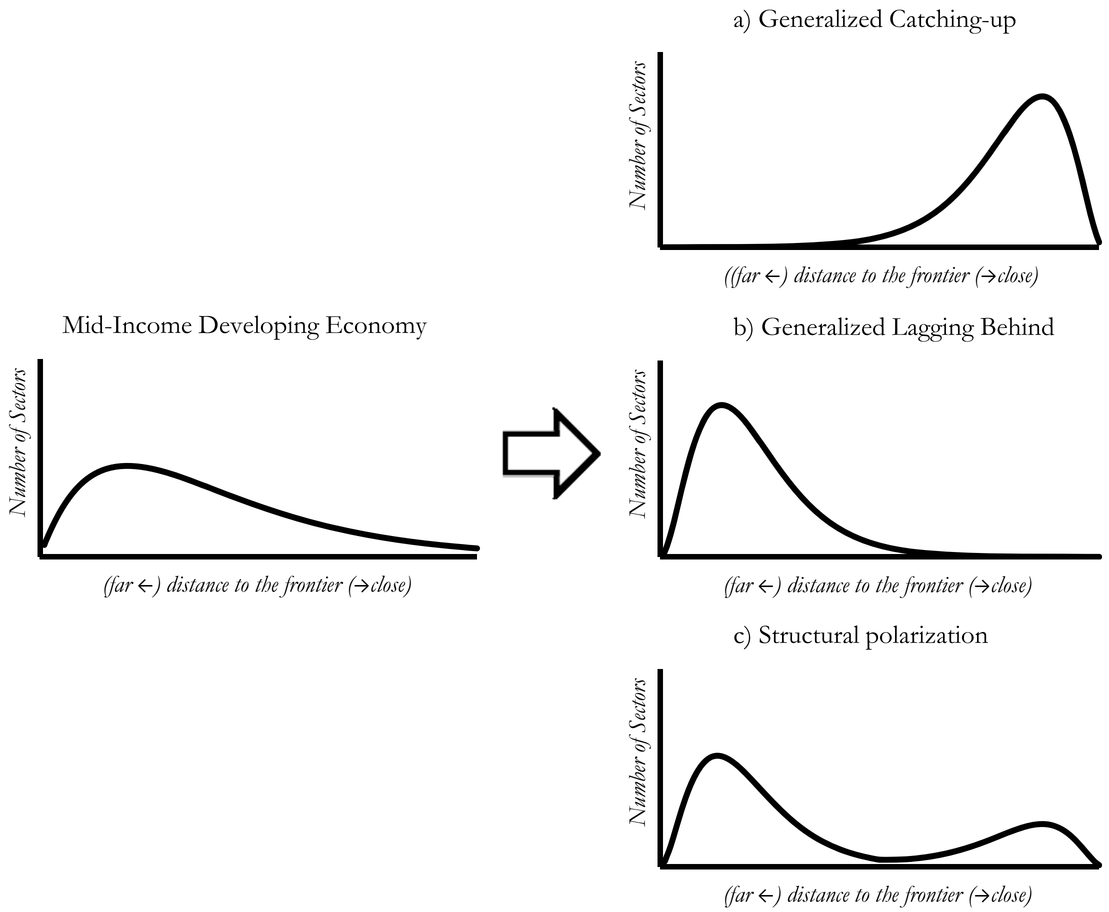


An important difference between Figure 2 and Figure 3 is related to the degree of dispersion showed by each distribution. As we can see, in Figure 2 both distributions are quite homogeneous in the sense that most of the sectors are concentrated close to the mean. In Figure 3, on the other hand, we can find all type of sectors, leading to a significantly more disperse distribution.

As we can see, studying these distributions in a particular point of time may give very interesting insights into the main structural characteristics of an economy. It gives elements to define the degree of sectoral heterogeneity (according to the degree of dispersion) and it also provides some intuition on the relative size of the "modernity" and "backwardness" of the economy. However, the evolution in time of these distributions deserves similar or even greater attention since it gives insights into the development process followed by each economy. In this regard, the core of our analysis consists in studying this type of distributions in two points of time and identifying the changes that take place between them.

Once more, under the risk of some oversimplification, we may state certain stylized trajectories that these distributions may show over time. Here, in particular, we concentrate in three possibilities[7]: a) Generalized Catching-Up; b) Generalized Lagging-Behind; and c) Partial Catching-Up with Structural Polarization[8].

Figure 4. Stylized movements in the distribution of sectors according to their technological gap



[7] These trajectories only represent a subset of all the possible trajectories that can be considered. Since our focus will be on the largest economies of Latin America, we decided to use as starting point the figure of a Mid-Income Developing Economy. A whole trajectory, however, would start from the figure of a Low-Income Developing Economy and would evolve towards any of the four outcomes depicted in Figure 4.

[8] In this paper we only look at the changes in the distributions between the endpoints of the period. This analysis, however, could be enriched by looking at middle points within the period and defining different trajectories in reaching these outcomes. This is an interesting avenue that we intend to explore in future research.

In Figure 4 we illustrate each of these trajectories for a middle-income developing economy. In the first case, the economy manages to catch up successfully with the world frontier, meaning that most sectors narrow the technological gap. In graphical terms, this is reflected by a shift of the whole distribution towards the right hand side. In the second case, the economy either sticks in the same point (showing no signals of relative progress) or it goes even backwards, lagging further behind. This would mean either a similar distribution in the two points of time (mainly concentrated on the left hand side) or, even, a generalized shift towards the left hand side. Finally, the third case represents an intermediate situation in which only a fraction of the economy manages to narrow the technological gap while the rest remains at the same position or lags further behind. Graphically, this would imply a bipolarization of the distribution, where a small number of sectors moves to the right hand side while the rest remains where they were or shift even more to the left. This last case is the most interesting in terms of our analysis since it has not been given sufficiently attention and it seems to bear special importance when analyzing Latin America.

Once characterized the structural trajectories followed by the countries under analysis, the next step of our approach consists in studying the sectoral dynamics behind these structural trajectories. From the wide range of elements that we may take into consideration to study these dynamics, here we concentrate exclusively in two main aspects: the sectoral evolution of technological gaps and the distribution of productivity gains.

1.2. Sectoral dynamics

In this step we examine the “type” of sectors which have driven the trajectories analyzed in the previous step. In order to do so, we study the catching-up hypothesis at a disaggregate level and we identify the industries which have managed to reduce the technological gap. Throughout this analysis, particular attention is paid to the employment generation capability of the “successful” sectors. As it has been recently highlighted, achievements of higher sectoral productivity by means of employment rationalization may lead to “growth-reducing” structural change, where the displaced labour ends up in activities with lower productivity and economy-wide growth is hampered (McMillan and Rodrik, 2011). We try to capture this kind of effects by studying whether the catching up industries have created or destroyed employment during the period.

In order to characterize the different branches of manufacturing, we follow a typology proposed in Katz and Stumpo (2001) which distinguish three types of industries: natural-resource-intensive, labour-intensive and engineering-intensive industries.

Our disaggregate analysis of catching up follows the methodology put forth by Matheson and Oxley (2007). Using time series techniques, these authors propose a sequential approach, in which, firstly it is tested if the series are stationary and if so, secondly it is analyzed the nature of the deterministic components driving them.

To implement this approach, we define the technological gap at each manufacturing branch as the (log) ratio between the labour productivity (*P*) of the country under analysis (*c*) at the industry (*i*) and the US productivity at the same industry:

$$g_{i,t}^{c} = ln\left(P_{i,t}^{c}/P_{i,t}^{us}\right) \qquad (1)$$

Then we test whether the evolution in time of this variable follows a unit root. In order to do so, we use the following augmented Dickey-Fuller (ADF) regression, including constant and time trend:

$$\Delta g_{i,t}^{c} = \beta_i + \alpha_i g_{i,t-1}^{c} + \gamma_i t + \sum_{j=1}^{p} \varphi_{ij} \Delta g_{i,t-j}^{c} + \varepsilon_{i,t} \qquad (2)$$

where, t is a linear time trend, p is the lag structure of the ADF test[9] and ε_t is the error term. The null hypothesis of this test is presence of unit root (α_i=0). If this is the case, the series can be characterized as non-stationary (random walk), and thus it is not possible to determine any long-run trend. Rejection of the null hypothesis, on the other hand, is indicative of a form of convergence or divergence, depending on the nature of the deterministic components driving the series. Following Matheson and Oxley (2007), we analyze the nature of these components using the following regression:

$$g_{i,t}^{c} = \beta_i + \gamma_i t + \varepsilon_{it} \qquad (3)$$

If $\gamma_i > 0$ it means that the gap is diminishing over time (catching up)[10] and if $\gamma_i < 0$ it is growing over time (lagging behind). Catching up is thus implied by a positive and significant time trend (γ_i), while lagging behind is implied by a negative and significant γ_i.

