What determined labour productivity in the Brazilian manufacturing industries in the 2000s?

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Abstract

In the 2000-2008 period (which covers the analysis of this paper), while the average real GDP growth was 3.72 per cent per year, the labour productivity had a negative variation of -0.95 per cent per year. There has been a "*cliché*" to evaluate the low economic growth rates as a result of low labour productivity growth in the last few decades in the Brazilian economy. However, according to the so-called Kaldor-Verdoorn Law, the reciprocal could also be true: the low growth rates of labour productivity in Brazil could be an effect of the low growth rates of the real GDP. We regress the change in labour productivity in the 2000-2008 period of 21 Brazilian manufacturing industries on three main variables: real GDP (which captures the Kaldor-Verdoorn Law), the ratio of gross investment to value added and technological innovation. In the several econometric models we ran, the real GDP growth was the most significant variable to explain the behaviour of labour productivity in the manufacturing industries in Brazil in the 2000s. This result suggests that the larger and more sustainable the real GDP growth in Brazil is, the greater will be its labour productivity growth rates. This result is also consistent with the Kaldor-Verdoorn Law, according to which the labour productivity growth is highly dependent on the growth rates of the economy as a whole. The investment only showed to be significant when it was included into the model with a lag of one period and when innovation (which was also significant) was incorporated as one of the explanatory variables of the labour productivity. Although this result seems to be consistent with theoretical expectations, it must be carefully analysed because, as innovation data is available for only few years, the number of observations is too few to make the empirical conclusion robust. In relation to the gross investment, specifically, although the literature suggests that labour productivity growth should respond positively to increasing gross capital formation, this latter explanatory variable was not significant in most models we ran. Even so, this unexpected result is consistent with some descriptive statistics on the behaviour of gross investment by sector of economic activity in Brazil between 2000 and 2008. In specific terms, between 2000 and 2008, the growth rates of gross capital formation in more knowledge-based sectors (capital goods and intermediate goods) and industries from medium to high technological sophistication (mass consumption) were less (3.5 per cent and 3.1 per cent, respectively) than those of the economy as a whole (4.8 per cent). In a few words, rather than concluding that, in general terms, gross investment is not important for boosting labour productivity in the economy, our results suggest that, in the case of Brazil in the 2000s, gross capital formation grew at very low rates – in fact, at rates lower than those of the economy as a whole – in sectors with a high capacity of technological innovation and a high capacity to spill over their gains from productivity to the economy as a whole.

Resumo

No período 2000-2008 (que cobre a análise deste artigo), enquanto a taxa de crescimento do PIB real foi de 3,72% a.a., a produtividade do trabalho teve variação negativa de -0,95% a.a. Já se tornou um "*clichê*" atribuir as baixas taxas de crescimento econômico no Brasil às reduzidas taxas de incremento da produtividade do trabalho. No entanto, de acordo com a chamada Lei de Kaldor-Verdoorn, a recíproca também é verdadeira: as reduzidas taxas de incremento da produtividade do trabalho podem ser consequência das baixas taxas de crescimento econômico no país ao longo da última década. Neste trabalho, fizemos diversos exercícios de regressão econométrica da produtividade do trabalho em 21 setores da indústria de transformação no Brasil no período 2000-2008, tendo como variáveis explicativas as taxas de variação do PIB real, o investimento bruto como proporção do valor adicionado setorial e uma variável associada à inovação tecnológica. Nos diversos modelos econométricos implementados, a taxa de variação do PIB real foi a variável mais significativa para explicar o comportamento da produtividade do trabalho na indústria brasileira. Estes resultados são consistentes com a Lei de Kaldor-Verdoorn, que sugere que as taxas de incremento da produtividade do trabalho são fortemente dependentes da taxa de crescimento da economia como um todo. O investimento só se revelou significativo quando incluído com defasagem de um período e quando a variável associada à inovação também foi incluída no modelo. Embora este resultado seja coerente com o esperado, de acordo com a literatura teórica, o mesmo deve ser analisado com cautela, já que, como os dados associados à inovação tecnológica só estão disponíveis para poucos anos do período analisado, o número de observações ficou bastante reduzido para tornarem robustas as conclusões empíricas. Em relação ao investimento propriamente dito, embora a literatura sugira que a produtividade do trabalho deva responder positivamente aos incrementos da taxa de investimento, estes últimos não foram significativos para explicar o comportamento da produtividade da indústria brasileira entre 2000 e 2008. Apesar de surpreendentes, tais resultados são confirmados pelas estatísticas descritivas sobre o comportamento do investimento na indústria brasileira na década de 2000. Com efeito, entre 2000 e 2008, as taxas de crescimento da formação bruta de capital fixo nos setores industriais mais intensivos em conhecimento (bens de capital e bens intermediários) e nas indústrias de média e alta tecnologias (consumo de massa) foram menores (3,5% e 3,1%, respectivamente) do que as da economia como um todo (4,8%). Em outras palavras, longe de sugerir que o investimento bruto em geral não seja importante para fomentar a produtividade do trabalho nos diversos setores da economia, nossos resultados sugerem que a formação bruta de capital fixo na indústria de transformação cresceu a taxas bastante reduzidas na década de 2000 – na verdade, a taxas menores do que as verificadas na economia como um todo - justamente naqueles setores com maior capacidade de inovação tecnológica e maior poder de disseminação de seus respectivos ganhos de produtividade para o restante da economia brasileira.

