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Structural analysis of the rise and stagnation of labour productivity in Argentina (2004-2019): A growing subsystems approach

HERNAN ALEJANDRO ROITBARG, FRANCISCO LEIVA, JOAQUIN LUCERO

Abstract:
This article aims to examine the recent rise and fall of productivity in Argentina through a subsystems approach. Specifically, indicators based on hyper vertically integrated (HVI) sectors for Argentina are developed using OECD Input-Output Tables. The analysis spans the period 2004-2019, harmonizing activities across 36 sectors. The results confirm, on the one hand, that productivity growth in the 2004-2011 period was due to improved macroeconomic conditions. On the other hand, they show a declining trend in productivity from 2010 onwards, highlighting the significance of a concentrated pattern of technical change and evidence of disinvestment in direct and indirect labour, and, to a lesser extent, demand composition, attributable to the growing importance of services.

Roitbarg: National Council for Scientific and Technical Research, Litoral National University, email: hroitbarg@fce.unl.edu.ar
Leiva: Study Center - Santa Fe Board of Trade, email: fleiva@bcsf.com.ar
Lucero: Litoral National University, email: luceroj95@gmail.com

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Argentina's economic performance over the last two decades of the last century has been marked by volatility. After the exit of the currency board, a period of sustained growth began, accompanied by favourable external conditions for Argentina and all countries in Latin America. The international financial crisis put an end to this growth cycle, which was followed by stagnation in per capita growth and productivity (Baumann Fonay and Cohan, 2018).

The significance of the stagnation in productivity extends beyond its impact on competitiveness or the potential to increase salaries without exacerbating distributional conflicts. It is crucial for fostering greater growth by mitigating external conditions (Thirlwall, 1979). For example, this can be achieved by increasing foreign exchange reserves through exports or by reducing both direct and indirect imports associated with the use of inputs. Another strategy is the substitution of final goods previously imported with domestically priced alternatives.

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The aim of this paper is to analyse the behaviour of productivity in Argentina during the 21st century based on the “hyper-vertically integrated (HVI) sectors” or “growing subsystem” approach developed by Pasinetti (1981), using input-output tables. Specifically, the period 2004-2019 is covered in order to investigate the structural causes of the boom of the first decade and its subsequent stagnation and fall.

Our findings indicate that the dynamics of productivity and its determinants can be divided into two periods, the first spanning from 2004 to 2011 and the second from 2012 to 2019. During the first period, productivity and labour grew uniformly from the point of view of subsystems and were anchored mainly in direct labour savings. From a structural point of view, the share of market services in HVI labour grew, driven mainly by the level of demand. These subsystems, together with light industry and the automotive industry, turned out to be the dynamic subsystems of the period. During the second period, productivity assumed a downward trend, concentrated and with evidence of direct and indirect labour savings. There was stagnation in the share of industry in HVI labour and a growth of services, especially those that had boosted productivity in the previous stage. However, in this stage these subsystems became laggards from the point of view of productivity; but they were generators of HVI labour, which is consistent with a dynamic of negative structural change.

After this brief introduction, the paper is structured as follows: section 1 deals with a review of the literature on productivity in Argentina; section 2 details the methodology used; section 3 discusses the empirical results obtained; finally, section 4 presents the main conclusions.

1. Literature review

Studies on technical change can be divided between those who analyse the general productivity of an economy based on neoclassical theory using total factor productivity (TFP) and those non-neoclassical authors who analyse it based on labour productivity. This last group may include works from a variety of heterodox traditions.

The basic neoclassical approach measures the productivity of an economy in a residual form, from the difference between the growth rate of output and the growth rate of factor endowments, both weighted by their share in the income distribution. The value obtained is called total factor productivity (TFP) and reflects the efficiency with which an economic system combines its productive factors (Pagés, 2010). As Grotz (2020) points out, this way of measuring the productivity of an economy has an intrinsic weakness, since it is not obtained directly. However, numerous methodologies have been developed that enable factor endowments to be “adjusted” (according to the quality of labour, hours worked, intensity of capital stock use, etc.) to reduce the unexplained component of the variation in output that is usually computed as TFP. From this perspective, technological change is exogenous and neutral, that is, it affects all factors of production equally.

From a classical perspective, Solow’s model gives an incorrect treatment of the capital factor since, as a reproducible good, it is subject to technical change and therefore assumes a non-neutral treatment of technological change.[1] The subsystem approach considers productivity changes as a technological phenomenon that can be measured in physical units and is always ultimately labour-saving (Pasinetti, 1981). Following Brondino (2019), another characteristic of the neoclassical approach is the consideration of productivity as a firm-level phenomenon that is determined by internal managerial capabilities. However, in economies where production is

[1] For an in-depth treatment of the Solow-Pasinetti debate on productivity, see Garbellini and Wirkierman (2023).

fragmented (i.e., many sectors are involved in the production of the same final good), sectoral productivity is determined by the general conditions of the economy. The subsystem approach adopted in the present paper enables the capture of the inter-sectoral relationships that influence the dynamics of total productivity.

Another relevant criticism of the neoclassical approach was made by post-Keynesian economists. The Kaldor-Verdoorn law (KVL) states that it is output growth that drives productivity[2] from the deployment of increasing returns to scale, reversing the causality of mainstream theory[3] and questioning the limits imposed by the notion of potential output (Thirlwall, 1979; Borgoglio and Odisio, 2012). This means that productivity may be boosted by demand. Following Amico et al. (2011), this process can occur through two effects. First, an increase in demand leads to increased investment spending, which will have a direct effect on productive capacity and (to the extent that each new piece of capital equipment incorporates a degree of technical progress) also on productivity. Second, the demand and product expansion supports 'learning by doing' processes that boost the overall productivity of the economy.

The literature addressing the phenomenon of productivity in Argentina's economy has not been profuse compared to that of other countries in the region (Carvalho Lopes and Viego, 2021). Moreover, most of the studies on the topic adopt a neoclassical approach with a high level of aggregation, which does not allow for a structural analysis. A first group of papers are those that analyse TFP for Argentina in an aggregate form. Within this group is the work conducted by Baumann Fonay and Cohan (2018), which decomposes growth factors in an adjusted way and calculates the potential GDP for 1993-2017. The authors report that, from 1999 onwards, the contribution of TFP to growth is negative, particularly from 2012 onwards. The growth of economic activity and productivity after the exit from the currency board regime, which they characterise as extensive, is due to the large number of idle factors (both labour and capital) that enable the economy to expand without tensions.

A second group of studies disaggregates the TFP behaviour on a sectoral basis. One of them is Coremberg's work (2011), which analyses the changes in Argentina's growth profile between 1990 and 2006 in an aggregate way and at a sectoral level, differentiating relevant subperiods (1990-1994, 2002-2006, 1998-2006, 1990-2001 and 1990-2006). At the same time, these sectoral variations are disaggregated according to whether they are changes within each sector or the product of inter-sectoral relations based on a shift-share analysis. Unlike Baumann Fonay and Cohan (2018), the author argues that the growth of output and productivity during the 1990s maintained an extensive character, with a negative contribution of TFP and based on a low rate of utilisation of installed capacity and not on long-term productivity gains due to improvements in the organisation of production processes. In the years following the turn of the century, TFP would be slightly positive, although it would not change the extensive nature of the economic growth. Among the causes of this erratic behaviour, he points to macroeconomic instability and the inability of dynamic sectors to generate externalities and complementarities that drive sustained TFP growth, as well as a persistent misallocation of resources.

Finally, a third group of research uses firm-level information to compute TFP and analyse inter-sectoral patterns. Within this group is the work by Galiani et al. (2019), which computes firm-level TFP for the manufacturing sector and then aggregates the information into 27 sub-

[2] Originally, the Kaldor-Verdoorn law was proposed for the industrial sector; however, in a more general view, it can be argued that productivity is a function of GDP growth (Amico et al., 2011).

[3] Borgoglio and Odisio (2012) argue that Kaldor did not deny reverse causality, i.e., from productivity to demand; however, he considered it to be less regular and systematic than the opposite relationship. The notion of cumulative growth held by Kaldor is based on the coexistence of both casualties.

sectors. Unlike the works mentioned above, this one does not perform a longitudinal cut-off analysis but stops at two particular moments: 2010-2012 and 2014-2016. This is due to the fact that the database used is the National Survey on Labour and Innovation Dynamics (ENDEI for its Spanish acronym), which was carried out only twice. For the authors, the causes of Argentina's poor productivity performance are to be found in macroeconomic instability, distortions generated by tax and regulatory regimes hostile to investment (domestic and foreign) and trade, and insufficient investment in infrastructure and innovation.

In general terms, the works cited above agree with the following: i) the characterisation of TFP behaviour in Argentina as procyclical is a stylised fact; ii) the growth of output and TFP in the early 2000s had an extensive character, based on the use of idle capacities and on the accumulation of productive factors without altering the fundamentals that affect long-term productivity growth; and iii) there was a negative contribution of TFP to the growth of the economy during the last decade.

In this context, the present paper makes two relevant contributions to the study of productivity in Argentina's economy. The first one is the adoption of the subsystem approach, which provides an alternative view to the neoclassical paradigm and has been scarcely used in this type of research in the country. Some examples include, on the one hand, the studies by Coatz et al. (2013), Fabris (2016), and Molina et al. (2021), which characterise the Argentine productive system through sectoral classifications based on the degree of interaction, the analysis of multipliers, and the structure of direct and vertically integrated labour. On the other hand, some examples include the works by Malvicino (2019a, 2019b) and Zack et al. (2020), which incorporate the country's international insertion into their analysis.

The second contribution of our research is a structural analysis of the causes behind the behaviour of the variables of interest, enriching the understanding of certain particularities of Argentina's economy that are not evident using other methodological tools. Some studies have used similar methodologies for other countries in the region. Villani (2015) uses the approach of vertically and hyper-vertically integrated sectors to analyse the evolution of Chile's production structure in terms of productivity, employment, and imports. His main conclusion is that the most dynamic sectors in the period analysed (1998-2006) are not those linked to natural resources, mainly mining.

For the case of Brazil, the works of Wirkierman (2010), Fevereiro et al. (2015), and Morrone et al. (2022), which use the subsystems approach for different purposes, are noteworthy. The first paper draws on a longer time period (1990-2005) to analyse the overall productivity dynamics of the economy and the direction of technical change. The second study makes a comparison between direct labour productivity and total labour productivity, while identifying the dynamic subsystems between 2000 and 2008. The authors found that traditional indicators underestimate the performance of the industrial sector and overestimate that of the service sector, with the most dynamic sectors being those that supply the manufacturing sector; this is captured by the subsystems approach. Along the same lines, the authors of the third paper examine the early deindustrialization process that occurred in the Brazilian economy. Their findings indicate that this process, measured using a subsystems approach, has been less pronounced than indicated by research using traditional indicators and is attributed to greater integration with the service sector.