An important remark in this two-step procedure is related with the fact that non rejection of the unit root hypothesis (in the first step) can be the result of a miss-specification in the ADF test. For this reason, in those cases in which the null cannot be rejected using specification (2), we test again excluding the time trend and, if it cannot be rejected with this specification, we test once more excluding the time trend and the constant. Moreover, it has been shown that ADF test may fail to reject the null if the series has structural breaks (Perron, 1989). Thus, in those cases in which the null hypothesis cannot be rejected with any specification of the standard ADF test, we use the Zivot and

[9] Chosen using the Ng-Perron sequential-t criteria

[10] Positive values of the time trend are associated with a diminishing gap because this represents an increase in the relative productivity as defined in expression (1). The higher the relative productivity with respect to US, the smaller the gap.

Andrews' (1992) iterative procedure to test for a unit root in the presence of an endogenously determined structural change (ZA test). Formally, we estimate the following regression[11]:

$$\Delta g_{i,t}^{c} = \hat{\beta}_i + \hat{\alpha}_i g_{i,t-1}^{c} + \hat{\gamma}_i t + \hat{\theta} DU_t(\hat{\lambda}_i) + \hat{\phi} DT_t(\hat{\lambda}_i) + \sum_{j=1}^{p} \hat{\varphi}_{ij} \Delta g_{i,t-j}^{c} + \varepsilon_{it} \quad (4)$$

where, DU_t is a dummy variable that accounts for a shift in the intercept occurring at each possible breaking point $(\hat{\lambda})$ that takes 1 if $t > T\hat{\lambda}$ or 0 otherwise; DT_t is a dummy variable that accounts for a shift in the trend occurring at each possible breaking point $(\hat{\lambda})$ that takes $t\text{-}T\hat{\lambda}$ if t > $T\hat{\lambda}$ or 0 otherwise; and $\hat{\lambda}$ is the time of the break (t^*) relative to the sample size (T). In this case, the null hypothesis is that the series contains a unit root with a drift that excludes any structural change $(\hat{\alpha} = 1)$, while the alternative is a trend-stationary process with one-time break in the trend function occurring at an unknown point of time. In this test, an iterative procedure identifies the breakpoint (t^*) that gives the most weight to the trend-stationary alternative. The resulting test statistic is then compared with the corresponding critical values.

If the null is rejected, we follow the same procedure explained above: we analyze the deterministic trend of the series in the two periods (before and after the break year), and we try to determine whether the industry is catching up or lagging behind in each of these sub-periods.

1.3. Distribution of productivity growth

The last step of our approach consists in analyzing the distribution of productivity growth across industries. The main goal of this analysis is to explore whether productivity gains are concentrated in a particular set of industries or are widespread, affecting all the productive structure. This analysis follows an approach proposed in Harberger (1998) that has been used to analyze the general patterns of structural change in Asian manufacturing (Timmer and Szirmai, 2000) and, more recently, to analyze the impact of ICT technologies on aggregate productivity growth (van Ark and Smits, 2005; Inklaar and Timmer 2007). The main idea behind this approach is to look at the distribution of industry contribution to aggregate productivity growth and distinguish different patterns according to how disperse or concentrated is this distribution. In particular, Harberger distinguish two main patterns: a mushroom pattern (in which only a few industries account for most of the aggregate

[11] Following Perron (1989), Zivot and Andrews (1992) distinguish three models to test for unit root in presence of structural break: model A allows for a change in the intercept; model B allows for a change in the trend; and model C allows both. Here we use model C, which has been shown to be the best specification when the break point is treated as unknown (Sen, 2003).

productivity growth) and a yeast pattern (in which industries contribute more equally to productivity growth)[12].

Following these authors, we complement our previous characterization of Latin American manufacturing growth patterns using Lorenz-type diagrams in which the cumulative contribution of industries to aggregate productivity growth is depicted against the cumulative share of these industries in aggregate value added. These figures provide interesting insights on the degree of concentration of productivity gains within each economy. Formally, this is measure by the area between the line of "perfect equality" (the 45° line) and the observed Harberger curve. The larger this area, the more concentrated the productivity gains are.

To ensure the concavity of the diagrams, we rank the industries according to the following indicator:

$$Rank_i = \frac{C_i}{\omega_{i,t_0}^{va}} \quad (5)$$

where, C_i is the contribution of industry *i* to total labour productivity growth in manufacturing between t_0 and T , and ω_{i,t_0}^{va} is the share of industry *i* in Total Manufacturing value added in time t_0.

In computing these contributions we use a modified shift-share method proposed in van Ark and Timmer (2003) that corrects the negative between-contribution of sectors that are losing employment share. In order to make this correction, first we decompose the contribution of each sector to aggregate productivity growth into two effects: the intra-effect (intra-sectoral productivity growth) and the shift-effect (productivity growth due to changes in the sectoral allocation of labour). Formally, these two effects are defined as:

$$C_i^{intra} = \left(P_{i,T} - P_{i,t_0}\right) * \overline{\omega}_i^n \quad (6)$$

$$C_i^{shift} = \left(\omega_{i,T}^n - \omega_{i,t_0}^n\right) * \overline{P_i} \quad (7)$$

where P_i represents the labour productivity in industry *i*, ω^n its share in total employment, and $\overline{\omega}_i^n$ and $\overline{P_i}$ are averages over the period t_0 - *T*. In conventional shift-share analysis, the contribution of each sector to aggregate productivity growth equals the sum of both effects. In the approach proposed by van Ark and Timmer, instead, the shift effect is computed only to those sectors with are expanding their share in employment over the period. Thus, we distinguish between the set of sectors which expand their labour share (subset *K*) and the set of sectors which are shrinking (subset J), and we compute the contribution of individual sectors to aggregate productivity growth as follows:

[12] This analogy comes from the fact that "while yeast causes bread to expand very evenly, mushrooms have the habit of popping up, almost overnight, in a fashion that is not easy to predict" (Harberger, 1998, p. 6).

$$\forall i \in J: \quad Ci = C_i^{intra} = \left(P_{i,T} - P_{i,t_0}\right) * \overline{\omega}_i^n \tag{8}$$

$$\forall i \in K: \; Ci = C_i^{intra} + C_i^{shift^*} = \left(P_{i,T} - P_{i,t_0}\right) * \overline{\omega}_i^n + \left(\omega_{i,T}^n - \omega_{i,t_0}^n\right) * \left(\overline{P}_i - \overline{P}_J\right) \tag{9}$$

were, $\overline{P}_J$ is the labour productivity averaged over all shrinking sectors:

$$\overline{P}_J = \frac{\sum_{i \in J}\left(\omega_{i,T}^n - \omega_{i,t_0}^n\right) * \overline{P}_i}{\sum_{i \in J}\left(\omega_{i,T}^n - \omega_{i,t_0}^n\right)}$$

This reallocation of effects implies that only sectors which expand their employment share get credited for the shift effect. This effect, however, can be either positive or negative. If the expanding sector's productivity is higher than the average productivity of the shrinking sectors, the effect will be positive. Otherwise, it will be negative.

1.4. Hypotheses

The approach described will be use to test the following hypotheses:

A) The manufacturing sector in Latin American economies is characterized by:

- *i) High degree of sectoral heterogeneity; and,*
- *ii) Trend towards deeper structural polarization*

B) At the sub-sectoral level this implies that:

- *iii) Only a few industries manage to catch up while the rest lags further behind; and,*
- *iv) The productivity gains are concentrated in a small number of industries.*

4 Data

In this paper we apply the approach described in the previous section to test our set of hypothesis in the manufacturing sector of the three largest economies of Latin America: Argentina, Brazil and Mexico. In order to have a benchmark for comparison, we also analyze the cases of Japan (as an example of a developed economy) and South Korea (as an example of a successful catching up experience).

As it has been previously stated, our main focus is placed on sectoral technological gaps, which are empirically approximated with measures of relative labour productivity with respect to the US (assumed here to be the technological leader in all industries). Formally, these measures are given by the following expression:

$$g_{i,t}^c = \frac{P_{i,t}^c}{P_{i,t}^{us}} = \left(\frac{VA_{i,t}^c}{N_{i,t}^c}\right) \Big/ \left(\frac{VA_{i,t}^{us}}{N_{i,t}^{us}}\right) \tag{10}$$

where, $g_{i,t}^{c}$ represents the relative labor productivity of industry *i* in the country *c*, and is defined as the ratio between the labour productivity ($P_{i,t}^{c}$) of that industry and the labor productivity of the same industry in the US ($P_{i,t}^{us}$). Labour productivity, in turn, is defined as the ratio between Value Added and the Number of Employees[13].

Since we are comparing different countries our proxy for labour productivity should be expressed in an international comparable measure. Obtaining such measures, however, is not free from difficulties and is still a matter of debate in the literature. In practice, two main approaches have been used: the expenditure approach and the industry-of-origin approach. In the first case, the conversion factors are based on purchasing power parities (PPPs) calculated under the International Comparisons Project, while in the second case, the conversion factors are based on unit value ratios (UVRs) calculated with information of each country on sales values and quantities of goods and services (O'Mahony, 1996). While the first approach has been extensively used for comparisons at the aggregate level (GDP and per capita income, for example), its applicability for industry-level comparisons has been strongly criticized (van Ark and Timmer, 2001). The second approach, on the other hand, seems to be more appropriate for industry-level comparisons among countries. For this reason, in the present paper we follow this approach and we convert our original data into an international comparable currency using available estimations on UVR conversion factors.