1. Introduction

Since Adam Smith (1776), productivity growth has been understood as one of the main drivers of economic development. Krugman (1994) expressed this idea well in the quotation below:

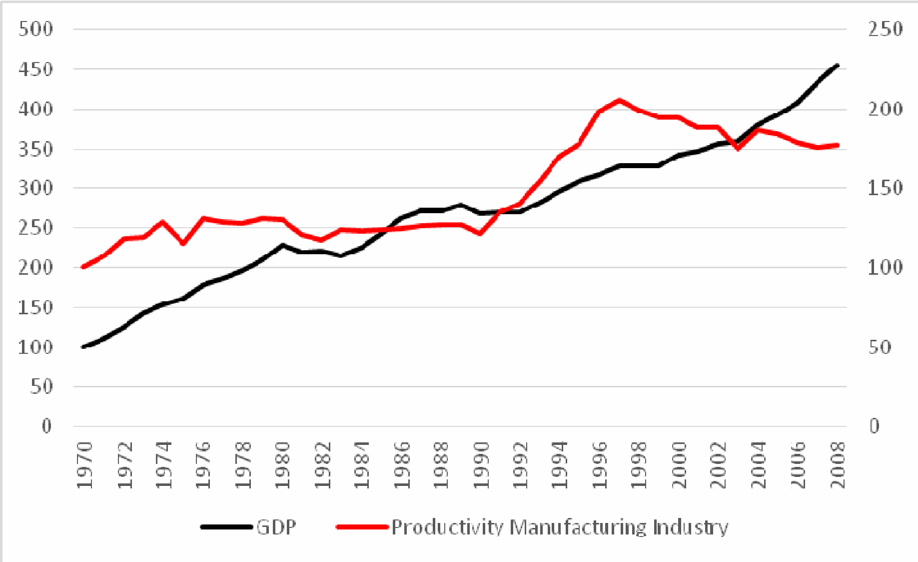
> *Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker.*

Industrialisation, in turn, has always been associated with a quick increase in aggregate productivity, since industry, manufacturing in particular, has strong backward and forward linkages,[1] allowing productivity gains to be easily transmitted throughout the productive structure.[2] Higher levels and rates of productivity growth are expected to be observed in economies that have already reached a mature industrial structure.

The Brazilian economy is one relatively successful example of a late industrialised country in Latin America. Its industrialisation process started taking shape after the Second World War and gained momentum during the 1970s when GDP grew at above 7% on average per annum. Figure 1 shows the change in both manufacturing productivity and GDP from the 1970s to 2008. Higher GDP rates were observed in the 1970s, when industrial productivity also increased at positive rates. Growth rates of both variables were close to zero in the 1980s for both indicators, and although labour productivity increased in the 1990s due to the opening up process of the economy, GDP recovery was at lower rates than observed in the 1970s. The 2000s exhibited a different picture as GDP growth coincided with a decrease in manufacturing productivity. Specifically, in the 2000-2008 period (which covers the analysis of this paper), while the average real GDP growth was 3.72 per cent per year, the labour productivity had a negative variation of -0.95 per cent per year. These results highlight the loss of weight of the manufacturing industry in total GDP, due to early de-industrialisation and significant demographic changes.