2. Methods

2.1. Input-output and growing subsystem approach

This paper proposes a subsystem analysis (Sraffa, 1960; Pasinetti, 1973), an approach which offers advantages over the most commonly used analyses in Argentine literature. For example, TFP approaches consider capital as a homogeneous unit capable of being measured independently of the price system (and distribution) and even consider fixed capital as a non-produced primary factor. Some studies suggest that such measurement may not adequately account for the technical change occurring in capital goods or may be influenced by distributive changes (Elmslie and Milberg, 1996; Wirkierman, 2012). Such a measurement also proposes improvements over direct productivity indicators (based on total deflated output divided by the number of workers per industry). In particular, these indicators only partially reflect the technique in use, as technical change may originate in the inputs used by the industry or required for expansion (Wirkierman, 2012; Fevereiro et al., 2015).

Starting from input-output accounting, the equality between production and sales allows for the creation of a system of linear equations for 'n' industries, where the expenditure system assumes the following equality:

$$x = Z^d i + f^k + f^c \tag{1}$$

Following the notation from Miller and Blair (2009), x defines the total product as the sum of intermediate domestic transactions (Z^d) and final sales destined to consumer goods (f^c) and capital (f^k).[4]

Note that net product, in addition to goods for immediate consumption, also comprises final goods, which can have an effect on productive capacity. In particular, final sales of consumer goods are made up of the categories of private and public consumption and exports (c, g and e), and capital goods are made up of gross investment (public and private) for the replacement and expansion of installed capacity, based on the demand for consumer goods.

The subsystem approach offers an alternative representation of the economic system outlined in equation (1). The key distinction lies in categorising the industries that sell intermediate and final goods into 'n' HVI subsystems. Essentially, the original system, as depicted in equation (1), is subdivided into 'n' such segments, aligning with the number of consumption goods (Pasinetti, 1988). Each subsystem encapsulates the intricate labour and productive capacity interdependencies across all necessary inputs within every production chain 'n'. In essence, this approach involves segmenting the system based on the direct, indirect, and hyper-indirect requisites essential for producing the entire quantity of the 'n' final consumption goods.

Note that, due to the identification of capital goods, in this case the quantities are no longer in a stationary state. Thus, this approach is usually called "growing subsystems" (Pasinetti, 1981).

Analytically, for a subsystem 'j', production is represented by the following equality

[4] Regarding notation, matrices are represented with capital letters and vectors are represented with lower-case letters (all are column vectors and their transposition is explicitly indicated with the superscript T). A vector with a circumflex accent (e.g., v) indicates a diagonal matrix with elements on its main diagonal. Vector i is a column vector $n * 1$ that sums around the columns; the same applies for vectors iT with respect to rows. Vector ij is a column vector $n * 1$ that selects the $j - th$ column. In principle, all vectors are dimension $n * 1$ and all matrices $n * n$. Superscript d on the right-hand side of the matrix elements alludes to domestic production (as opposed to imported production, which is referenced by superscript m).

$$x_j = (I - \Lambda)^{-1} f^c i_j, \;\; j = 1 \dots n \tag{2}$$

where lambda – Λ – is composed of the matrix of technical coefficients (A^d) and the matrix of investment coefficients (A^k). Specifically, it is defined by the following equalities:

$$\Lambda = A^d + A^k$$

$$A^d = Z^d \hat{x}^{-1}$$

$$A^k = F^k \hat{x}^{-1} \tag{3}$$

where F^k is a matrix of order n, which defines in the rows the supplying sectors and in the columns the target industries for the capital goods.

Assuming that the labour inputs of the system are derived by considering a constant relationship between labour unit requirements and production ($a_l^T = l^T \hat{x}^{-1}$), it is possible to define "HVI labour" at the subsystem level as the direct, indirect, and hyper-indirect jobs required for a given level of expanding consumer goods.

In analytical terms, by multiplying equation (2) by the coefficient of direct labour inputs, the hyper-vertical labour of subsystem «j» assumes the form

$$L_{hvi,j} = a_l^T x_j = v_{hvi}^T f^c i_j \tag{4}$$

where v_{hvi}^T represents the "HVI labour requirements" per unit of net product. It is given by:

$$v_{hvi}^T = a_l^T (I - \Lambda)^{-1} \tag{5}$$

Starting from equation (4), slightly adapted to identify total HVI employment in each sector (${L_{hvi}}^T = v_{hvi}^T \widehat{f^c}$), it is possible to calculate the effects on HVI employment caused by changes in the HVI employment coefficient or consumer demand. In particular, an input-output structural decomposition analysis can identify the source of these shifts (Skolka, 1989). In this case, the proposed structural decomposition analysis (SDA) draws on Miller and Blair, (2009, p. 595). Despite not all authors agreeing with this procedure (Fromm, 1968), a version of Dietzenbacher and Los (1998) is employed, which asserts, as an acceptable approach, the use of the average of results from a decomposition with a base year of 0 for demand and 1 for HVI labour coefficients, and vice versa.

It is given by:

$$\Delta L_{hvi} = \tfrac{1}{2} \Delta v_{hvi}^T (\widehat{f_1^c} + \widehat{f_0^c}) + \tfrac{1}{2} (v_{hvi,1}^T + v_{hvi,0}^T) \Delta \widehat{f^c} \tag{6}$$

where $\Delta v_{hvi}^T (\widehat{f_1^c} + \widehat{f_0^c})$ refers to the effect of technical change measured in changes of the HVI employment coefficient and $(v_{hvi,1}^T + v_{hvi,0}^T) \Delta \widehat{f^c}$ identifies the change in employment explained by demand transformations.

It is important to acknowledge that, while structural decomposition techniques are commonly used to analyse changes in variables by breaking them down into their determinants, this methodology is not without problems. Some authors, such as Dietzenbacher and Los (2000), have highlighted a potential risk of endogeneity. Structural decomposition techniques assume that the determinants are independent. However, it has been observed that several determinants are not fully independent, leading to what is termed as full dependence, where changes in one determinant cannot occur without corresponding changes in another determinant. Specifically, when analysing the relationship between the variables, it was observed that demand is significantly associated with the highly vertically integrated employment vector, with a negative coefficient (–0.49), indicating that, as demand increases, the coefficient tends to decrease (technical progress to rise). Despite this relationship, the goodness of fit of the model is low; around 28.4% of the variance of the dependent variable (demand) is explained.

2.2. Indicators of technical change

In simple terms, a productivity indicator is a quotient between a given number of outputs produced and a set of inputs required. In other words, it is the quantity of inputs used to achieve an output. Although the issue seems easily measurable by aggregating quantities by means of prices of each of the required inputs (labour, capital and raw materials), such an approach may not be entirely accurate in separating technical change (in its broad definition) from distributional changes reflected through relative prices (De Juan and Febrero, 2000). The subsystem approach proposes a way to overcome the problems derived from the usual indicators.

Defining productivity as the quantity of inputs required to produce one unit of net output, the subsystem approach enables the reduction of all the different inputs to homogeneous physical units such as labour. For each unit of net output, a certain amount of direct, indirect and hyper-indirect labour is required.

Based on this definition, the total labour productivity (TLP) for subsystem 'j' is derived from the ratio of net output and total labour inputs, which is equivalent to the inverse of the HVI labour coefficient (α_{hvi}).

$$TLP_j = \frac{f^{c,j}}{v_{hvi,j} f^{c,j}} = \frac{1}{v_{hvi,j}} = \alpha_{hvi,j} \tag{6}$$

Under this definition, the technical change of each sector depends on the variation of productivity in each subsystem ($\Delta\%\alpha_{hvi,j} = d\ ln\ \ \alpha_{hvi,j}$). Among several advantages of the indicator (De Juan and Febrero, 2000), the authors note that, unlike other measures, it does not depend on net output, a magnitude of capital or an exogenous technological parameter; nor does it include distributional connotations if they assume constant prices for the product (Brondino, 2019). In other terms, it is a physical measure of the productive capacity of the economy in each industry that contemplates the inter-relations of the system (De Juan and Febrero, 2000).

In summary, the general trend in productivity is the weighted average of the productivity growth of each subsystem, which is an indicator known as the "standard rate of growth of productivity" (Pasinetti, 1981). In mathematical terms, the weighted average rate is defined as rho:

$$\rho^*_{hvi} = \sum_{j=1}^{n} \quad \frac{L_{hvi,j}}{\underline{L}} dln\ \alpha_{hvi,j} \tag{7}$$

where $\underline{L}$ is total labour for the year, $L_{hvi,j}$ represents the HVI employment by subsystem j, d reflects the difference between the natural logarithm of alpha ($\alpha_{hvi,j}$) at $t1$ and $t0$, and rho (ρ^*_{hvi}) is the standard rate of productivity growth (SRPG) based on HVI productivity. It should be noted that the labour used to calculate weighting and aggregate growth rates refers to HVI labour activated by the final demand for consumer goods in each sector respectively (equation 4).

Starting from a similar definition of general productivity, it is possible to apply a shift-share analysis (McMillan and Rodrik, 2011). In particular, we propose an adaptation of the methodology of Timmer and Szirmai (2000) and Brondino (2019). Specifically, we begin with the following equation:

$$(ln\ \alpha_{hvi}{}^{T})_{t1}(\sum_{j=1}^{n} \frac{L_{hvi,j}}{\underline{L}})_{t1} - (ln\ \alpha_{hvi}{}^{T})_{t0}(\sum_{j=1}^{n} \frac{L_{hvi,j}}{\underline{L}})_{t0} \quad (8)$$

Note that this calculation of the variation in general productivity does not start from general productivity as the weighted sum of variations (equation 8); instead, it calculates it as the variation in the weighted sum of productivity. However, when evaluating the degree of association between both variables, we note that there exists a positive and highly significant relationship between them, with an R-squared of 89.05%.

When adapting the methodology to our analysis, the terms under consideration are identified in the following equation:

$$d\ (ln\ \alpha_{hvi}{}^{T})(\sum_{j=1}^{n} \frac{L_{hvi,j}}{\underline{L}})_{t0} + \left[(ln\ \alpha_{hvi}{}^{T})_{t0} d(\sum_{j=1}^{n} \frac{L_{hvi,j}}{\underline{L}}) + (ln\ \alpha_{hvi}{}^{T})_{t0} d(\sum_{j=1}^{n} \frac{L_{hvi,j}}{\underline{L}}) \right] \quad (9)$$

with d representing the delta between periods, and the subscripts $t1$ and $t0$ corresponding to the values at time 1 and the previous time 0, respectively. In summary, the first term of the sum is computed as the "intra effect", while the second term includes the "shift effect". By dividing these by the previous equation, the explanatory percentage of each factor is formed. Note that these results may differ significantly from the average of sectoral levels, as they are highly sensitive to the level of aggregation (De Vries et al., 2012).

2.3. Sources of technical change

To analyse the components of technical change, it is possible to disaggregate total labour productivity into changes associated with direct and indirect productivity (Garbellini and Wirkierman, 2010, p. 11). Specifically, total productivity is understood to comprise two components:

$$\alpha_{hvi,j} = \frac{1}{a_{l,j}} + \frac{1}{a_{l,j}\Lambda(I-\Lambda)^{-1}} \quad (10)$$

In our analysis, it is of interest to compare the temporal variation of total labour productivity (TLP or $\alpha_{hvi,j}$) and direct labour productivity (DLP o $\frac{1}{a_{l,j}}$).