Therefore, to build our data we proceed as follows. Firstly, we define a certain benchmark year and we estimate figures on Value Added –at current prices in local currency units– and Employment disaggregated by manufacturing branches. These figures are estimated both for the country under analysis and for the US using the best available information (mainly, data based on National Accounts).

Secondly, we convert the monetary variables into international dollars using sector-specific conversion factors. These factors are taken from different studies which have estimated sectoral UVRs following the industry-of-origin approach for the countries of our sample. Once the sectoral value added is expressed in international dollars, we estimate the relative labor productivity as given in *Equation (10)* for the benchmark year. Finally, we extrapolate these figures using quantity indexes for the remaining years of our analysis.

[13] Our measure of labour productivity could be improved using hours worked instead of number of employees. This would minimize any bias due to differences in working hours among countries. Unfortunately this information is not available at the level of disaggregation used here for the whole period of analysis. In the same vein, it was not possible to use other measures of productivity –such as Total Factor Productivity– due to data constrains. In particular, it is extremely difficult to obtain data on capital stock by manufacturing branches for Latin America for the whole period.

In the cases of Argentina and Brazil, the benchmark year was set in 1985. In Argentina, the information used to build the figures of that year was mainly taken from Pilat and Hofman (1990), while in Brazil was taken from Mulder et al (2002). Both studies present information on value added (at current prices in local currency units) and employment disaggregated by manufacturing branches, based on the respective national accounts. In addition, they present sector-specific conversion factors estimated using the ICOP methodology. The level of disaggregation, however, is not as detailed as the one used in the present paper. Thus, in some cases the information provided by these studies was further opened using the sub-sector shares (in value added and employment) detailed in the Program for Analysis of Industrial Dynamics (PADI) elaborated by ECLAC[14]. This compressive data set encompasses detailed information on production and trade variables for 26 Latin American countries and the US during the period 1970-2005, and all its monetary variables are expressed in constant dollars from 1985.

In the case of Mexico, we followed a similar procedure than in Brazil, but since the original data presented in Mulder et al (2002) is referred to 1987, we set that as the benchmark year. Thus, it was no longer possible to use the information provided by PADI to open the sub-sectoral value added. For this reason, we used –instead– the information provided by two other sources: the OECD Database for Structural Analysis (STAN) and the UNIDO Industrial Statistics Database (INDSTAT). Both datasets also encompass detailed data on manufacturing production and employment by subsectors, and the monetary variables are all expressed in local currency units.

In the cases of Japan and South Korea, the benchmark year was set in 1997 and the information used was mainly taken from Inklaar and Timmer (2008). Once more, the sectoral disaggregation did not coincide exactly with the one used in this paper and hence, in some cases, the information provided by this study was further opened using two other sources: the EUKLEMS dataset and the INDSTAT.

In all these cases, the sectoral labour productivities at international dollars estimated for the benchmark year were compared with those of the US. Thus, we had to estimate three different benchmarks for the US: 1985, 1987 and 1997[15]. For the first year, we used the information provided in Pilat and Hofman (1990) and we further opened it using the sub-sectoral shares of PADI. For 1987,

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[14] In these cases, the conversion factor used to express the sectoral value added in international dollars does not refer exactly to the same industry but to an aggregation of similar industries. In the Appendix 1 we present the conversion factors used for each branch in each country.

[15] Unfortunately it was not possible to build all our benchmarks for the same year. Nevertheless, this should not bring any important bias in our estimations since all comparisons are made with respect to one particular country (the US) at the same valuation (international dollars of 1985 in the cases of Argentina and Brazil, international dollars of 1988 in the case of Mexico and international dollars of 1997 in the cases of Japan and Korea).

the estimations were built using the data detailed in the EUKLEMS database, opened (when needed) by the sub-sectoral shares provided in the INDSTAT dataset. For 1997, the estimations were done using the same procedures than in the cases of Japan and South Korea.

All this information was later extrapolated to the remaining years using indexes of sectoral value added at constant prices and employment taken from PADI for Argentina, Brazil, Mexico and US, and indexes of industrial production and employment taken from INDSTAT for Japan and South Korea.

The following Table summarizes the different sources used to build our dataset:

Table 1. Data Sources by Country

Country	**Benchmark year**	**Extrapolation**
Argentina	**1985**: *Pilat and Hofman (1990) + PADI (ECLAC)*	*PADI (ECLAC)*
Brazil	**1985**: *Mulder et al (2002) + PADI (ECLAC)*	*PADI (ECLAC)*
Mexico	**1988**: *Mulder et al (2002) + STAN (OECD) + INDSTAT (UNIDO)*	*PADI (ECLAC)*
South Korea	**1997**: *Inklaar and Timmer (2008) + EUKLEMS + INDSTAT (UNIDO)*	*INDSTAT (UNIDO)*
Japan	**1997**: *Inklaar and Timmer (2008) + EUKLEMS + INDSTAT (UNIDO)*	*INDSTAT (UNIDO)*
United States	**1985**: *Pilat and Hofman (1990) + PADI (ECLAC)* **1988**: *EUKLEMS + INDSTAT (UNIDO)* **1997**: *Inklaar and Timmer (2008)+ EUKLEMS + INDSTAT (UNIDO)*	*PADI (ECLAC)*

Following these procedures, we constructed a data set which contains indexes of relative labour productivity at international constant dollars for each economy at 3 digit levels of the ISIC rev. 2 between 1970 and 2005[16]. These indexes where then used to build the distributions of relative labour

[16] Since the indexes of Industrial Production from the UNIDO databases have been discontinuated, our estimations at constant prices for Japan and Korea cover the period 1970-2002. For this reason, all our figures for these two countries are referred to a shorter period.

productivity, imputing each sector to a particular range of relative productivity. We used cumulative ranges of 10 percentage points (ranging from 0 to 99% of US productivity) and a last range for those sectors with had equal or higher labour productivity than the US. In terms of our theoretical section, the last range encompasses those industries which are already at the technological frontier.

The distributions were constructed for two points in time: 1973 and 2003[17]. In both cases, the estimations represent five-year averages of the sectoral relative productivities in each country. Along with the graphs we also present estimations of the degree of sectoral heterogeneity that characterize each economy in each point of time based on the coefficient of variation of the five-year averaged distributions.

It is worth noticing that our empirical approximation is limited in several regards. Firstly, it focuses only on the largest economies of Latin America (Argentina, Mexico and Brazil), although we also analyse the cases of Japan and South Korea in order to have a benchmark for comparisons. Efforts are currently being made to incorporate into our analysis other economies from Latin America, such as Chile, Colombia and Venezuela.

Secondly, we concentrate exclusively on manufacturing industries. As it has been previously stated, a vast body of literature has pointed out the importance of this sector as the engine of growth of the economy. In this sense, analyzing the structural trends followed by this sector bears a clear importance. However, we should keep in mind that this coverage restriction may bring some important limitations on the characterization we intend to do. A large bunch of what we have previously defined as the backwardness of the economy probably lies in the service sector, and –especially in the case of Latin America– an important fraction of the modernity may be constituted by primary activities. In future work we will try to extend our analysis to all productive activities.

Finally, for simplicity and data availability we carry out our analysis using a quite rudimentary measure for technological gaps: the relative labour productivity (in terms of international dollars) with respect to the US. By focusing on this measure we are assuming that the world frontier is always represented by the US and that the relative labour productivity is a good proxy to measure the technological gap. Both assumptions are subject to criticism but, even with their limitations, the indexes used here are significantly useful for the purposes of the present paper. In the future we aim at improving both the proxies used for technological gaps (by combining relative productivity estimates with measures of goods types and innovative activities) and the benchmark for comparison (by having a set of different countries that can represent the international frontier in a particular sector/year according to their relative productivity).

[17] For the reasons previously stated, in the cases of Japan and South Korea, the second period represents five year averages around the year 2000.

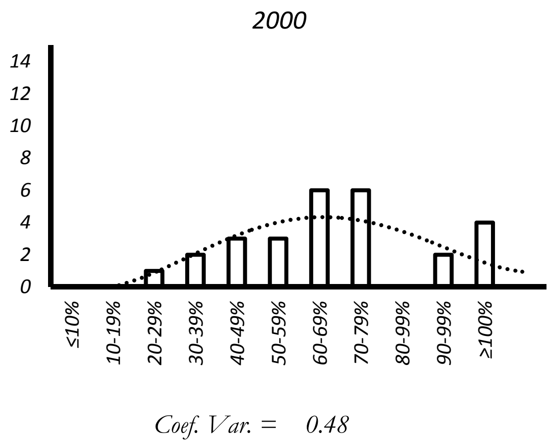
All these being said, we turn now to present and analyze our empirical results.