[1] See Hirschman, 1981.
[2] See Kaldor, 1978.

Figure 1: Change in manufacturing labour productivity and real GDP 1970-2008 – in index number: 1970=100



Source: ECLAC-PADI database for manufacturing productivity and IPEA data for real GDP.

Table 1 presents growth rates estimates for labour productivity in Brazil covering the 1961-2012 period, based on the recent work by Bonelli and Fontes (2013). In this long-term perspective, one can say that Brazilian labour productivity has shown a strong pattern of underperformance since the 1980s. Yearly labour productivity growth in Brazil was negative in the 1980s, close to zero per cent in the 1990s, and slightly more than one per cent between 2001 and 2012.

Table 1: Yearly growth rates of aggregate labour productivity in Brazil (1961-2012 – in percentage)

Average	Labour productivity
1961-1970	3.5
1971-1980	4.8
1981-1990	(-0.9)
1991-2000	0.7
2001-2012	1.2

Source: Bonelli and Fontes (2013:7)

The evidence above could reinforce the conclusion that one of the main factors to explain the low real GDP growth in Brazil in the past three decades is the low rates of labour productivity. Hence, productivity is the key variable to be explained in order to shed some light on the issue of why the Brazilian economy has lost its vigour to grow since the 1980s.

Although the mainstream economic literature analyses productivity as a variable mostly explained by forces from the supply side, this paper will argue that productivity is better understood when one investigates it considering forces from both the demand and supply sides. This means that, in addition to a firm's stimulus to increase its productivity in order to increase or maintain its profit rate and market share, the stimulus from the macroeconomic environment should also be taken into account. In this perspective, this paper aims not only to show the concept, determinants and a theoretical model for explaining labour productivity in general (see Section 2), but also to show empirical evidence on the main determinants of this indicator in the Brazilian manufacturing industries between 2000 and 2008 (see Section 3).[3] The last section, Section 4, presents the conclusion and some policy implications for Brazil, taking into account the empirical evidence shown in Section 3.

2. Labour productivity: concept, determinants and a theoretical model

Productivity is the measure of the efficiency of the combination of all inputs in the production process. Mainstream economists, based on the concept of a production function, measure the level and variation of productivity through the so-called total factor productivity (TFP). Neoclassical economists consider TFP a superior measure for productivity in relation to the measurement of the contribution of a single factor productivity, since, differently from the latter, the former is invariant to the intensity of use of observable inputs (Syverson, 2010).

TFP is based on Solow's theoretical and empirical growth model (1956 and 1957), which, however, suffers from some shortcomings. We will mention three of them: first, since the estimation of productivity by TFP is based on either a microeconomic production function (at the firm or sectoral level) or a macroeconomic production function (at the aggregate level), it is hard to conceive a production function which actually reflects an adopted technology since technology is not a homogeneous good, even at the firm level, as it is possible to match different "vintages" of embodied knowledge at the same place and time; second, assuming that a great part of the technical progress is embodied in capital goods, it is difficult to find a realistic measure for the contribution of the capital stock for the total productivity growth; third, and perhaps more importantly, as technical progress is exogenous in Solow's model, the estimation of the contribution of this factor is always done as a residual.[4]

In an influential critique to Solow's model (and the TFP estimation), Nelson (1981: 12) pointed out that "technological advance, while acknowledged as a central feature of growth, is treated in a very simple way, and the Schumpeterian proposition that technological advance (via entrepreneurial innovation) and competitive equilibrium cannot coexist is ignored". The author concluded that "the sources of growth (subjacent to Solow's model and TFP estimations) are viewed

[3] Due to the lack of compatible statistical data, we cannot extend our model for the post-2008 period.
[4] Since the estimation of the residual is subject to all sorts of issues, Abramovitz (1993) referred to the residual as "some sort of measure of ignorance".

as operating independently and additively".[5] Abramovitz (1986 and 1993) also defies the estimation of the contribution of the technical progress as a residual, arguing that it misses important elements for productivity variation such as education, on-the-job training, and research and development (R&D). According to the author (Abramovitz, 1993: 218), "all these missing elements were unmeasured and difficult to measure but still embedded in the residual".