Furthermore, it is also necessary to assess whether changes in the use of indirect inputs are accompanied by changes in vertically integrated imports. The behaviour of intermediate imports triggered by the demand for final goods is relevant because the behavior can explain variations in productivity that are not strictly technical advances or setbacks. For example, a saving in domestic labour per unit of production in an industrial sector may, in fact, correspond to the transfer of part of the production process to another country, which leads to an increase in intermediate imports. This phenomenon is particularly relevant in emerging economies that rely heavily on imports to incorporate new technologies (Abeles and Amar, 2017). Such a phenomenon is called the reverse import substitution process. In this case, assuming a constant ratio between intermediate imports and output ($a_m^T = i^T A^m = Z^m \hat{x}^{-1}$), the calculation of HVI imports (m) arises from the following equation:

$$m_{hvi}^T = a_m^T (I - \Lambda)^{-1} \quad (11)$$

It should be clarified that, due to a lack of information regarding external prices, this indicator may contain price effects that could alter the incorporated analysis.

Lastly, there is also the possibility that increased indirect labour does not correspond to increased input usage. In other words, it may be that inputs are used in the same proportion but with more labour-intensive inputs, or with the same inputs but reduced efficiency. To evaluate the presence of these possibilities, changes in the intensity of intermediate goods usage are studied. Following Rampa (1981) and Brondino (2019), to summarise the intensity of domestic intermediate input usage, we propose the use of the maximum eigenvalue of the following matrix corresponding to each subsystem k:

$$\lambda^*(\Lambda^{(k)}) \quad (12)$$

where λ^* represents the maximum eigenvalue, and the matrix $\Lambda^{(k)}$ is derived from the following expression:

$$\Lambda^{(k)} = \Lambda \widehat{S_{\cdot k}} \quad (13)$$

where Λ is the matrix from equation (3), and $\widehat{S_{\cdot k}}$ is a diagonal matrix formed by the kth column of matrix S. The latter represents the proportion of total production of good i necessary to produce final good j ($S = \widehat{x^{-1}}(I - \Lambda)^{-1}\widehat{f^c}$).

The scalar obtained can be interpreted as the weighted average of intermediate input usage within the system. In other words, it would be like a weighted average of the share of intermediate sales relative to the total sales of each good.

In summary, with all the elements defined above, a deeper analysis of labour productivity and the sources of its change can be carried out. For this, averages are computed per period of the logarithmic differences between: total labour productivity, direct labour productivity, intensity of domestic input usage, and intensity of import usage. From these indicators, the following taxonomies have been identified (Brondino, 2019; Garbellini and Wirkierman, 2010).

If the growth of direct productivity exceeds that of total productivity, the process is mostly direct labour saving. On one hand, if the growth of direct productivity is accompanied by the increased use of local inputs, we term it mechanisation. Such a process implies import substitution if the use of foreign inputs decreases, or a kind of reverse substitution if imported inputs increase, as direct labour is replaced by both local and foreign inputs.

On the other hand, if local inputs decrease, circumstances arise to speak of economies of scale. These may not imply greater efficiency if they are accompanied by more imports of inputs; in that case, there is reverse substitution, as local inputs replace foreign ones.

If the growth of direct productivity is lower than that of total labour productivity, technical progress is mostly indirect labour saving. On one hand, if more local inputs are used, there may be a shift towards techniques using more and better inputs (which may even replace imports if they decrease). On the other hand, if fewer inputs are used, economies of scale may also emerge; which may also offset greater efficiency if imports of inputs increase.

The opposite interpretation follows for cases of decrease. For example, if direct productivity decreases faster than total productivity and is accompanied by more inputs, we can speak of diseconomies of scale; and, if it is followed by fewer inputs, we refer to these processes as involving decreased mechanisation. In this case, more direct labour is used and fewer inputs (if compensated with more imported inputs, there is reverse substitution).

2.4. Subsystem classification

It is widely recognized in the economic development literature that not all productive sectors contribute to the same extent to boost growth and productivity. In order to identify those subsystems that explain the behaviour of these variables to a greater extent in the periods considered, we use the taxonomy developed by Garbellini and Wirkierman (2014). This classification is based on the joint analysis of the dynamics of HVI productivity and total employment in each subsystem.

	$\varDelta\%\boldsymbol{\alpha}_{\boldsymbol{n}}^{(\boldsymbol{t})} < \boldsymbol{\rho}^{*}$	$\varDelta\%\boldsymbol{\alpha}_{\boldsymbol{n}}^{(\boldsymbol{t})} > \boldsymbol{\rho}^{*}$
$\varDelta\%L_n^{(t)} < 0$	Productivity lagging subsystems/labour expelling subsystems	Dynamic productivity/labour expelling subsystems
$\varDelta\%L_n^{(t)} > 0$	Productivity lagging subsystems/labour driving subsystems	Dynamic subsystems

Dynamic subsystems are those that have productivity growth above the standard rate of the economy and also increase their share of total employment. These subsystems present increasing returns to scale. In contrast, if the subsystem's share in total employment decreases, it is considered a dynamic subsystem that expels labour.

If the productivity growth rate of a subsystem is lower than the average of the economy, it is considered a laggard. If this subsystem increases its share of total employment, it is called labour-driving; if it decreases its share of total employment, it is considered labour-expelling.

3. Data and methodological definitions

To compute TLP and related indicators, the input-output tables and sectoral labour statistics provided by the Organisation for Economic Cooperation and Development (OECD) are used. In addition, the basic price indexes required for deflating refer to 2004-2020 according to the National Institute of Statistics and Census (INDEC for its Spanish acronym) of Argentina.

Specifically, the first source is based on the 2022 edition of the OECD's Inter-Country Input-Output (ICIO) database, which includes matrices from 1995 to 2020 for 77 economies and 45 sectors, using the International Standard Industrial Classification (ISIC), fourth revision. In the case of labour, the data refer to the same period and classification but are derived from the OECD Trade in employment (TiM) 2023 database, which is limited to 50 countries.

Regarding prices, the base is derived from the basic price deflator for Argentina's gross value of production and value added provided by INDEC. The base year is 2004, and the industrial classification used reports data for 56 industries. A double deflation of the matrices was conducted to obtain this information at constant prices. Firstly, the deflators were converted to current dollars; subsequently, the matrices in current dollars were deflated to obtain constant prices of 2004.

To deflate import prices, a single deflator was used for all imports. Specifically, the calculation was based on the INDEC "Indexes of value, price, and quantity of imports by economic use, base 2004=100. Years 1986-2023". These indexes classify imports by economic use into capital goods, intermediate goods, fuels, accessories for capital goods, and consumer goods. We omitted consumer goods, as we are interested only in intermediate imports. Capital goods were deflated using an average between the deflator for capital goods and that for their accessories and parts. Most sectors used the deflator for intermediate goods, except for D05T06 (Mining energy), D19 (Coke and refined), and D35 (Electricity, gas), which used the deflator for fuels and lubricants. Additionally, industries D26, D27, D28, DD29, D30, and D31T33 were considered as capital goods.

Due to the differences in the disaggregation of sectors from one base to another, the matrices, labour data, and deflators were harmonised and consolidated into 36 sectors. The table of correspondence between them can be found in the appendix (table A1).

For the construction of the lambda matrix, we followed the methodology developed by Brondino (2019). In particular, the investment coefficients assume the distribution of the investment vector according to the relative importance of each sector for such a demand category. Specifically, due to the absence of information on the sectoral destination of investment (F^k), a square matrix 'J'assumes that all industries demand capital in the same proportion. In analytical terms:

$$F^k = J = f^k s^T$$

where f^k is a column vector representing gross investment in final demand ($n * 1$), and s^T is the transpose of a column vector ($1 * n$) that represents the proportion of investment in each industry. Specifically:

$$s = \frac{f^k}{i^T f^k}$$

Then, the investment coefficients are:

$$A^k = J\hat{x}^{-1} \qquad (14)$$

Although it may appear to be a strong assumption, its utilisation provides advantages for periods of strong growth. If it is assumed that demand growth has an accelerator effect (Samuelson, 1939) and induces investment processes, as asserted in part of the literature regarding the first subperiod (Amico et al., 2011), this methodology serves to accurately identify which sectors induced greater changes in employment directly, indirectly, and hyper-indirectly through their expansion.

Furthermore, in relation to the productivity of vertically integrated sectors, the simple linear regression reveals a highly significant coefficient. The multiple R-squared value is 0.9753, suggesting that approximately 97.53% of the variability in standard, HVI productivity growth is explained by the same indicator derived from vertically integrated sectors.

4. Results

4.1. General aspects

Table 1 shows the annual rates of change of value added at basic prices, labour, and the standard rate of productivity for Argentina's economy in the period considered. As observed in table 1, the predominant feature across all these variables is volatility and decline, which is particularly evident post-2011. Specifically, the table indicates that, since that year, both employment and productivity have experienced diminished growth rates, with some instances showing negative trends.

Productivity and value added grew steadily until 2011, with the exception of the drop due to the international financial crisis. During this stage, the established macroeconomic scheme (exchange rate administration, export rights, boost to aggregate demand) added to high exports and terms of trade, and it promoted productivity growth, although some authors maintain that a structural transformation was not promoted (Fernández Bugna and Porta, 2008; Coatz et al., 2013; Abeles and Amar, 2017; Abeles et al., 2018]).

From 2012 onwards, an erratic behaviour of value added began, with alternating growth and decline years. This dynamic was interrupted in 2018 as a result of a crisis in the balance of payments that led the economy into a recession. The total productivity of the Argentine economy followed the described dynamics, confirming the procyclicality of this variable (Grotz, 2020; Amico et al., 2011).

The dynamics of labour generation throughout the period did not accompany the general volatility, decreasing only in 2015, 2018, and 2020. A certain stability is reflected in the generation of labour with respect to the level of activity, which could be linked to the behaviour of productivity (Carvalho and Viego, 2021). As pointed out by Amico et al. (2011), when economies emerge from a recession, production increases by a greater proportion than employment, and, when economies enter a recession, production decreases by a greater proportion than employment. This lies behind the pro-cyclicality of productivity.

Between 2005 and 2011, productivity grew at an average annual rate of 2.77%; between 2012 and 2019, the average rate of variation was –1.21%. For reference, Argentina's GDP at constant prices grew, on average, 5.7% during the first period and –0.62% during the second, according to OECD data.

When observing the joint dynamics of labour and productivity, a question arose as to the structural causes that could be behind the break from 2011 onwards. In order to obtain a first approach, a shift-share analysis exercise was carried out (Timmer and Szirmai, 2000) to decompose the variation in productivity into two factors: i) an external factor, caused by the displacement of the labour force given a certain level of productivity (*shift effect*), and ii) an internal factor, caused by changes in the general productivity of the economy given a certain sectoral distribution of labour (*intra effect*) (Brondino, 2019).