5 Results

1.5. Sectoral distributions and structural trajectories

For the sake of the exposition and in order to have better elements to analyze the trends in the countries of Latin America we start our analysis by briefly characterizing the sectoral distribution of manufacturing relative labour productivities in Japan and the Republic of Korea[18].

Figure 5. Distribution of sectors by relative labour productivity in Japan (five year average).

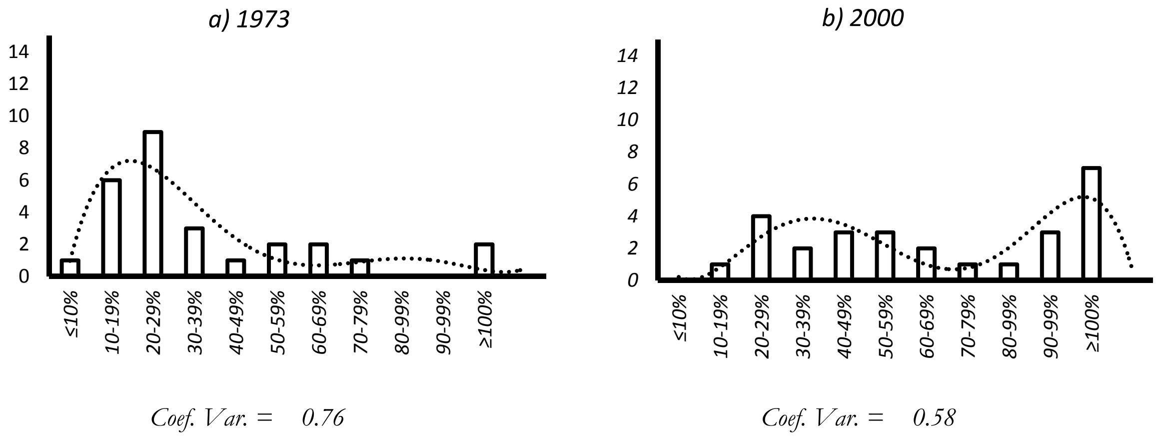


As it is clear from Figure 5, the sectoral distribution of Japan's manufacturing is quite in line with our expectation for a rich developed economy. The majority of manufacturing branches are concentrated on the right-hand side of the graph, reflecting the high relative labour productivity that characterizes most Japanese industries. Indeed, only a few industries lies on ranges with lower than half of the US productivity, while all the rest are clustered mainly on ranges higher than 60%. This clusterization of the distribution seems to reflect an economy characterized by its homogeneity (rather than heterogeneity), and thus, coefficients of variation close to the one presented for Japan can be associated with low levels of sectoral heterogeneity.

[18] In each graph of this section we have plotted the frequency diagram together with a polynomial approximation of order 5 linking all the points in a smoother "trend". This trend facilitates the visual examination but it should not be interpreted as the exact distribution lying behind the frequencies. Unfortunately the small number of observations impedes more sophisticated methods to characterize these distributions.

We turn now to analyze the case of South Korea, as an example of a successful catching-up experience.

Figure 6. Distribution of sectors by relative labour productivity in the South Korea (five year averages)

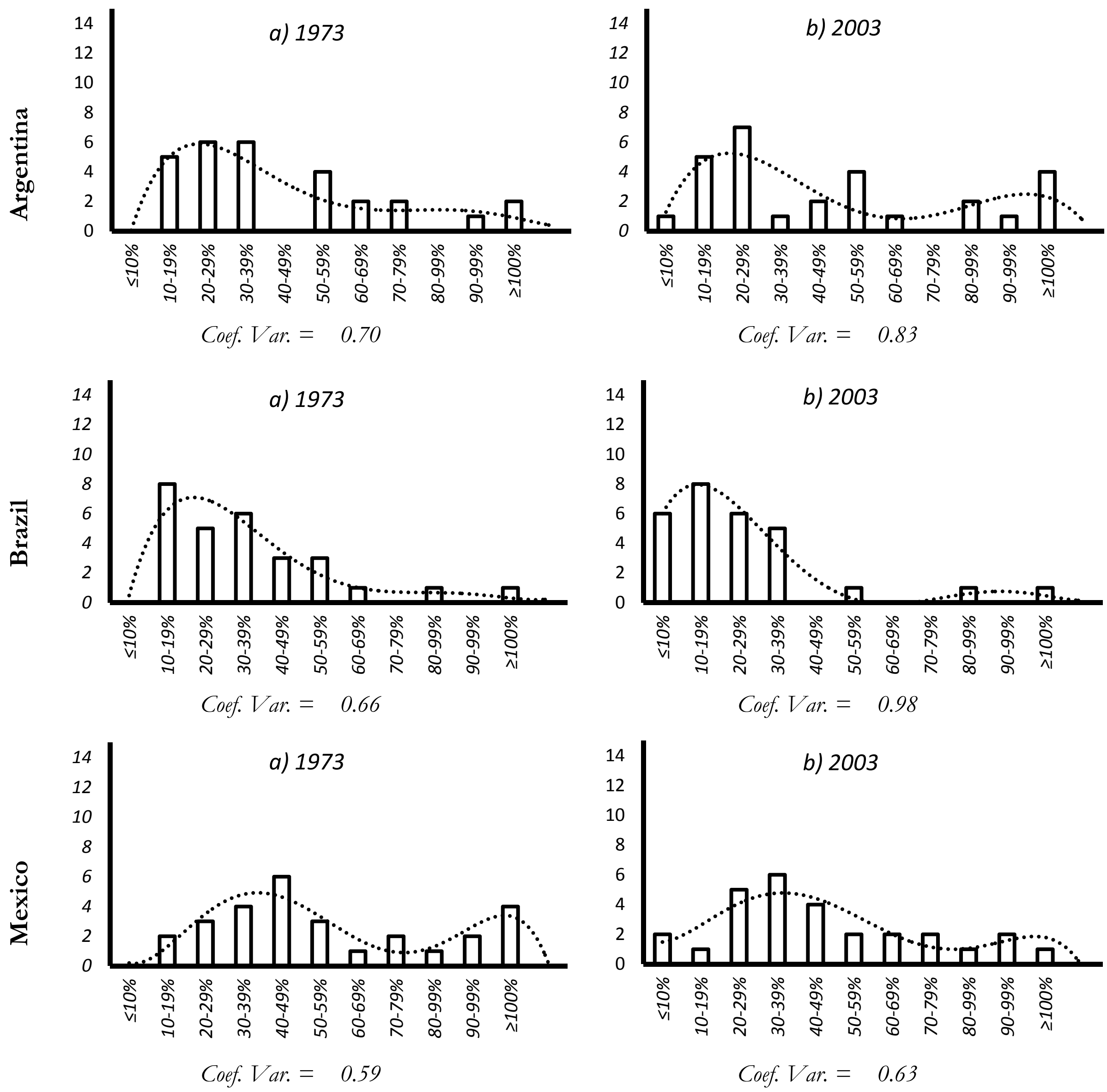


Once more, the figures presented are quite in line with our expectation. In this case, the panels of the graph resembles very much to those presented in Figure 4.a. As we can see, at the begging of the 70s the distribution of manufacturing industries in Korea was quite close to our stylized picture for a middle-income developing economy. Although most sectors lie on the left hand side of the distribution, there are some industries which in the 70s already showed a relative productivity close to the one of US. This wide range of cases leads to a high sectoral heterogeneity, as it can be seen in the value of the coefficient of variation (0.76), which is much higher than the one of Japan.

The picture, however, changes dramatically after 30 years. As we can see in the second panel of Figure 6, most manufacturing branches form Korea managed to narrow the technological gap with the world frontier. Not surprisingly, the whole distribution moves to the right, showing a pattern closer to the one associated before with rich-developed economies. In this sense, Korea represents an excellent example of the kind of structural trajectories previously defined as generalized catching-up. The estimations of the coefficient of variation also support this idea: by the 2000 this coefficients goes down to 0.58, approaching to the one of our developed economy example.

We turn now to analyze the Latin American economies. In Figures 6 we present the sectoral distribution for the three Latin American countries under analysis.

Figure 7. Distribution of sectors by relative labour productivity in Latin American countries (five year averages)



The different panels of Figure 7 provide important insights into the structure of the manufacturing sector in these economies. The first feature that stands out is the high concentration of sectors on the left hand side of the distributions. This characteristic is present in every single case, regardless of the point in time, reflecting the poor performance of these economies in terms of technological catching-up. In all figures most sectors have a labour productivity that does not even reach half of the productivity of the same industries in the US.

This general picture, however, hides interesting features that deserve more careful attention. The first one is the high level of sectoral heterogeneity that we can find in all these economies at the beginning of the period. All of them have a coefficient of variation higher than those stated in the previous cases. More important, these coefficients tend to rise in the three cases. In terms of our theoretical framework this seems to reflect a trajectory of partial catching up with structural polarization. The cases of Argentina and –to a lesser extent– Mexico are quite illustrative in this regard: the productive structures tend to show a more polarized distribution in the 2000s than in the 70s. These distributions seem to be moving towards a bimodal shape, in which most industries are concentrating on the left hand side, but a (smaller) cluster of industries is achieving very high levels of relative productivity.