For estimating the change in economic efficiency in the Brazilian manufacturing industries in the 2000s in this paper, we follow a more traditional view of productivity change and prefer to use a measurement of the labour productivity. Among several reasons for making this choice, we will mention just three: i) by capturing the intensity of use of the other production factors, labour productivity indirectly incorporates the contribution of all of them[6]; ii) once it is translated by the ratio of the value added in a sector or even in the total economy to the respective number of workers, labour productivity is a reliable measure for evaluating the efficiency at both the microeconomic and macroeconomic levels; and iii) together with the per capita income growth over time, labour productivity has traditionally been used for evaluating economic and social convergence or divergence among countries (see, for instance, Baumol, 1986, León-Ledesma, 2002, and McMillan and Rodrik, 2011).

The concept of labour productivity could be seen as totally determined by supply-side forces. However, as many theoretical and empirical studies have emphasised, the behaviour of labour efficiency is affected by both supply and demand forces (see, for instance, Dixon and Thirlwall, 1975, DeLong and Summers, 1991, León-Ledesma, 2002, and Syverson, 2010). As Syverson (2010: 43) recognized, although "productivity is typically thought of as a supply-side concept, a new strand of research has begun to extend the productivity literature to explicitly account for such idiosyncratic demand effects as well". In his survey on the subject, Syverson (2010) argued that the behaviour of the labour productivity could jointly be affected not only by an efficient combination of capital, labour and other inputs, but also by other elements such as information technology (IT), R&D, the level of internal and external competition, and even by government policies.

Structuralist literature, based on Myrdal's (1957) and Kaldor's (1966 and 1970) tradition of explaining long-term growth as a process of cumulative causation, develops theoretical and empirical studies in which the growth of labour productivity is highly dependent on the initial conditions of the economy. In this sense, all else being equal, the higher the level of industrialisation of an economy, the greater its capacity of sustaining higher rates of growth and, therefore, also of labour productivity. The reason for that is because the manufacturing industry presents increasing static and dynamic returns to scale, a crucial assumption to explain productivity growth.[7] Therefore, the relation between growth and productivity change is given by the so-called Kaldor-Verdoorn Law, which

[5] For more details on the critique of the theoretical and empirical estimations of productivity based on Solow's model, see Nelson (1981).
[6] Note that, differently from the above mentioned Syverson's (2010) conclusion, this characteristic of labour productivity can provide an advantage in choosing it as an appropriate indicator for measuring economic efficiency.
[7] See Young (1928), Kaldor (1966) and McCombie and Thirlwall (1994), among others.

postulates that labour productivity growth rates are positively influenced by output growth rates. Far from representing a tautology (high labour productivity growth causes high economic growth rates, which, in turn, imply high labour productivity growth), according to the cumulative causation principle, the operation of the Kaldor-Verdoorn Law means that as long as an economy builds a large and diversified manufacturing industrial base, it augments its potential of exploiting static and dynamic economies of scale insofar as it is capable of sustaining high economic growth.[8] Since this latter phenomenon is closely associated with high investment rates and rapid technical progress, an economy which shows high rates of GDP growth tends also to sustain high labour productivity growth. As McCombie and Thirlwall (1994: xxi) argued, “a faster growth of output leads to a faster growth of productivity through the “Verdoorn effect” which is caused by, *inter alia*, a higher rate of induced investment and of induced technical progress”.