Following the above periodisation, during the first period (2005-2011) the variations in standard productivity were exclusively due to increases in productivity at the subsystem level and not to shifts in the labour force between subsystems. Thus, the *intra effect* explained, on average, 99% of the variation in the standard rate of growth of productivity (SRGP). This finding is in line with previously cited studies, which assert that productivity growth during this period was driven by macroeconomic conditions. On the other hand, in the second period (2012-2019), the *shift effect* explained, on average, 41% of the variability in productivity. This indicates that, in part, the poor performance is explained both by the displacement of the labour force from high-productivity sectors to low-productivity sectors and, to a greater extent, by the behaviour of productivity at the subsystem level.

Regarding the first aspect, when the shift is from low-productivity sectors to high-productivity sectors, part of the specialised literature refers to this phenomenon as the "*structural bonus hypothesis*". In particular, this hypothesis has been the subject of research on the processes of development and structural change in both advanced nations (Peneder, 2003) and emerging nations (Timmer and Szirmai, 2000; Singh, 2004). However, in this case, there is evidence for the study of the opposite hypothesis, which some authors have defined as the "*structural burden hypothesis*" (Di Meglio et al., 2018).

The conjunction of a decreasing average total productivity and a higher relevance of the effect that explains the displacement of the labour force during the second period leads the research on the dynamics of HVI labour at the subsystem level.

Table 1 – *Annual change in value added, labour and productivity, Argentina, 2005-2019 (%)*

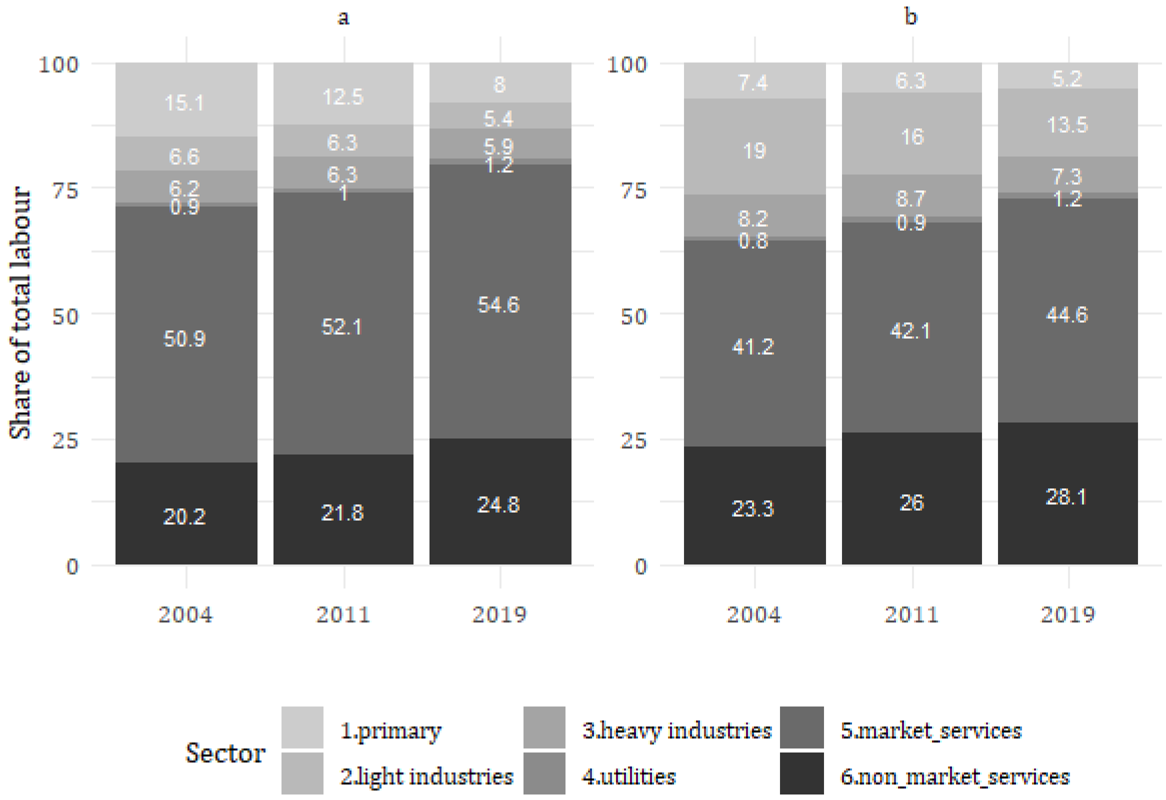
Year	Value added	Labour	SRGP	Intra effect	Shift effect
2005	9.13	4.89	4.40	90.51	9.49
2006	7.52	4.13	4.14	163.45	–63.45
2007	8.26	2.30	4.65	96.17	3.83
2008	4.09	0.81	2.40	66.61	33.39
2009	–5.54	1.19	–6.12	82.74	17.26
2010	10.24	1.18	7.50	95.06	4.94
2011	6.57	2.20	2.45	96.15	3.85
Average (2005-2011)	7.64	2.39	2.77	98.67	1.33
2012	–0.98	0.99	–3.28	34.31	65.69
2013	3.77	0.81	1.20	122.99	–22.99
2014	–1.03	1.13	–2.38	72.81	27.19
2015	2.82	0.24	0.35	–95.82	195.82
2016	–2.45	2.16	–3.46	102.38	–2.38
2017	2.23	1.62	0.12	26.60	73.40
2018	–5.68	1.12	–2.51	103.06	–3.06
2019	–1.51	1.41	0.25	103.11	–3.11
Average (2012-2019)	–0.35	1.19	–1.21	58.68	41.32

Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.

4.2. Production structure, labour, and demand

In principle, the Argentine productive structure – its transformations and impacts on productivity – can be explored in figure 1. This graph demonstrates both the true size of the industrial sector and the absence of major structural changes, even with a greater presence of services at the expense of industry.

Figure 1 – *Industry-level jobs and HVI labour by sector, 2004, 2011, and 2019, Argentina*



Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.

On the left side ('a'), the graph incorporates the distribution of direct labour among the six sectoral aggregations considered[5] for the base year of the analysis (2004), the last year of the first period (2004-2011), and the last year of the second period (2012-2019). On the right side ('b'), the figure shows the percentage distribution of HVI labour among the six industrial categories for the same study years. In other words, the left side indicates where the labour is recorded, while the right side refers to which subsystem accounts for the labour.

[5] The categorisation is based on Montresor and Marzetti (2011) but disaggregating the industries into light industry and heavy industry.

For 2004, jobs involved mainly services (72%), the primary sector (15.1%), and manufacturing (12.9%). Of particular importance are market services (50.9%), followed by non-market services (20.2%), the primary sector (15.1%), light industries (6.6%), heavy industries (6.2%), and water and electricity supply (0.9%).

For 2011, the first period indicates a strong growth of services (+2.9 percentage points, p.p.) at the expense of the representation of the primary extractive sector (−2.6 p.p.). Water and electricity supply services, market services, and non-market services grow 0.1 p.p., 1.2 p.p. and 1.6 p.p., respectively. Industry shows relative constancy; the slight decline in light industry (−0.3 p.p.) is balanced by the increase in heavy industry (0.1 p.p.).

In 2019, the importance of services saw a significant increase compared to 2011, driven by a growing dynamism in market services (+2.6 p.p.) and non-market services (+3 p.p.). Conversely, the primary sector experienced a marked decline in its relative importance (−4.5 p.p.), while the industrial sector exhibited a less pronounced tendency towards stagnation (−1.3 p.p.). Specifically, light industry saw a decrease of -0.9 p.p. and heavy industries experienced a decrease of −0.4 p.p.

Regarding the use of subsystems, it proposes continuities and ruptures with respect to the structure previously described.

For 2004, although services continue to account for most of the labour (65.3%), the representation of industry grows strongly (it represents 27.3% of labour) and the primary sector decreases in relevance as a generator of labour (7.4%). The industry that most increases its importance is light industry (19%), whereas the services that lose proportion are the market services (41.2%, a decrease of almost 10 p.p.).

The first period of analysis (2004-2011) maintains the trend highlighted at the industrial level; services grow (with a greater relevance of non-market services) and, unlike the previous approach, the importance of both industry and the primary sector had similar decreases, with percentage-point losses much more accentuated in the case of light industry (−3 p.p.).

In 2019, a similar trend in job levels was observed, albeit with variations in the percentage points of change. Services experienced less growth (+4.9 p.p), which was attributed to a slower increase in non-market services (+2.1 p.p.). Conversely, the industrial sector demonstrated a significant decline (−3.9 p.p.), particularly driven by decreases in light industries (−2.5 p.p.) and heavy industries (−1.4 p.p.).

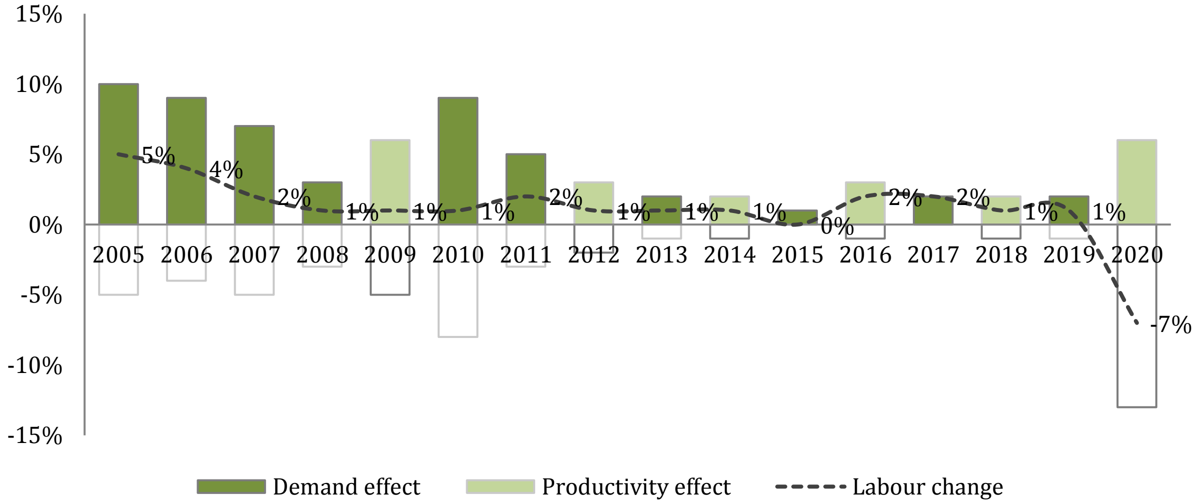
In summary, at the subsystem level, the initial growth phase witnesses a decline in both primary and industrial labour, highlighting a significant surge in service-driven employment, particularly in subsystems oriented towards non-market sectors. Moving into the subsequent period, while the significance of services remains pronounced (this time including both market and non-market services), it is at a reduced level compared to industry job levels. Additionally, notable changes are evident at the aggregate level, which are attributed to decreased levels in the primary sector (−1.1 p.p.) and industry (−3.9 p.p.), mainly influenced by declines in light industries. These results are in line with the work of Molina et al. (2021) and with the thesis of Pagés (2010), according to which the increase in employment in low-productivity services has contributed to low aggregate productivity growth in Latin America.