Comparing the three economies among each other, we can find interesting contrasts. Argentina and Brazil are characterized by a higher polarization than Mexico. In the case of Argentina, the emergence of two peaks in the distribution during the second period of analysis, make quite evident the increase in the degree of sectoral heterogeneity. In the case of Brazil, we also find an important increase in the dispersion of the distribution (reflected in a growing coefficient of variation which rises from 0.66 to 0.98), but the general picture resembles more to the one of a generalized lagging-behind. Mexican manufacturing, on the other hand, also show an increase in the coefficient of variation, but of a smaller magnitude than in the other two cases.

The general trends above described support our first set of hypothesis: the manufacturing sector in the three largest economies of Latin America is characterized by a high and persistent sectoral heterogeneity. Moreover, in the three cases this characteristic has been reinforced during the last decades leading to a deeper structural polarization.

1.6. Sectoral dynamics

We turn now to analyze the sectoral dynamics behind these structural trajectories. With this purpose, in Tables 2 and 3 we present the main results of our econometric exercise. In Table 2, we summarize the results of the unit root tests carried out to identify which industries are governed by some type of deterministic trend. Thus, we only show the cases in which the unit root hypothesis can be rejected (either with standard ADF test or with ZA test which allows for structural breaks). In Table 3, in turn, we summarize the results of our analysis on the deterministic components of those industries that according to Table 2 do not present unit roots. To this end, we detail the coefficient estimates for the deterministic trend (γ_i), distinguishing between industries in which the unit root hypothesis is rejected with standard ADF tests and industries in which the test is only rejected when structural breaks are considered (ZA test). For the latter, we analyze the nature of the deterministic components before and after the year of the break (t^*).

Recalling our methodological section, we will associate positive and significant coefficients (γ_i) with industries that have managed to reduce the technological gap (catch up) during the period. These cases are highlighted in Table 3 and constitute the main focus of our analysis. In addition, for the catching-up industries we also detail the compound annual growth rate in the number of workers within the catching-up periods (that is, 1970-2005 if no structural break has been detected or the corresponding sub-period –before or/and after the structural break– when such breaks has been detected).

Table 2. Unit Root Tests. Argentina, Brazil, Mexico and South Korea. 1970-2005 (1)

	ARGENTINA				BRAZIL				MEXICO				KOREA			
	Augmented Dickey Fuller			Zivot and Andrews	Augmented Dickey Fuller			Zivot and Andrews	Augmented Dickey Fuller			Zivot and Andrews	Augmented Dickey Fuller			Zivot and Andrews
	Trend and Constant	Constant	None		Trend and Constant	Constant	None		Trend and Constant	Constant	None		Trend and Constant	Constant	None	
TOTAL MANUFACTURING		**-3.053 ****							**-4.616 *****						**-3.117 *****	
Natural-resources-intensive												**-4.9470 ***			**-1.6750 ***	
Food manufacturing				-5.445 **									-3.251 *			
Beverage industries		-3.395 **									-1.729 *				-2.109 **	
Tobacco manufactures									-5.971 ***						-3.638 ***	
Manufacture of paper and paper products					-3.651 **				-3.544 *						-3.584 ***	
Manufacture of industrial chemicals				-4.800 *	-4.192 **											-6.277 ***
Petroleum refineries				-4.337 *			-1.840 *					-4.181 *				-4.549 *
Manufacture of miscel. products of petroleum and coal								-4.650 *								-4.549 *
Manufacture of rubber products	-3.501 *					-2.650 *						-4.708 *				
Manufacture of plastic products not elsewhere classified					-3.707 **											-5.800 ***
Iron and steel basic industries			-1.887 *		-3.277 *										-2.812 ***	
Non ferrous metal basic industries				-4.276 *								-4.300 *			-2.396 **	
Labour-intensive															**-1.971 ****	
Manufacture of textiles	-4.390 ***					-3.192 **										
Manufacture of wearing apparel, except footwear								-4.257 *				-5.352 **		-2.873 *		
Manufacture of leather and products of leather, except footwear		-3.367 **			-3.339 *						-2.134 **					-4.978 *
Manufacture of footwear					-3.330 *											
Manufacture of wood and wood products, except furniture								-5.136 **							-1.838 *	
Manufacture of furniture and fixtures, except primarily of metal								-4.431 *	-3.904 **							
Printing, publishing and allied industries				-4.154 *								-4.288 *				
Manufacture of other chemical products	-3.495 *				-3.706 **				-3.526 *						-1.712 *	
Manufacture of pottery, china and earthenware				-4.193 *									-3.250 *			
Manufacture of glass and glass products				-4.187 *				-5.410 **	-3.501 *							-5.021 *
Manufacture of other non metallic mineral products				-4.615 *				-5.108 **								-4.505 *
Other Manufacturing Industries				-4.380 *											-1.660 *	
Engineering-intensive				**-4.199 ***	**-3.737 ****										**-1.764 ***	
Manufacture of metal products, except machinery and equipment				-4.355 *												-6.133 ***
Manufacture of machinery except electrical								-5.318 **				-4.132 *				-4.293 *
Manufacture of electrical machinery, appliances and supplies	-3.387 *							-5.070 *								
Manufacture of transport equipment					-3.654 **											-5.159 **
Manufacture of scientific, measuring and photographic equipment				-4.348 *	-3.518 *											

(1) In the case of Korea, the last year is 2002; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Deterministic trend estimates by manufacturing industries. Argentina, Brazil, Mexico and South Korea. 1970-2005 (1)

	ARGENTINA					*BRAZIL*					*MEXICO*					*KOREA*				
	$\gamma_i(t)$	Break Year	$\gamma_i(t_0\text{-}t^*)$	$\gamma_i(t^*\text{-}T)$	Δ% Emp (yr. av.)	$\gamma_i(t)$	Break Year	$\gamma_i(t_0\text{-}t^*)$	$\gamma_i(t^*\text{-}T)$	Δ% Emp (yr. av.)	$\gamma_i(t)$	Break Year	$\gamma_i(t_0\text{-}t^*)$	$\gamma_i(t^*\text{-}T)$	Δ% Emp (yr. av.)	$\gamma_i(t)$	Break Year	$\gamma_i(t_0\text{-}t^*)$	$\gamma_i(t^*\text{-}T)$	Δ% Emp (yr. av.)
TOTAL MANUFACTURING	**0.003**										-0.015 ***					**0.036** ***				3.6%
Natural-resources-intensive industries												1983	-0.003	**0.009** **	0.2%	**0.055** ***				2.8%
Food manufacturing		1989	-0.044 ***	**0.024** ***	0.0%											**0.041** ***				2.6%
Beverage industries	-0.013										-0.017 ***					**0.056** ***				-2.2%
Tobacco manufactures											-0.003					**0.065** ***				-3.8%
Manufacture of paper and paper products						**0.017** ***				0.9%	**0.001**					**0.037** ***				3.6%
Manufacture of industrial chemicals		1987	-0.006	**0.018** **	-0.7%	-0.024 ***											1991	**0.052** ***	**0.007**	3.3%
Petroleum refineries		1987	**0.021**	**0.058** ***	-1.5%	**0.024** *				0.5%		1986	**0.035** *	**0.041**	2.8%		1985	**0.048** ***	**0.031** ***	3.1%
Manufacture of miscel. products of petroleum and coal							1984	-0.018	**0.041** ***	7.1%							1985	**0.048** ***	**0.031** ***	-6.1%
Manufacture of rubber products	**0.003**					-0.016 ***						1984	-0.009	-0.011 ***						
Manufacture of plastic products not elsewhere classified						-0.026 ***											1981	-0.037	**0.005**	
Iron and steel basic industries	**0.038** ***				-2.8%	-0.004										**0.063** ***				3.4%
Non ferrous metal basic industries		1993	-0.009	**0.029** **	0.4%							1991	-0.002	**0.017**		**0.073** ***				5.6%
Labour-intensive industries																**0.042** ***				1.3%
Manufacture of textiles	-0.002					**0.005**														
Manufacture of wearing apparel, except footwear							1995	-0.057 ***	-0.129 ***			1975	-0.042	-0.040 ***		**0.009**				
Manufacture of leather and products of leather, except footwear	-0.007					-0.068 ***					-0.038 ***						1993	**0.081** **	-0.058 ***	10.3%
Manufacture of footwear						-0.032 ***														
Manufacture of wood and wood products, except furniture							1989	-0.033 ***	**0.006**							**0.012** ***				-0.9%
Manufacture of furniture and fixtures, except primarily of metal							1989	-0.039 ***	**0.016**		**0.004**									
Printing, publishing and allied industries		1991	**0.001**	**0.010**								1997	**0.010** ***	-0.028 ***	1.4%					
Manufacture of other chemical products	**0.012** **				-2.1%	-0.031 ***					-0.006 **					**0.065** ***				3.3%
Manufacture of pottery, china and earthenware		1991	-0.044 ***	**0.008**												**0.063** ***				1.0%
Manufacture of glass and glass products		1988	**0.002**	**0.065** ***	-2.2%		1987	**0.039** ***	**0.017** **	-0.5%	**0.022** ***				0.6%		1978	-0.036	**0.031** ***	0.9%
Manufacture of other non metallic mineral products		1988	-0.010	**0.028** **	-3.2%		1987	-0.024 *	**0.018** **	-2.9%							1978	**0.039** **	**0.048** ***	1.1%
Other Manufacturing Industries		1997	**0.011** **	-0.110 ***	-2.7%											**0.023** ***				-0.5%
Engineering-intensive industries		1996	-0.014 *	-0.078 ***		-0.016 ***										**0.032** ***				7.2%
Manufacture of metal products, except machinery and equipment		1992	-0.006	-0.021 ***													1975	**0.034**	**0.011**	
Manufacture of machinery except electrical							1997	-0.048 ***	-0.113 **			1975	-0.117	-0.046 ***			1989	-0.009	-0.147 ***	
Manufacture of electrical machinery, appliances and supplies	-0.022 ***						1975	-0.056	-0.029 ***											
Manufacture of transport equipment						**0.009** **				1.8%							1977	**0.258** *	**0.039** ***	6.6%
Manufacture of scientific, measuring and photographic equipment		1988	**0.019** **	-0.014	-1.5%	-0.010														