León-Ledesma (2002) estimated a structural model for a set of OECD countries in the 1965-94 period, in which he presents an estimation for labour productivity considering the effects of aggregate demand, investment-output ratio, innovation and a variable capturing the catching up effect of innovation. By doing so he emphasised, in addition to the impacts of investment and the traditional Kaldor-Verdoorn Law, the direct and indirect effects of innovation and technical progress on the behaviour of labour productivity. In the author’s words, “innovation not only leads to a higher degree of product differentiation and quality but also to process innovation leading to increased productivity” (León-Ledesma, 2002: 204). In this paper, we will use a modified version of León-Ledesma’s equation for productivity, considering that labour productivity variation is jointly explained by the effect of investment, innovation and the aggregate demand growth (the Kaldor-Verdoorn Law). In this way, we aim to explain productivity as a result of the short and long-term effects induced by the physical investment, innovation and technical progress. This general model can be expressed as:

$$r = a + \alpha y + \beta \left(\frac{I}{VA} \right) + \varphi Innov \qquad (1)$$

where *r* is the labour productivity growth; *a* is the constant term; *y* is the real GDP growth; *I/VA* is the investment ratio, that is to say, the ratio of the gross investment to the value added; and *Innov* is a variable associated with innovation. $\propto$, β and φ

[8] The debate on the role of static and dynamic economies of scale (directly associated with the manufacturing sector, and, today, with some tradable segments of the service sector) is relatively old in economics. Graham (1923) had shown that, the more an economy reallocates resources from industries subject to increasing returns to scale to industries subject to constant returns to scale, the less would be its capacity for sustaining economic growth in the long run. Young (1928) also showed that, by incorporating activities subject to increasing returns to scale, the enlargement of the market tends to boost international competitiveness and accelerate long-term growth. In his classic study, Kaldor (1966) emphasised the importance of static and dynamic economies of scale inherent to the manufacturing sector for boosting long-term growth.

are positive coefficients. In the next section, we will translate the theoretical model represented by equation (1) into an econometric estimation in order to show empirical evidence for the labour productivity growth of the Brazilian manufacturing industries in the 2000s.

3. Labour productivity: empirical evidence for the Brazilian manufacturing industries in the 2000s

The aim of this section is to first briefly describe the variables and the sources of the statistical data used in the estimation of the theoretical model and second to present our estimates. As mentioned earlier, the theoretical model of manufacturing productivity growth associates its dynamic to the growth of aggregate demand, investment in fixed asset and technological innovation. One limitation of the empirical estimation for the productivity of the Brazilian manufacturing industries lies in the lack of comprehensive data for demand of investment. Another limitation is due to the lack of enough observations in relation to data on innovation. As the statistical data used in our estimation comes from different sources, a compatibilisation exercise had to be performed in order to harmonise the sectoral classifications.[9]

Statistical data for demand of investment in the manufacturing industry was obtained from Miguez *et al* (2014) who estimate a matrix of investment absorption for the 2000-2009 period. As far as we know, that is the most comprehensive statistics available for demand of investment for the manufacturing industry for the 2000s. From the input-output matrices available, the authors disaggregate the final demand vector of fixed capital formation into institutional and activities sectors. For our proposal, based on the estimates of the national and imported matrices of investment absorption at basic prices, we calculated the investment rate for the Brazilian manufacturing industry.

The proxy for the innovative activity in the manufacturing industry was obtained from the Industrial Technological Survey (PINTEC according to the Portuguese acronym) carried out by the Brazilian Institute of Geography and Statistics (IBGE). This survey is available for the years 2000, 2003, 2005 and 2008, and it covers all manufacturing industries with ten or more employees that performed any innovative activity – either in the productive process or in improving a product or even introducing a new one into the market. From this dataset we calculated for each sector the ratio of total expenditure in innovative projects (research and development – R&D) by firms in that period and the total net revenue with sales of products and services from all manufacturing firms. Then, the innovation variable of equation (1) was calculated as the ratio of R&D of an industry of the Brazilian manufacturing sector to the total net revenue with sales of product and services from that industry.

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[9] This exercise basically involved the classification of industries. We follow an aggregation of industrial sectors considering science, engineering and knowledge based industries, natural resource-based industries and labour intensive industries. A description of the sectors included in each group is in Annex 1.