Although there have been no major changes among HVI labour categories since 2011, the continuous rise of some service sectors is observed. The changes in some sectors and the statistics at the subsystem level are sufficient to have a partial impact on the total productivity level. To study the reasons for the transformations, it is assumed that changes in HVI labour may be caused by technical changes and/or changes in the level of demand. To distinguish the weight of both contributions, a structural decomposition analysis (SDA) is proposed (cf. Miller and Blair, 2009, p. 593).

Figure 2 depicts labour growth and its sources, with the absolute changes in each year divided by the level of labour in the previous year. In effect, each percentage corresponds to the year-over-year growth in labour, disaggregated due to unique changes in demand or productivity. As we can observe, the prominent feature of the graph is the shift in dynamics for both demand and productivity effects since 2012.

The first period reflects positive average labour growth (+2.4%), explained by a demand dynamic (+5.4%) higher than the effect of productivity growth[6] (–3%). The second period shows stagnation in labour generation (+0.4%), explained by the opposite dynamics of the previous period. In this case, demand stagnates and even destroys jobs (–0.7%), and the decline in technical change increases the number of jobs generated at the same level of demand (+1,1%).

Figure 2 – *Labour growth dynamics, productivity, and demand effects, 2005-2020, Argentina*



Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.

Figure 3 provides a deeper look at activated labour by demand category. The graph illustrates another aspect of changes in demand, wherein there have been minor yet significant transformations in composition.

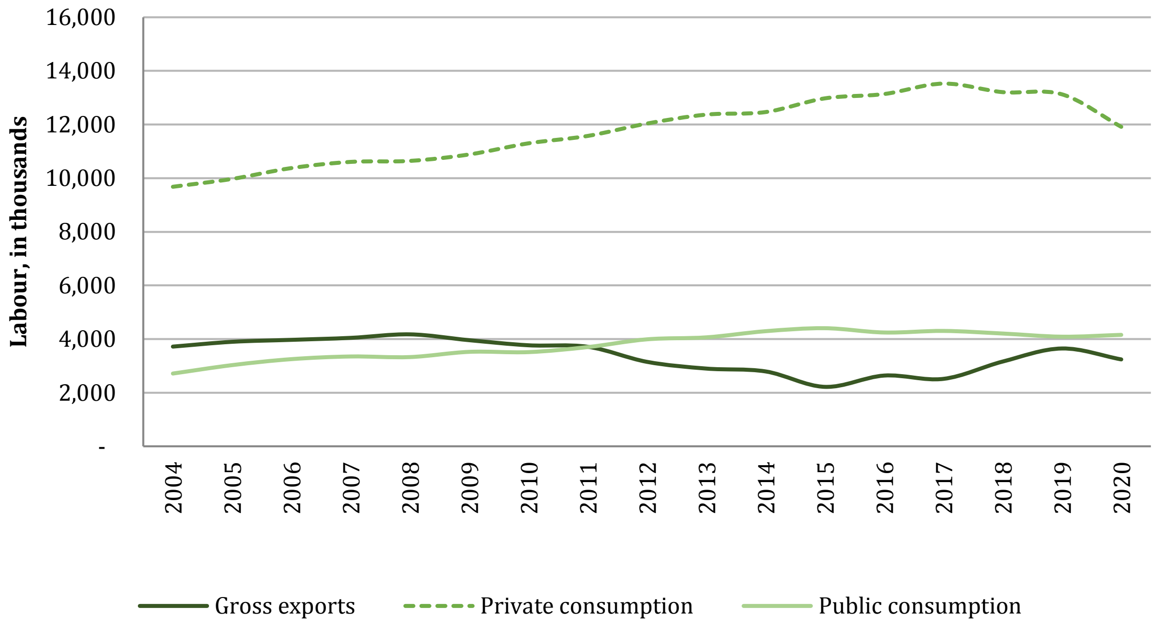
The changes in the significance of the components have not altered the fundamental nature of demand-driven labour, which is mostly generated by private consumption. Indeed, in relative terms, private consumption explains 59% of activated labour in the first period and 64% in the second, showing that its importance has even increased. In absolute terms, it represents 10.5 million (M) and 12.6 M jobs, respectively.

However, among the structural differences from one period to the other, the loss of significance of jobs generated from exports and the increase in the relative share of labour activated by public consumption stand out. In relative terms, exports decrease from an average of

[6] Note that an increase in productivity is equivalent to a decrease in HVI labour per unit of net output, which decreases labour if there is no change in demand.

22% of activated labour in the first period to 15% in the second, whereas labour activated by public sector demand increases from 18% to 21%. In absolute terms, the average increase in labour due to public spending (0.9 M) compensates for the loss of jobs due to the behaviour of foreign demand (–0.9 M). Both phenomena are linked to changes at the subsystem level, a relative loss of weight of the primary sectors, and a continuous increase in the proportion of labour linked to non-market services.

Figure 3 – *HVI labour by final demand components, 2004-2020, Argentina*

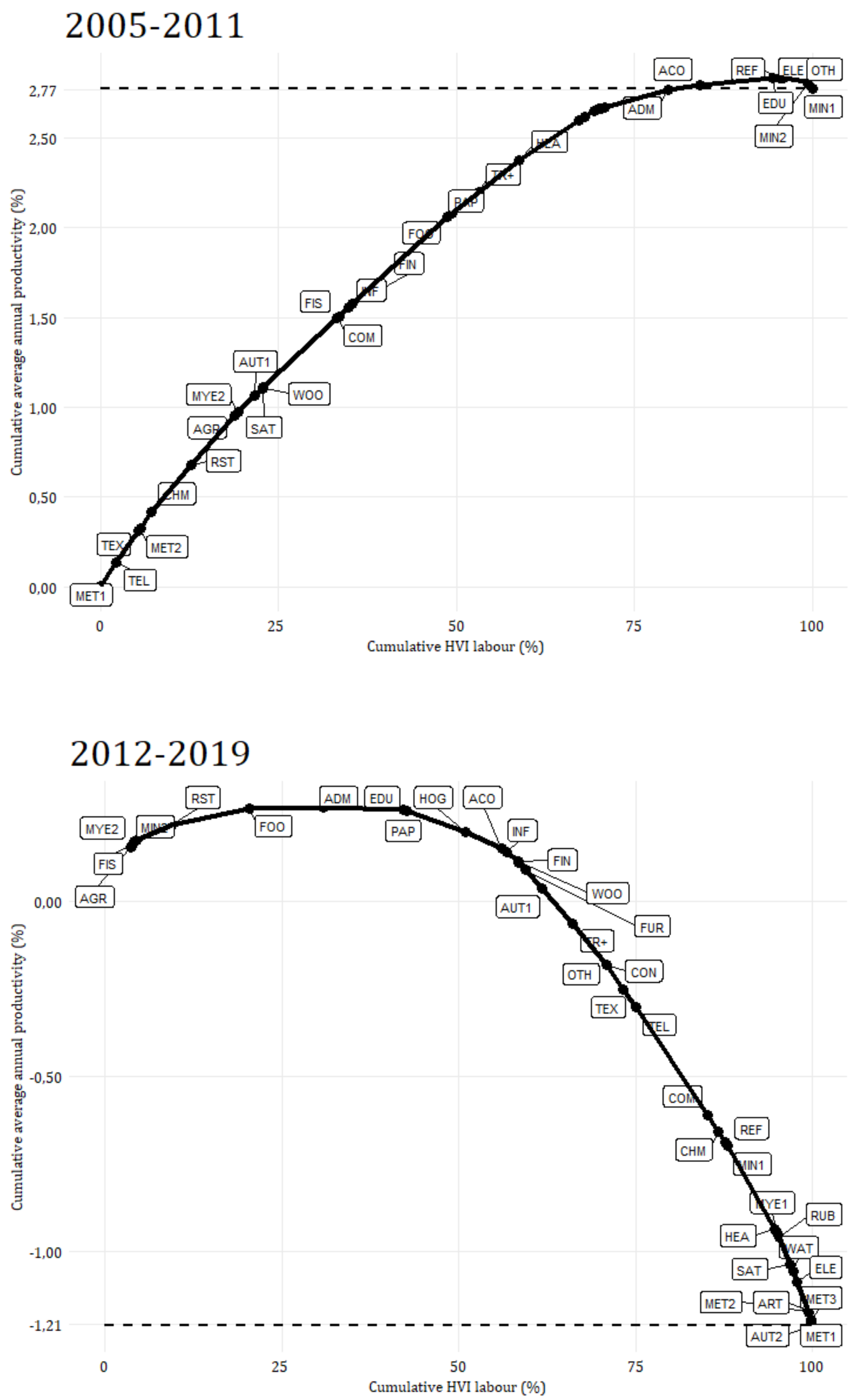


Source: Own elaboration based on OECD (2022), TiM (2023) and INDEC (2023) data.

4.3. Technical change

When analysing technical change, it is useful to consider the concepts of "mushroom and yeast processes" (Harberger, 1998). Some changes exhibit explosive growth, akin to a mushroom sprouting overnight. Others show gradual and uniform growth over time, resembling the growth of yeast. This distinction is crucial, as productivity growth in industry can be driven by explosive growth in a few companies or by uniform growth across all productive sectors. Although the next visualisation is not the original Harberger diagram, it draws on the concept and the spirit, making it a useful tool to study this phenomenon. These adapted Harberger diagrams are constructed on the basis of the contribution made by each subsystem to the SRPG, in correspondence with the share of HVI labour of the subsystem at the beginning of each period, 2004-2011 and 2012-2019, respectively (Wirkierman, 2022). The Harberger diagrams for each period studied are presented in Figure 4. In essence, the figure illustrates how the concentration of technical change was greater during the second period.

Figure 4 – *Adapted Harberger diagrams for the periods under analysis*



Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.

During the first period, there was uniform growth in the 31 sectors that contributed positively to the variation in productivity. However, it is worth noting that the seven subsystems with the highest productivity growth accounted for more than 50.00% of HVI labour at the beginning of the period. In turn, the negative contribution of the rest was relatively small, accumulating only 0.06% among the Refining (REF), Electricity supply (ELE), Others services (OTR), Non-energy mining and support (MIN2), and Energy-mining (MIN1) subsystems (see table A2 in the appendix). In this regard, similar patterns can be read in Carvalho Lopes and Viego (2021), where the productivity of the sectors during this first period resulted in a uniform increase in productivity in each of them.

Regarding the second period studied, although seven subsystems contributed positively to the SRPG variation, only three of them had a significant contribution: Agriculture (AGR) at 0.16%, Food and beverages (FOO) at 0.05%, and Real estate and administrative activities (RST) at 0.05%; the other four had positive contributions below 0.01%. On the other hand, the negative contributions can be divided into three groups, with 18 subsystems having contributions in the 0.00 to –0.05% range, seven subsystems having contributions in the –0.05 to –0.10% range, and three subsystems having contributions in the 0.10 to –0.24% range. The net effect during the period constitutes a decrease in the SRPG, which illustrates a particular form of the Harberger diagram, as can be observed. During this period, the sectors that accounted for the majority of HVI labour had a poor performance. Five other sectors, together comprising almost 40% of HVI employment, experienced declines (Commerce, –0.31%; Household activities, –0.06%; Health, –0.24%; Accommodation, –0.05%; Others, –0.12%; and Transportation, –0.10%); this resulted in a cumulative decrease of -0.87% out of the total –1.21% for the period.