(1) In the case of Korea, the last year is 2002; * significant at 10%; ** significant at 5%; *** significant at 1%

As it can be seen in Table 2, using different specifications for the unit root tests it is possible to conclude that most industries show some type of deterministic trend during the time-span considered in this paper. In Argentina, Brazil and South Korea in two-thirds of the series the unit root hypothesis can be rejected. In the case of Mexico, the number of industries is lower but still is quite significant.

The results shown in this table also stress the importance of taking into consideration possible structural breaks when analyzing long periods of time. Indeed, many industries that according to standard ADF tests would be characterized as non-stationary (and thus, little inference could be done regarding its long-run trends), become stationary when one (endogenous determined) structural break is considered (ZA tests).

We turn now to analyze the results of Table 3. As we have previously stated, the main goal of this exercise is to identify, for each country, those industries which showed the best performance in terms of catching-up with the technological frontier. For this reason, we concentrate our analysis on those industries which have a positive and significant γ_i coefficient.

A brief look at the results for the three Latin American countries seems to confirm our second hypothesis: although none of these countries show evidence of catching-up at the aggregate level of manufacturing, it is always possible to find a restricted number of branches which managed to reduce their gap with the world frontier.

In the case of Argentina, 10 of the 28 branches show positive and significant γ_i coefficient. Most of them, however, manage to reduce the technological gap only after a certain breaking year. Before that turning point, their relative labour productivity was either stuck or lagging behind. Among these industries we find *Food Manufacturing* (between 1989 and 2005), *Industrial Chemicals* (1987-2005), *Petroleum Refineries* (1987-2005), *Non-ferrous Metals* (1993-2005), *Glass and Glass Products* (1988-2005) and *Other Non-metallic Mineral Products* (1988-2005). A common feature of all these industries is that the turning point seems to be at the end of the eighties or beginning of the nineties, coinciding with the set of structural reforms implemented in those years. Only two branches show a catching up trend during whole period: *Iron and Steel* and *Other Chemicals Products*.

In the characterization of these successful branches, two main features stand out. The first one is the strong concentration in Natural Resource Intensive industries. As we can see, most of these branches fall in this type of sector. The second feature is related with the fact that 9 of the 10 catching up industries show negative growth rates in the number of employees. That is, these industries managed to increase their relative labour productivity mainly by reducing employment. As we have stressed before, this fact is extremely important from a structural change point of view, because it means that the most successful industries are expelling (instead of absorbing) labour force. Following McMillan and Rodrik (2011), this may be associated with a growth-reducing structural change.

In the case of Brazil, we find a smaller number of catching up industries (6 of the 28), but most of them show this trend throughout the whole period. This is the case of *Paper and Paper Products, Petroleum Refineries*, *Glass and Glass Products* and *Transport Equipment*. Two industries, on the other hand, managed to reduce the technological gap within a restricted sub-period: *Miscellaneous Products of Petroleum and Coal* (1984-2005) and *Other Non-metallic Mineral Products* (1987-2005). Once more, we can see an important presence of Natural Resource Intensive industries, but in this case, many of the successful catching up industries are able to generate employment as well.

Finally, for the case of Mexico, we can only find 3 successful catching up industries and only one with a positive tendency in the relative productivity for the whole period: *Glass and Glass Products*. The other two, show significant evidence of catching up only previously to the breaking point. After that year, the evidence is not concluding. These industries are *Petroleum Refineries* (1970-1986) and *Printing and Publishing* (1970-1997). It is worth mentioning that in this case, all the successful branches manage to reduce the gap in a context of growing employment.

The trends depicted for the three Latin American countries clearly contrast with the results obtained for South Korea. In this economy, the evidence shows a clear trend towards fast catching up at the aggregate level of manufacturing, and this trend is reproduced in most branches within the sector (17 of the 28). Equally important, with only four exceptions, all the successful catching up industries shows positive growth rates in employment.

Summing up, the results of this sections stress once more the importance of using a disaggregate approach and are in line with our main hypotheses. We turn now to analyze the concentration of labour productivity gains in the economies under analysis.

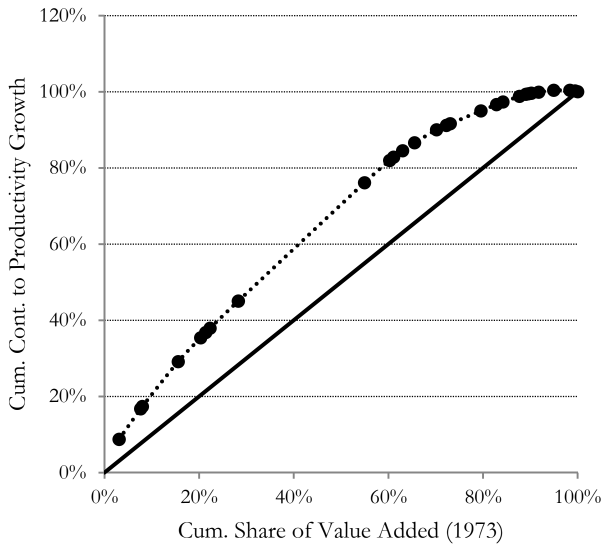
1.7. Distribution of productivity growth

In this section we complement our previous analysis with a more conventional shift-and-share exercise aimed at studying the concentration of productivity gains across industries in the three Latin American economies between 1970 and 2005. Therefore, our focus is placed now on the evolution of sectoral labor productivity (instead of relative productivity with respect the US), and our key indicator will be the degree of concentration of productivity gains between the end points of the period. A strong concentration of these gains in few industries (a mushroom pattern in terms of Harberger typology) will reinforce the idea that these economies have followed a trajectory of partial catching up with structural polarization. If, however, productivity gains are distributed evenly among all industries (yeast pattern), then the differences in the dynamics of technological gaps across industries will mainly respond to differences in the speed at which the world frontier (US productivity) is moving in each sector (and only to a lesser extent to the domestic dynamics in sectoral productivity growth).

The results of this analysis are summarized in Figures 8 to 10, in which we present the Harberger diagrams for the three Latin American countries under study. At the bottom of each figure we also present the values for the relative areas between the diagram and the diagonal line. To the same extent that traditional Lorentz curves show income distribution concentration, these areas give us an idea about the concentration in aggregate manufacturing productivity growth. In the extreme case in which all sectors have the same productivity growth, the curvature of the diagram will coincide exactly with the 45° line (equal-distribution), and the area will equal zero. As long as the curvature growth, the area is larger and so is the concentration of productivity growth.

Figure 8. Concentration of Labour Productivity Growth among Industries.