Based on the classification proposed by Montresor and Marzetti (2011), the diagrams indicate that, in both periods, the contribution made by the "market services" subsystem was decisive, standing out for the amount of HVI labour nucleated within its component sectors. With respect to growth in the first period, the subsystem contributed 1.30% out of the total 2.83%, whereas in the second period it contributed –0.74% of the total –1.32%. On the other hand, the "utilities" subsystem was the one that contributed the least in both the first and the second periods, being also the classification with the lowest amount of HVI labour in both periods.

Inklaar and Timmer (2007) developed diagram metrics that enable the study of the diagrams with an additional degree of rigour, allowing the above description to be put together in numerical values. Indeed, the authors linked the share of industries with positive growth as an indicator of pervasiveness of growth and the curvature of the diagram as an indicator of the concentration of growth. The results of both indicators are intuitive in relation to the above description. Indeed, the pervasiveness indicator yields a value of 83.33% for the first period – corresponding to the 31 sectors that grew, compared to the total number of sectors – and 19.44% for the second period – with only seven sectors contributing positively to the SPRG. The curvature of the diagram for the first period was 14.75%, whereas for the second period it was 23.71%. Thus, the value associated with the period 2005-2011 is in line with the mention of relative uniformity in the contribution made by each of the 31 subsystems, while in the second period a slight increase is observed in the indicator, calculated with a relatively smaller number of sectors.

4.3.1. *Sources of technical change: direct and indirect labour productivity dynamics*

Beyond its performance at the sectoral level, another relevant aspect of the change in productivity refers to its composition. A subsystem may show productivity increases as a result of the lower use of direct labour inputs or due to savings in the labour requirements necessary to produce indirect inputs. In order to recognise the effects of direct and indirect technical change, the methodological works of Garbellini and Wirkierman (2010) and Brondino (2019) are used.

Table 2 – *Total productivity change analysis, Argentina, 2004-2011 and 2012-2019*

		2004-2011					**2012-2019**				
Classification	**Sectors**	**Net surplus**	**TLP**	**DLP**	$\lambda^{*}(\Lambda)$	**Imports**	**Net product**	**TLP**	**DLP**	$\lambda^{*}(\Lambda)\lambda^{*}(\Lambda)$	**Imports**
1. Primary	AGR	4.7%	4.8%	4.5%	–2.4%	8.8%	4.3%	3.9%	5.6%	1.0%	29.5%
	MIN1	1.2%	–4.4%	–19.7%	–6.7%	14.7%	0.5%	–3.1%	3.2%	–3.9%	32.5%
	MIN2+	0.5%	–4.0%	–7.2%	12.8%	18.1%	0.5%	1.2%	6.1%	–10.7%	26.6%
	FIS	0.3%	3.8%	1.9%	–3.3%	5.3%	0.3%	3.4%	8.7%	7.9%	32.3%
	Subtotal	**6.8%**	**0.1%**	**–5.1%**	**0.1%**	**11.7%**	**5.6%**	**1.4%**	**5.9%**	**–1.4%**	**30.2%**
2. Light industries	FOO	16.6%	3.7%	2.6%	–0.7%	10.1%	14.9%	0.4%	–2.5%	1.8%	30.8%
	WOO	0.1%	4.0%	0.6%	–4.0%	9.6%	0.1%	–1.9%	–2.3%	–1.0%	30.5%
	PAP	0.8%	3.5%	–0.2%	–3.7%	3.2%	0.7%	–0.4%	1.2%	0.2%	30.2%
	TEX	3.4%	6.1%	4.7%	–3.5%	4.4%	2.7%	–2.6%	–3.1%	–2.0%	30.8%
	Subtotal	**20.9%**	**4.3%**	**1.9%**	**–3.0%**	**6.8%**	**18.4%**	**–1.1%**	**–1.7%**	**–0.2%**	**30.6%**
3. Heavy industries	AUT1	2.6%	4.0%	7.9%	4.8%	10.8%	2.7%	–2.0%	–6.7%	–3.6%	31.5%
	AUT2	0.1%	1.3%	–1.2%	–0.7%	10.9%	0.1%	–9.1%	–11.7%	10.9%	42.3%
	RUB	0.7%	1.8%	–1.1%	–2.6%	8.3%	0.5%	–3.9%	–4.0%	–4.5%	31.6%
	INF	0.4%	3.8%	15.1%	8.3%	9.2%	0.7%	–1.3%	1.5%	–6.6%	26.1%
	MET1	0.2%	6.9%	10.6%	0.9%	7.2%	0.2%	–7.6%	–11.5%	6.4%	32.1%
	MET2	0.8%	6.0%	–1.9%	0.9%	6.4%	0.6%	–4.9%	–10.4%	4.9%	31.9%
	MET3	0.4%	1.2%	0.8%	–5.6%	10.7%	0.3%	–5.0%	–6.1%	3.8%	32.4%
	FUR	0.8%	2.4%	1.7%	–1.9%	8.0%	0.7%	–1.9%	–2.7%	–1.0%	28.0%
	MYE1	0.4%	2.0%	5.9%	2.4%	12.4%	0.4%	–3.4%	–14.1%	1.6%	29.9%
	MYE2	0.3%	4.2%	10.5%	0.9%	11.2%	0.3%	2.4%	4.4%	–6.3%	24.4%
	CHM	3.7%	5.8%	5.6%	–2.8%	5.6%	4.1%	–2.7%	–1.5%	–2.9%	30.4%
	REF	2.6%	0.0%	–3.7%	–3.4%	12.6%	1.9%	–2.8%	5.4%	–0.6%	33.3%
	Subtotal	**13.1%**	**3.3%**	**4.2%**	**0.1%**	**9.5%**	**12.4%**	**–3.5%**	**–4.8%**	**0.2%**	**31.2%**

4. Utilities	WAT	0.3%	1.7%	2.0%	–0.1%	11.7%	0.3%	–4.5%	–4.1%	11.9%	31.2%
	ELE	1.3%	–0.3%	–1.6%	–0.2%	12.1%	1.5%	–4.6%	0.0%	1.7%	34.1%
	Subtotal	**1.7%**	**0.7%**	**0.2%**	**–0.1%**	**11.9%**	**1.8%**	**–4.5%**	**–2.1%**	**6.8%**	**32.7%**
5. Market services	ACO	3.7%	0.6%	2.6%	5.3%	13.3%	3.8%	–0.8%	–1.9%	0.5%	29.9%
	ART	2.0%	2.3%	–3.5%	–3.3%	8.4%	1.7%	–4.8%	–10.1%	–8.2%	28.5%
	COM	10.3%	3.9%	4.8%	5.2%	12.5%	10.3%	–2.7%	–1.6%	0.9%	34.4%
	CON	0.0%	1.1%	–1.3%	0.0%	10.1%	0.0%	–2.4%	–4.5%	0.0%	26.8%
	TEL	3.8%	6.2%	12.9%	5.0%	8.4%	4.0%	–2.6%	1.4%	–3.5%	28.2%
	SAT	1.1%	4.0%	7.0%	13.3%	16.1%	1.5%	–4.2%	–5.0%	2.0%	30.4%
	FIN	3.3%	3.8%	3.2%	–4.4%	6.7%	3.9%	–1.5%	–0.8%	–6.3%	30.2%
	HOG	0.7%	2.8%	2.8%	0.0%	0.0%	0.6%	–0.7%	–0.7%	0.0%	0.0%
	RST	8.5%	4.8%	5.0%	–3.3%	5.2%	9.3%	0.8%	0.3%	–0.1%	23.8%
	OTH	2.3%	–0.6%	0.8%	5.0%	15.8%	2.4%	–2.2%	–3.0%	–2.3%	26.6%
	TR+	5.0%	3.3%	1.5%	0.0%	8.7%	5.5%	–2.0%	–3.1%	–1.2%	28.7%
	Subtotal	**40.7%**	**2.9%**	**3.2%**	**2.1%**	**9.6%**	**43.0%**	**–2.1%**	**–2.6%**	**–1.7%**	**26.1%**
6. Non-market services	ADM	7.6%	1.1%	1.4%	4.1%	10.8%	8.5%	0.0%	–1.2%	–3.1%	23.4%
	EDU	4.7%	0.4%	0.8%	7.1%	15.9%	5.1%	–0.1%	–0.4%	–2.2%	25.0%
	HEA	4.5%	3.2%	4.0%	0.0%	11.3%	5.1%	–3.1%	–3.6%	–1.2%	28.0%
	Subtotal	**16.8%**	**1.6%**	**2.1%**	**3.7%**	**12.7%**	**18.7%**	**–1.0%**	**–1.7%**	**–2.2%**	**25.5%**

Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.
Note: $\lambda^*(\Lambda)$ refers to the variation of the logarithm of the dominant eigenvalue of lambda (see equation 1).

Table 2 shows the performance of the subsystems in the two periods under analysis, and it demonstrates the patterns of technical change over different periods. In summary, it aims to highlight the differences concerning mechanisation and scaling processes, as well as the significance of the substitution process, whether it is reversed or not.

The variables considered are: the weight of each sector in total surplus (or total consumption), the average year-on-year variation of TLP, of direct labour productivity (DLP), of the intensity in the use of intermediate inputs (the scalar indicator lambda, cf. Rampa, 1981), and of the coefficients of HVI imports. In turn, the subtotals corresponding to the sectoral classification of Montresor and Marzetti (2011) are incorporated.

As table 2 shows, the first period of productivity growth indicates that 32 out of 36 sectors increase in average TLP; these subsystems account for 94.6% of the surplus for final consumption.

At the aggregate level, the highest average increase in productivity is recorded in light industries (4.3%). In this sense, at the subsystem level, the textile sector is the sector with the best performance (6.1%).

In relation to the type of technical change, 16 sectors show a higher direct technical change than the total, and another 20 have a lower direct technical change dynamic. The former account for 51% of the surplus, whereas the latter represent the remaining 49%. Therefore, it can be stated that the first period was characterised by processes of both direct and indirect labour saving.

The greater use of inputs can be linked to a process of mechanisation (Brondino, 2019). This refers to the replacement of direct labour by machines that consume new and more raw materials (and more indirect labour that compensates for direct savings) or to greater indirect labour but with equal or lower input use, a process registered when there is no change in the proportion of local input use and the inputs come from sectors with decreasing productivity.

At the aggregate level, the increase in the level of mechanisation was present in 14 out of 16 subsystems, while economies of scale were identified in only two sectors. This generates new evidence for studies of industrial reactivation in Argentina, since, although some studies point to the process of incorporation of capital goods in industry (Kulfas, 2016), most conclude that the period was dominated by economies of scale (Rivas and Robert, 2015). Nevertheless, mechanisation was present and included some heavy industries (5 out of 12) and some market services (5 out of 11), such as telecommunications, professional, scientific, and technical activities or wholesale trade and retail trade.

However, when analysing the behaviour of imported inputs, the higher relative use of indirect labour is not accompanied by fewer imports, giving rise to a process of import substitution. On the contrary, all these sectors increase their total imports per unit of product. This phenomenon is in line with some of the literature that has pointed out the import bias of certain industries under special regimes, especially the automotive and electronics industries (Kulfas et al., 2014; Bekerman and Vázquez, 2016; Kulfas et al., 2017).

The remaining 20 sectors with higher indirect labour savings mostly exhibit fewer local inputs (17). Likewise, such savings are accompanied by foreign inputs, leading to a process of reverse substitution of inputs.

At the aggregate level, this behaviour is observed in most of the primary sector, most of the light industries (among the most significant ones, the textile industry), some heavy industries (6 out of 12), and some market services (3 out of 11). Among the most relevant subsystems, the food sector (16.6% of the surplus), transportation (5% of the surplus), and the chemical sector (4% of the surplus) stand out. In this case, the agreement with the literature is partial, since the process of input savings has not been studied in depth, although some studies have pointed out the import bias in capital goods in growth industries such as metalworking, textiles, chemicals, automobiles and electronics (Wainer and Schorr, 2015).

The second period is characterised by lower productivity, which has also been reported in the literature (Carvalho Lopes and Viego, 2021). Only 6 out of 36 sectors show an increase in productivity, representing 37.8% of the surplus. The rest of the sectors present negative dynamics, absorbing 62.2% of the surplus. In other words, the majority of the most relevant sectors presented a negative dynamic.

Regarding the rate of technical change, the second period does not include an equal distribution between sectors with higher and lower direct productivity than total productivity. As for the percentage of the surplus, those with greater indirect labour savings account for 66% of the surplus, whereas those with lower indirect labour savings account for 34%. In other words, there is greater inefficiency in the use of indirect than direct labour.

Among the 15 sectors that present direct labour savings greater than the total (less indirect labour savings), only 7 increase their use of inputs. In turn, the greater use of local inputs may not imply greater inefficiency if it is accompanied by lower imports, which may indicate some substitution. This process is not present in any sector.

The other 8 sectors decrease the use of their inputs and increase imports while incurring more indirect labour; such a phenomenon implies the use of more indirect techniques (a process present in 4 heavy industries).

The second group of 21 sectors presents lower direct labour savings; that is, it shows some savings in indirect inputs that compensate for the higher use of direct labour. In this case, if this process is linked to a lower use of internal inputs, there is a lower level of mechanisation. This type of process was observed in 12 sectors, including among the most important ones: Textiles (TEX), Automotive (AUT1), Accommodation (ACO), and Transportation (TR+). The 9 other sectors include some processes of diseconomies of scale and more imports in major heavy industries: Auxiliary automotive (AUT2), Metal products (MET3), and Electric products (MYE1).

4.4. Summary

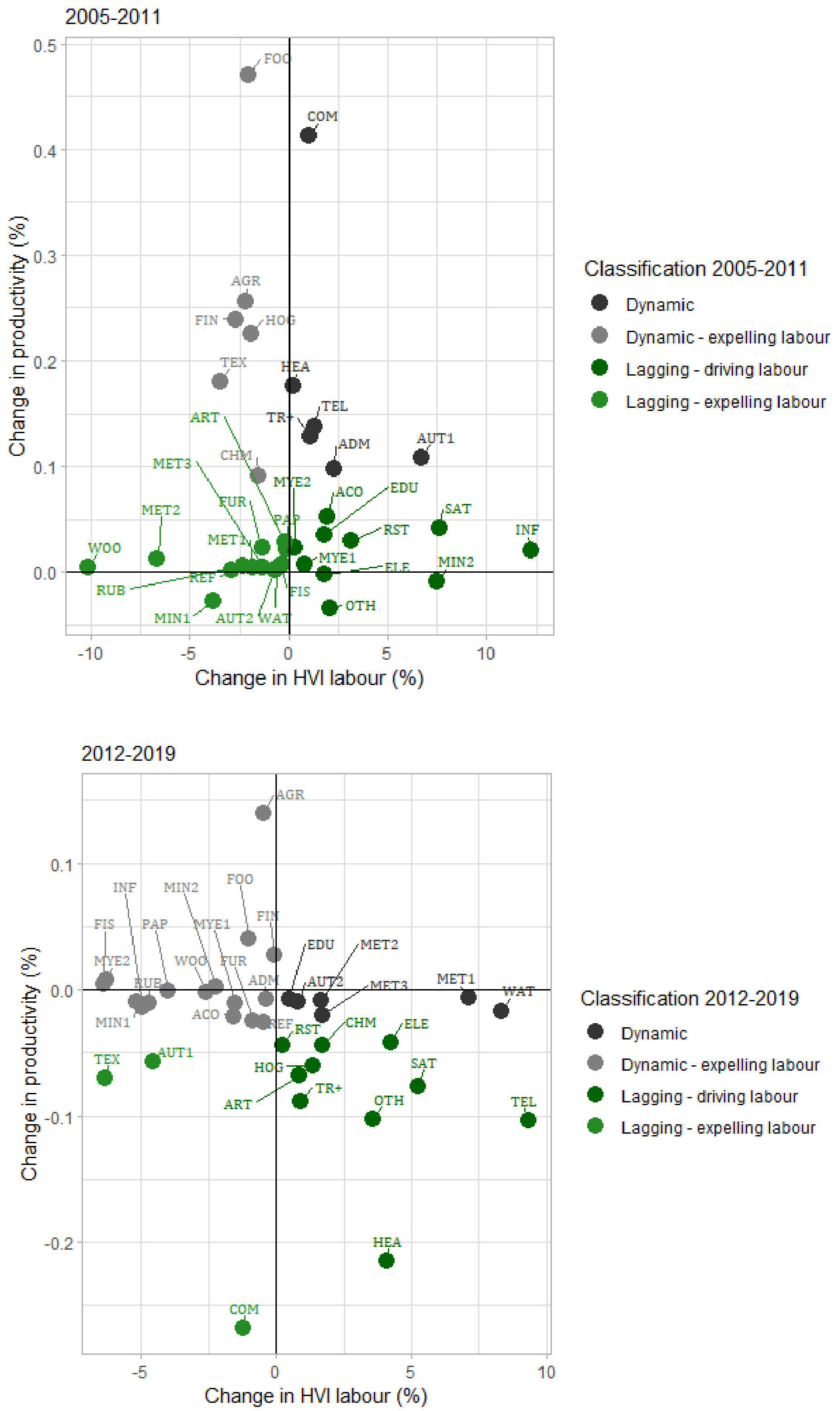
From a structural point of view, not all subsystems play the same role during the development process. Therefore, it is relevant to add to our analysis a characterisation of the subsystems in each period, differentiating between those that have the capacity to drive sustained growth. For this purpose, we adopt the classification described in Garbellini and Wirkierman (2014), described in the methodological section.

Figure 5 shows the subsystems within each classification for each subperiod considered. In particular, it illustrates the dynamic sectors of the first period and their transformation into lagging sectors in the second period. The vertical axis shows the variations in the productivity of each subsystem, whereas the horizontal axis shows the variations in the share of total labour for each subsystem.

During the first period (2005-2011), dynamic subsystems contributed 1.06% to productivity growth and increased, on average, their share in total labour by 2.08%. These are, to a greater extent, services, mainly market services. specifically, Trade (COM), Publishing and telecommunication (TEL), and Transportation (TR+), although there are also systems belonging to non-market services, such as Public administration (ADM) and Health (HEA). The dynamic-expelling subsystems grew by 1.46% in productivity and decreased their share in total labour, on average, by 2.31%. The subsystems belonging to the light industry, such as Food and beverage (FOO) and Textiles (TEX), stood out. Agriculture (AGR) and real estate (RST) and administrative activities are also included. The lagging-driving and lagging-expelling subsystems contributed to productivity growth by 0.16% and 0.09%, respectively, whereas the former increased their share of total labour by 3.93% and the latter decreased by 2.48%. Among the lagging-driving subsystems, market services such as Accommodation (ACO), Science and technology (SAT[7]), Education (EDU), and Financial services (FIN) stand out. However, within this subgroup, the one that has increased its share of total labour the most is the Informatic technology (INF) sector, a heavy industry.

[7] These are sometimes labelled as knowledge-intensive business services (KIBS).

Figure 5 – *Sectoral dynamics of productivity and labour in Argentina*



Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.

During the second period (2012-2019), in which total average productivity decreases in the whole economy, there is clear evidence of a greater number of dynamic subsystems, but with a negative contribution in productivity of -0.07% and an increase in the share of total average labour of 3.36%. This group includes mainly heavy industry sectors such as Auxiliary automotive (AUT2) and Iron and Steel (MET1, MET2, MET3) but also utilities such as Water supply (WAT). As in the first period, the dynamic-expelling subsystems have a greater contribution to total productivity, on the order of 0.09%, and their share in total labour is decreases by, on average, 2.66%. The agricultural sector (AGR) stands out as the most dynamic sector during this period in the entire economy, and the fishing industry (FIS) stands out as the one that loses the largest share of jobs. The lagging-driving subsystems increase their share in total labour by an average of 3.16%, whereas the lagging-expelling subsystems lose their share in total labour by an average of -4.03%. It is worth noting that among the lagging subsystems are sectors that were dynamic during the previous period, such as Communications (TEL), Households activities (HOG), Chemical (CHM), Transportation (TR+), and Health (HEA), which in turn are among those that increase their share of labour the most.

In summary, the dynamic subsystems that drive productivity growth during the first period are services, both market services (communications, commerce, transportation, real estate) and non-market services (public administration and health), which is in line with similar studies (OIT and CEPAL, 2023). Within the transforming industries, only two subsystems of light industry (food and textile) and two of heavy industry (automotive and chemical) stand out. This is in line with the work of Abeles et al. (2018), which argues that, in the first decade of the 2000s, labour-intensive and engineering-intensive industries gained share in manufacturing value added, while the technological gap with core countries in these sectors increased.[8]

The general reduction in productivity in the second period is accompanied by a transformation of several dynamic subsystems (driving and expelling ones) into lagging subsystems. This applies to the health, household activities, transportation, and communications sectors. This behaviour is in line with our hypothesis of a negative structural change.

5. Conclusions

Beyond the debates regarding its drivers or measurement, there is a broad consensus on the importance of productivity in explaining the issues that hinder the growth and development of national economies. In this context, the present study revisits this key aspect by considering productivity and its interaction with the productive structure, as highlighted by the structuralist tradition, a feature that is fundamental to understanding the conditions of development in Latin American countries.

Moreover, the present paper follows an alternative approach to the conventional view of productivity, which constitutes an empirical contribution to the recent literature on the topic in Argentina.

The study of the standard productivity growth rate confirms a decreasing trend in productivity in general, highlighting as significant both the technical changes at the subsystem level and the structural change in demand.

The structure of labour, in spite of reflecting slight changes in the productive structure in Argentina, has a certain impact on the overall dynamics. In general, there is partial evidence of the hypothesis of negative structural change, marked by a reduction in the significance of industry

[8]According to Pagés (2010), this is a longer-term trend for all Latin American countries and includes the service sector.

and a greater presence of services. Among the factors that drive this transformation, links with demand, such as the lower relative significance of exports and the greater weight of public consumption, stand out.