Argentina 1973-2003



Relative Area = *0.23*

Figure 9. Concentration of Labour Productivity Growth among Industries.
Brazil 1973-2003

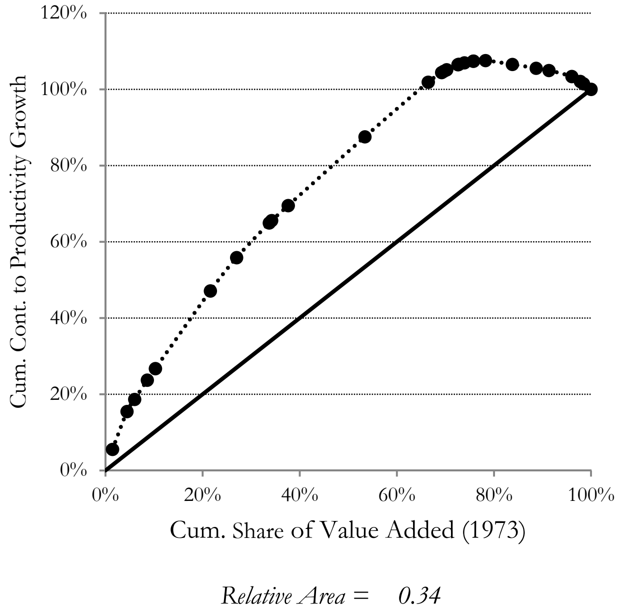
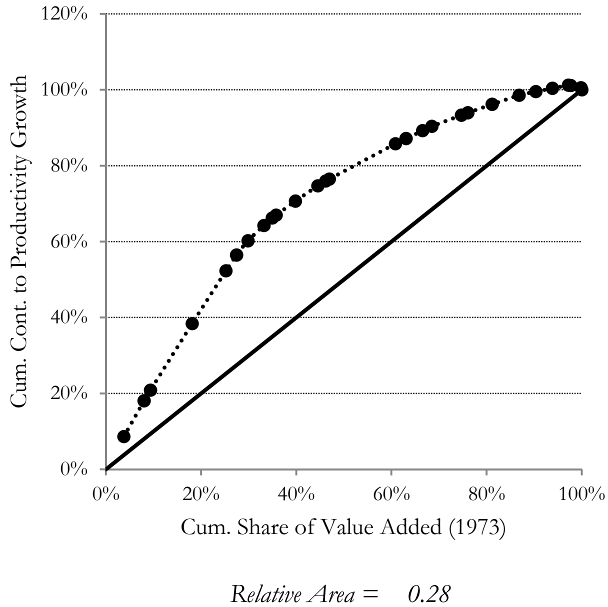


Figure 10. Concentration of Labour Productivity Growth among Industries.
Mexico 1973-2003



As we can see, in all the cases, the productivity growth is highly concentrated in a few sectors: from the 28 industries under consideration, the 10 most dynamic account for more than 80% of total productivity gains in Argentina and Brazil, and for around 60% in Mexico.

Once more, however, it is possible to identify interesting contrasts between the three economies. In this regard, the degree of concentration in the productivity gains seems to be much higher in Brazil and Mexico than in Argentina. The comparison can easily been made looking at the size of the relative areas: while in Brazil and Mexico these areas are 0.34 and 0.28 respectively, in Argentina it is *only* 0.23. Nevertheless we should bear in mind that this evener distribution seems to respond to the generalized rationalization of employment that characterized Argentinean manufacturing during the years under analysis.

To complement these figures, in Table 4 we present detailed data on sectoral productivity growth and contribution to aggregate manufacturing productivity growth for the most important industries (according to their contribution) in each country. There it is easy to see how concentrated this process has been. We detailed the industries that taken together explain at least 2/3 of total productivity growth. In all cases there are less than 7 industries which represent between 40 and 50% of total value added at the beginning of the period.

Table 4. Concentration of Labour Productivity Growth among Industries, by countries. Sectoral productivity 1973 vs. 2003 (five year averages)

		Labor Productivity Growth Rate (Annual Average) (1)	Contribution to Total Productivity Growth (2)	Initial Share of Value Added (3)	Cum. Sum of (2)	Cum. Sum of (3)
ARGENTINA	**TOTAL MANUFACTURING**	**4.0%**	**100%**	**100%**	**0%**	**0%**
	Food manufacturing	2.8%	31.1%	26.7%	31%	27%
	Petroleum refineries	3.3%	11.8%	7.6%	43%	34%
	Iron and steel basic industries	7.3%	8.7%	3.1%	52%	37%
	Manufacture of industrial chemicals	3.9%	8.0%	4.6%	60%	42%
	Manufacture of other chemical products	4.3%	7.1%	6.0%	67%	48%
	Remaining 22 industries	3.3%	33.3%	52.2%	100.0%	100.0%
BRAZIL	**TOTAL MANUFACTURING**	**2.5%**	**100%**	**100%**	**0%**	**0%**
	Manufacture of transport equipment	3.2%	20.4%	11.3%	20%	11%
	Manufacture of machinery except electrical	2.4%	18.0%	15.8%	38%	27%
	Food manufacturing	1.9%	14.3%	13.0%	53%	40%
	Manufacture of electrical machinery	5.4%	9.9%	3.0%	63%	43%
	Iron and steel basic industries	2.8%	9.1%	6.7%	72%	50%
	Remaining 23 industries	2.2%	28.2%	50.1%	100.0%	100.0%
MEXICO	**TOTAL MANUFACTURING**	**2.4%**	**100%**	**100%**	**0%**	**0%**
	Beverage industries	3.5%	17.5%	8.8%	18%	9%
	Manufacture of transport equipment	2.8%	13.9%	7.1%	31%	16%
	Iron and steel basic industries	4.6%	9.4%	4.2%	41%	20%
	Food manufacturing	1.8%	9.3%	13.9%	50%	34%
	Manufacture of electrical machinery	4.2%	8.6%	3.8%	59%	38%
	Manufacture of machinery except electrical	3.9%	4.2%	2.2%	63%	40%
	Manufacture of other chemical products	2.8%	4.0%	3.3%	67%	43%
	Remaining 21 industries	1.6%	33.0%	56.7%	100.0%	100.0%

Source: Own calculations based on PADI-ECLAC, Mulder et al. (2002), Pilat and Hofman (1990), OECD-STAN and UNIDO-INDSTAT.

Summing up, our analysis of the distribution of labour productivity growth across industries gives further evidence supporting our last hypothesis: the productivity gains in Latin American manufacturing have been highly concentrated in few sectors.

6 Conclusions and future steps

In this paper we proposed an approach to analyze some important features of the development path followed by certain developing economies. We empirically tested this approach for the manufacturing sector of three Latin American countries and we found evidence supporting our main hypothesis that these economies are characterized by a high, persistent and increasing sectoral heterogeneity. Our findings also suggest that these economies had followed a trajectory of partial catching-up with structural polarization. In short, these economies are lagging behind at the aggregate level of manufacturing, but show very heterogeneous trends within their own structures. While a small fraction of industries seems to be using technologies close to the frontier or has managed to achieve fast reductions in the technological gap, the remaining industries face a huge distance with the frontier and keep lagging further behind. Consequently, the degree of sectoral heterogeneity is large and increasing.

These findings raise a number of interesting questions that will be addressed in future research. Firstly, it is worth exploring the factors lying behind this particular type of trajectory. On one hand, it is important to analyze why certain sectors emerge as *island of modernity in a sea of backwardness*. On the other hand, it should be studied why these sectors are not capable of pulling the rest of the economy towards a process of generalized catching-up.

Secondly, it is important to inquiry about the impact of this kind of sectoral heterogeneities in the development potential of the region. In particular, it seems that this kind of phenomena may be highly correlated with the strong inequalities that characterized Latin American economies. Following Katz (2006), it would be possible to argue that these countries showed a fragmented convergence in which "the small fraction of society located in the modern sector of the economy enjoys well-above-average incomes and has gradually developed consumption patterns comparable to the great majority of citizens in developed industrial nations"[19]. Under this hypothesis, it would be very interesting to analyze the joint-causation of structural polarization on one hand, and fragmented convergence on the other hand, and the effects of both in the disappointing performance of Latin America long-run per capita and productivity growth.

Last but not least, these findings open a very fruitful policy debate. Given the current pattern of specialization (i.e. the type of industries which showed the best performance in terms of catching-up) we may ask which kind of industrial and technological policy strategy would be more effective: one that explicitly tries to change the specialization pattern stimulating the creation of new intensive-knowledge sectors or one aimed at fostering the linkages and spill-over of the existing successful ones. Any answer to this policy question, however, will heavily depend on the feasibility of such linkages and spill-overs in a context of an internationally integrated production system.

[19] Katz, J. (2006), p. 57.