Regarding technical change, by concentrating the analysis at the subsystem level, the main driver is direct productivity in the first period and the stagnation of direct and indirect productivity in the second period. It is possible to consider the first period as one of uniform growth, characterised by mechanisation processes without import substitution. In relation to the second period, it is understood as more concentrated and with lower levels of mechanisation and diseconomy-of-scale processes.

In summary, changes in both demand and the technical processes of the sectors that are dynamic in the first period explain the performance of productivity in recent times. In this sense, part of the macro volatility and distributive conflicts is framed in problems related to technical progress and the productive structure. Not only is the second stage marked by greater external constraints, but technical change is also a key determinant of wages and growth. This analysis provides a solid basis for understanding the current situation, although it is important to note that identifying these factors is only the first step. To effectively address these challenges and promote the economic development of the country, it is essential to design industrial and scientific policies that respond adequately to these problems.

Appendix

Table A1 – –*Correspondence between the 45 OECD sectors and the 36 sectors used*

OECD sector		**Actual sector**	
AGR	Agriculture, hunting, forestry	AGR	Agriculture
FIS	Fishing and aquaculture	FIS	Fishing
MIN1	Mining and quarrying, energy producing products	MIN1	Energy-mining
MIN2	Mining and quarrying, non-energy producing products	MIN2	Non-energy mining and support
MIN3	Mining support service activities		
FOO	Food products, beverages and tobacco	FOO	Food and beverages
TEX	Textiles, wearing apparel, leather and related products	TEX	Textiles
WOO	Wood and products of wood and cork	WOO	Wood
PAP	Paper products and printing	PAP	Paper
REF	Coke and refined petroleum products	REF	Refining
CHM1	Chemical and chemical products	CHM	Chemical
CHM2	Pharmaceuticals, medicinal chemical and botanical products		
RUB	Rubber and plastics products	RUB	Rubber

MET1	Other non-metallic mineral products	MET1	Non-metallic
MET2	Basic metals	MET2	Basic metals
MET3	Fabricated metal products	MET3	Metal products
INF	Computer, electronic and optical products	INF	Information technology
MYE1	Electrical equipment	MYE1	Electric products
MYE2	Machinery and equipment n.e.c	MYE2	Other electric
AUT1	Motor vehicles, trailers and semi-trailers	AUT1	Automotive
AUT2	Other transport equipment	AUT2	Auxiliary automotive
FUR	Manufacturing nec; repair and installation of machinery and equipment	FUR	Furniture
ELE	Electricity, gas, steam and air conditioning supply	ELE	Electricity supply
WAT	Water supply; sewerage, waste management and remediation activities	WAT	Water supply
CON	Construction	CON	Construction
COM	Wholesale and retail trade; repair of motor vehicles	COM	Commerce
TR1	Land transport and transport via pipelines	TR+	Transportation
TR2	Water transport		
TR3	Air transport		
TR4	Warehousing and support activities for transportation		
POS	Postal and courier activities	TEL	Publishing and telecomunication
PRO	Computer programming, consultancy and information services activities		
TV	Publishing, audiovisual and broadcasting activities		
TEL	Telecommunications		
RST	Real estate activities	RST	Real estate and administrative activities
SUP	Administrative and support services activities		
ACO	Accommodation and food service activities	ACO	Accommodation
FIN	Financial and insurance activities	FIN	Financial services
SAT	Professional, scientific and technical activities	SAT	Science and technology
ADM	Public administration and defence, compulsory social security	ADM	Public administration

EDU	Education	EDU	Education
HEA	Human health and social work activities	HEA	Health
ART	Arts, entertainment and recreation	ART	Arts
OTH	Other service activities	OTH	Others services
HOG	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	HOG	Household activities

Table A2 – *Contribution to the SPRG by subsystem for the period 2005-2011, in percentages (%)*

			2005-2011	
			Cumulative	
Subsystem	RPG	Employment share	Employment Share	RPG
MET1	0.56	0.00	0.00	0.00
TEL	0.52	0.02	0.02	0.14
TEX	0.50	0.03	0.05	0.32
CHM	0.47	0.02	0.07	0.41
MET2	0.46	0.00	0.07	0.43
RST	0.36	0.06	0.13	0.66
MYE2	0.30	0.01	0.14	0.69
COM	0.30	0.10	0.24	1.10
AGR	0.30	0.06	0.30	1.36
WOO	0.30	0.00	0.30	1.36
SAT	0.29	0.01	0.31	1.40
AUT1	0.29	0.02	0.33	1.51
FIN	0.28	0.01	0.34	1.56
INF	0.28	0.00	0.35	1.58
FOO	0.26	0.15	0.49	2.05
TR+	0.25	0.04	0.53	2.18
PAP	0.25	0.01	0.54	2.20

HEA	0.24	0.06	0.59	2.38
HOG	0.18	0.09	0.68	2.61
FIS	0.17	0.00	0.68	2.61
FUR	0.16	0.01	0.69	2.63
ART	0.15	0.01	0.71	2.66
MYE1	0.12	0.00	0.71	2.67
RUB	0.12	0.00	0.71	2.68
WAT	0.10	0.00	0.72	2.68
AUT2	0.09	0.00	0.72	2.68
ADM	0.08	0.08	0.80	2.78
MET3	0.06	0.00	0.80	2.78
CON	0.06	0.00	0.80	2.78
ACO	0.04	0.04	0.84	2.81
EDU	0.02	0.09	0.94	2.85
ELE	−0.03	0.01	0.95	2.84
REF	−0.04	0.01	0.96	2.85
OTH	−0.06	0.03	0.99	2.81
MIN2+	−0.28	0.00	0.99	2.80
MIN1	−0.28	0.01	1.00	2.77

			2012-2019	
Subsystem	RPG	Employment share	Cumulative	
			Employment share	RPG
AGR	0.25	0.04	0.04	0.14
FIS	0.24	0.00	0.04	0.14
MYE2	0.19	0.00	0.04	0.15
RST	0.05	0.05	0.09	0.18
FOO	0.02	0.11	0.20	0.22
MIN2+	0.00	0.00	0.20	0.22
ADM	−0.01	0.10	0.31	0.21
EDU	−0.01	0.11	0.42	0.21

PAP	–0.05	0.01	0.42	0.21
HOG	–0.07	0.08	0.51	0.14
ACO	–0.07	0.05	0.56	0.10
INF	–0.12	0.01	0.57	0.09
FIN	–0.14	0.02	0.58	0.07
TR+	–0.16	0.04	0.63	–0.02
AUT1	–0.17	0.03	0.65	–0.08
FUR	–0.18	0.01	0.66	–0.10
CON	–0.18	0.00	0.66	–0.10
OTH	–0.19	0.05	0.71	–0.21
COM	–0.20	0.10	0.81	–0.47
CHM	–0.20	0.02	0.82	–0.52
TEX	–0.22	0.03	0.85	–0.59
REF	–0.22	0.01	0.86	–0.61
HEA	–0.23	0.06	0.92	–0.83
MYE1	–0.25	0.00	0.93	–0.84
MIN1	–0.26	0.00	0.93	–0.85
RUB	–0.28	0.00	0.93	–0.86
TEL	–0.28	0.02	0.95	–0.96
SAT	–0.30	0.01	0.97	–1.04
FUR	–0.32	0.00	0.97	–1.04
ART	–0.33	0.01	0.98	–1.11
MET3	–0.36	0.00	0.99	–1.13
MET2	–0.38	0.00	0.99	–1.14
WAT	–0.42	0.00	0.99	–1.16
ELE	–0.43	0.01	1.00	–1.20
MET1	–0.48	0.00	1.00	–1.20
AUT2	–0.61	0.00	1.00	–1.21

Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.
Note: SRPG reflects the average annual variations by subsystem.

Table A3 – *Classification of subsystems according to their contribution to the SRPG and the variation in their participation in the total employment share (TES)*

		2005-2011	
Classification	Subsystem	SRGP	TES
Dynamic	ADM	0.10	2.29
	AUT1	0.11	6.67
	COM	0.41	1.00
	TEL	0.14	1.28
	HEA	0.18	0.20
	TR+	0.13	1.06
	Subtotal	1.06	2.08
Dynamic–expelling labour	AGR	0.26	–2.21
	FOO	0.47	–2.04
	HOG	0.23	–1.92
	RST	0.24	–2.71
	CHM	0.09	–1.54
	TEX	0.18	–3.45
	Subtotal	1.46	–2.31
Lagging–driving labour	ACO	0.03	3.11
	SAT	0.04	7.64
	EDU	0.04	1.83
	ELE	0.00	1.83
	FIN	0.05	1.97
	INF	0.02	12.24
	MIN2+	–0.01	7.48
	MYE1	0.01	0.80
	MYE2	0.02	0.31
	OTH	–0.03	2.09
	Subtotal	0.16	3.93

Lagging–expelling labour	WAT	0.00	–0.63
	ART	0.03	–0.22
	AUT2	0.00	–0.71
	RUB	0.01	–2.30
	WOO	0.00	–10.15
	MET1	0.00	–1.83
	MET2	0.01	–6.63
	MET3	0.00	–1.30
	MIN1	–0.03	–3.82
	FUR	0.02	–1.35
	PAP	0.02	–0.09
	FIS	0.01	–0.36
	REF	0.00	–2.88
	Subtotal	0.09	–2.48

		2012-2019	
Classification	Subsystem	SRGP	TES
Dynamic	WAT	–0.02	8.37
	AUT2	–0.01	0.81
	EDU	–0.01	0.50
	MET1	–0.01	7.12
	MET2	–0.01	1.66
	MET3	–0.02	1.71
	Subtotal	–0.07	3.36
Dynamic-expelling labour	ADM	–0.01	–0.35
	AGR	0.14	–0.47
	RUB	–0.01	–4.69
	FIN	–0.02	–1.58
	FOO	0.04	–1.02
	INF	–0.01	–4.96

	RST	0.03	–0.04
	WOO	0.00	–2.57
	MIN1	–0.01	–5.18
	MIN2+	0.00	–2.23
	FUR	–0.02	–0.85
	MYE1	–0.01	–1.53
	MYE2	0.01	–6.31
	PAP	0.00	–4.00
	FIS	0.00	–6.40
	REF	–0.03	–0.46
	Subtotal	0.09	–2.66
Lagging-driving labour	ACO	–0.04	0.26
	ART	–0.07	0.84
	TEL	–0.10	9.36
	SAT	–0.08	5.28
	ELE	–0.04	4.26
	HOG	–0.06	1.36
	OTH	–0.10	3.58
	CHM	–0.04	1.72
	HEA	–0.21	4.08
	TR+	–0.09	0.89
	Subtotal	–0.84	3.16
Lagging-expelling labour	AUT1	–0.06	–4.55
	COM	–0.27	–1.23
	TEX	–0.07	–6.31
	Subtotal	–0.39	–4.03

Source: Own elaboration based on OECD (2022), TiM (2023), and INDEC (2023) data.
Note 1: SRPG reflects the average annual variations by subsystem, while the TES reflects the average annual variation in total labour participation.
Note 2: The subtotals in the SRPG category represent the sum of its components; for the TES, they represent the average.

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