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Appendix 1. Sectoral Specific Conversion Factors by country and industry - Argentina, Brazil and Mexico

ISIC	Industry	Argentina (1) Unit Value Ratios (pesos/u$s) - 1985		Brazil (2) Unit Value Ratios (cruz./u$s) - 1985		Mexico (2) Unit Value Ratios (pesos/u$s) - 1988	
311	*Food manufacturing*	0.277	*[Food Manufacturing]*	3,180	*[Food Products]*	1,477	*[Food Products]*
313	*Beverage industries*	0.212	*[Beverages]*	3,180	*[Food Products]*	1,477	*[Food Products]*
314	*Tobacco manufactures*	0.074	*[Tobacco Products]*	2,486	*[Tobacco Products]*	1,224	*[Tobacco Products]*
321	*Manuf. of textiles*	0.994	*[Textile Mill Products]*	5,680	*[Textiles]*	1,773	*[Textiles]*
322	*Manuf. of wearing apparel, except footwear*	0.591	*[Wearing Apparel]*	3,988	*[Clothing and Apparel]*	1,247	*[Clothing and Apparel]*
323	*Manuf. of leather and its products, except footwear*	0.511	*[Leather Products and Footwear]*	2,927	*[Leather and Leather Products]*	1,489	*[Leather and Leather Products]*
324	*Manuf. of footwear*	0.511	*[Leather Products and Footwear]*	3,988	*[Clothing and Apparel]*	1,247	*[Clothing and Apparel]*
331	*Manuf. of wood and wood products, except furniture*	0.837	*[Wood Products, Furniture and Fixtures]*	2,692	*[Wood Products. Except Furniture]*	1,665	*[Wood Products. Except Furniture]*
332	*Manuf. of furniture and fixtures, except primarily of metal*	0.837	*[Wood Products, Furniture and Fixtures]*	1,777	*[Furniture and Fixtures]*	2,237	*[Furniture and Fixtures]*
341	*Manuf. of paper and paper products*	1.106	*[Paper Prodcuts, Printing and Publishing]*	4,613	*[Paper and Allied Products]*	2,139	*[Paper and Allied Products]*
342	*Printing, publishing and allied industries*	1.106	*[Paper Prodcuts, Printing and Publishing]*	9,554	*[Printing and Publishing]*	1,287	*[Printing and Publishing]*
351	*Manuf. of industrial chemicals*	0.650	*[Chemicals, Petroleum and Coal Products]*	6,383	*[Chemicals]*	1,956	*[Chemicals]*
352	*Manuf. of other chemical products*	0.650	*[Chemicals, Petroleum and Coal Products]*	6,383	*[Chemicals]*	1,956	*[Chemicals]*
353	*Petroleum refineries*	0.650	*[Chemicals, Petroleum and Coal Products]*	6,383	*[Chemicals]*	1,956	*[Chemicals]*
354	*Manuf. of miscellaneous products of petroleum and coal*	0.650	*[Chemicals, Petroleum and Coal Products]*	6,383	*[Chemicals]*	1,956	*[Chemicals]*
355	*Manuf. of rubber products*	1.389	*[Rubber and Plastic Products]*	7,969	*[Rubber and Plastics]*	1,120	*[Rubber and Plastics]*
356	*Manuf. of plastic products not elsewhere classified*	1.389	*[Rubber and Plastic Products]*	7,969	*[Rubber and Plastics]*	1,120	*[Rubber and Plastics]*
361	*Manuf. of pottery, china and earthenware*	0.657	*[Non-Metallic Minearl Products]*	4,094	*[Non-metallic minerals]*	1,950	*[Non-metallic minerals]*
362	*Manuf. of glass and glass products*	0.657	*[Non-Metallic Minearl Products]*	4,094	*[Non-metallic minerals]*	1,950	*[Non-metallic minerals]*
369	*Manuf. of other non metallic mineral products*	0.657	*[Non-Metallic Minearl Products]*	4,094	*[Non-metallic minerals]*	1,950	*[Non-metallic minerals]*
371	*Iron and steel basic industries*	0.877	*[Basic and Fabricated Metal Products]*	4,520	*[Primary Metals]*	2,488	*[Primary Metals]*
372	*Non ferrous metal basic industries*	0.877	*[Basic and Fabricated Metal Products]*	4,520	*[Primary Metals]*	2,488	*[Primary Metals]*
381	*Manuf. of fabricated metal products, except machinery and eq.*	0.877	*[Basic and Fabricated Metal Products]*	4,520	*[Metal Products]*	1,395	*[Metal Products]*
382	*Manuf. of machinery except electrical*	0.757	*[Machinery and Transport Equipment]*	2,507	*[Machinery and Computers]*	1,994	*[Machinery and Computers]*
383	*Manuf. of electrical machinery apparatus, appliances and supplies*	0.415	*[Electrical Machinery and Equipment]*	6,766	*[Electronic & Electrical Equipment]*	2,111	*[Electronic & Electrical Equipment]*
384	*Manuf. of transport equipment*	0.757	*[Machinery and Transport Equipment]*	2,689	*[Transportation Equipment]*	1,961	*[Transportation Equipment]*
385	*Manuf. of professional, scientific, photographic and measuring eq.*	1.126	*[Other Manufacturing Industries]*	3,657	*[Professional Equipment]*	3,050	*[Professional Equipment]*
390	*Other Manufacturing Industries*	1.126	*[Other Manufacturing Industries]*	3,818	*[Other Industries]*	1,603	*[Other Industries]*

(1) Data taken from Pilat and Hofman (1990)

(2) Data taken from Mulder et al (2002)

Note: *The names between brakets correspond to the industries for which the conversion factors were originally estimated.*

Appendix 2. Sectoral Specific Conversion Factors by country and industry - Japan and South Korea

ISIC	Industry	Japan (1) GGDC-PPP (yen/u$s) for value added (double deflated) - 1997		Rep. of Korea (1) GGDC-PPP (won/u$s) for value added (double deflated) - 1997	
311	*Food manufacturing*	292	*[Food products, beverages and tobacco]*	1,537	*[Food products, beverages and tobacco]*
313	*Beverage industries*	292	*[Food products, beverages and tobacco]*	1,537	*[Food products, beverages and tobacco]*
314	*Tobacco manufactures*	292	*[Food products, beverages and tobacco]*	1,537	*[Food products, beverages and tobacco]*
321	*Manuf. of textiles*	129	*[Textiles, textile products, leather and footwear]*	1,567	*[Textiles, textile products, leather and footwear]*
322	*Manuf. of wearing apparel, except footwear*	129	*[Textiles, textile products, leather and footwear]*	1,567	*[Textiles, textile products, leather and footwear]*
323	*Manuf. of leather and its products, except footwear*	129	*[Textiles, textile products, leather and footwear]*	1,567	*[Textiles, textile products, leather and footwear]*
324	*Manuf. of footwear*	129	*[Textiles, textile products, leather and footwear]*	1,567	*[Textiles, textile products, leather and footwear]*
331	*Manuf. of wood and wood products, except furniture*	167	*[Wood and products of wood and cork]*	719	*[Wood and products of wood and cork]*
332	*Manuf. of furniture and fixtures, except primarily of metal*	167	*[Wood and products of wood and cork]*	719	*[Wood and products of wood and cork]*
341	*Manuf. of paper and paper products*	160	*[Pulp, paper, paper products, printing and publishing]*	1,146	*[Pulp, paper, paper products, printing and publishing]*
342	*Printing, publishing and allied industries*	160	*[Pulp, paper, paper products, printing and publishing]*	1,146	*[Pulp, paper, paper products, printing and publishing]*
351	*Manuf. of industrial chemicals*	128	*[Chemicals and chemical products]*	293	*[Chemicals and chemical products]*
352	*Manuf. of other chemical products*	128	*[Chemicals and chemical products]*	293	*[Chemicals and chemical products]*
353	*Petroleum refineries*	1,263	*[Coke, refined petroleum products and nuclear fuel]*	2,337	*[Coke, refined petroleum products and nuclear fuel]*
354	*Manuf. of miscellaneous products of petroleum and coal*	1,263	*[Coke, refined petroleum products and nuclear fuel]*	2,337	*[Coke, refined petroleum products and nuclear fuel]*
355	*Manuf. of rubber products*	173	*[Rubber and plastics products]*	562	*[Rubber and plastics products]*
356	*Manuf. of plastic products not elsewhere classified*	173	*[Rubber and plastics products]*	562	*[Rubber and plastics products]*
361	*Manuf. of pottery, china and earthenware*	165	*[Other non-metallic mineral products]*	453	*[Other non-metallic mineral products]*
362	*Manuf. of glass and glass products*	165	*[Other non-metallic mineral products]*	453	*[Other non-metallic mineral products]*
369	*Manuf. of other non metallic mineral products*	165	*[Other non-metallic mineral products]*	453	*[Other non-metallic mineral products]*
371	*Iron and steel basic industries*	142	*[Basic metals and fabricated metal products]*	975	*[Basic metals and fabricated metal products]*
372	*Non ferrous metal basic industries*	142	*[Basic metals and fabricated metal products]*	975	*[Basic metals and fabricated metal products]*
381	*Manuf. of fabricated metal products, except machinery and eq.*	142	*[Basic metals and fabricated metal products]*	975	*[Basic metals and fabricated metal products]*
382	*Manuf. of machinery except electrical*	114	*[Machinery, nec]*	840	*[Machinery, nec]*
383	*Manuf. of electrical machinery apparatus, appliances and supplies*	128	*[Electrical and optical equipment]*	926	*[Electrical and optical equipment]*
384	*Manuf. of transport equipment*	151	*[Transport equipment]*	934	*[Transport equipment]*
385	*Manuf. of professional, scientific, photographic and measuring eq.*	128	*[Electrical and optical equipment]*	926	*[Electrical and optical equipment]*
390	*Other Manufacturing Industries*	301	*[Manufacturing nec; recycling]*	546	*[Manufacturing nec; recycling]*

(1) Data taken from Appendix tables to Robert Inklaar and Marcel P. Timmer (2008), GGDC Productivity Level Database: International Comparisons Of Output, Inputs And Productivity At The Industry Level, GGDC Research Memorandum GD-104, Groningen: University of Groningen.

Note: *The names between brakets correspond to the industries for which the conversion factors were originally estimated.*

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