Productivity growth estimates were obtained from the ECLAC-PADI [10] database. This database presents structural statistics for the manufacturing sector for Latin American countries from 1970 to 2008. Therefore, it is an internationally harmonised database, which collects statistical information from national statistical offices. In the Brazilian case, the main source of information comes from the Industrial Censuses and the Annual Industrial Surveys carried out by IBGE. All information provided in ECLAC-PADI has been converted from each country's currency to 1985 constant dollar prices.

Lastly, the estimates for aggregate demand growth come from the National Accounts estimates for GDP.

To perform our estimate, equation (1) can be translated into the following standard econometric specification:

$$r_{it} = a + \alpha y_t + \beta \left(\frac{I}{VA}\right)_{it} + \varphi Innov_{it} + e_{it} \qquad (2)$$

where subscript *i* represents an industry of the manufacturing sector, *t* refers to the period of observation of the variable, and *e* is the error variable.

The estimate uses panel data models in the static and dynamic versions. Panel data models combine temporal and cross-sectional data, and this presents important advantages for our empirical exercise as it allows:

i) the use of a larger amount of information by combining sectoral data with time series, so that the available productivity data for the 21 sectors of the Brazilian manufacturing industry could be related to the explanatory variables between 2000 and 2008[11];
ii) the use of a larger number of observations, which, in turn, ensures the asymptotic properties of the estimators and increases the degrees of freedom of the estimates;
iii) the reduction of the risk of multicollinearity, since data from the different sectors of the manufacturing industry have different structures;
iv) the introduction of dynamic adjustments, which the cross-section analysis would not allow.

Initial estimates were made considering only panel data static models. The Hausman test showed that the best fit of the data was with random effects.[12] Table 2 summarises these results

[10] PADI is the acronym in Spanish for Analysis Program of Industrial Dynamics.
[11] For more information on the methodology for panel data, see Wooldridge (2002), and for the development of these models in the dynamic version, see Arellano-Bond (1991), Arellano-Bover (1995) and Blundell-Bond (1998).
[12] The Hausman test is used to decide which model is most appropriate: the random effects model (H0) or the fixed effects model (HA). Under the null hypothesis, the estimators of the model with random effects are consistent and efficient; under the alternative hypothesis, the random effects estimators are not consistent, but the fixed effects estimators are. The main differences between the models of fixed and random effects are that the models with random effects do not consider the constant as a fixed parameter, but as an unobserved random parameter. Additionally, in the model with fixed effects, the differences of individuals (industry sectors) are considered to be captured in the constant part, while in the random-effects models, these differences are considered to be represented in the error term.

Table 2: Labour productivity determinants - The static model

	Random effect (1)	Random effect (2)	Random effect (3)
Y_t	1.48***	1.90***	5.69***
	(3.96)	(2.98)	(4.91)
$(I/VA)_{it}$	-0.004	-0.005	
	(-0.42)	(-0.31)	
$I/VA_{i(t-1)}$			0.044**
			(2.09)
$Innov_{it}$		0.044*	0.071**
		(1.92)	(2.51)
a	-0.08***	-0.14	-0.23**
	(-3.15)	(-3.23)	-(3.05)

Note: *t* test in brackets, *** significant at 1%, ** significant at 5% and * significant at 10%

In these estimates, productivity growth is largely explained by GDP growth (Y_t), in accordance with the Kaldor-Verdoorn Law, in the three versions of the model (columns 1, 2 and 3). Investment rate was not statistically significant in explaining the behaviour of productivity when the model was run without innovation (column 1) or the variable investment rate in period *t* (column 2). These are interesting results as they suggest that the rate of investment impacts productivity but with a lag. Indeed, in column 3, both the investment rate lagged in one period and innovation in period *t* were shown to be significant.[13] The effect of innovation on productivity growth implies that the innovative sectors of the manufacturing industry have a significant impact on boosting aggregate productivity.

So far our first estimates confirm the importance of aggregate demand and innovative activities for stimulating productivity growth and that the investment rate also has a positive effect on productivity, but with a lag. As investment is a component of aggregate demand, we can conclude that its first impact on productivity is through its effect on aggregate demand (via the multiplier effect) and its next is on increasing industrial productivity. However, this conclusion calls attention to the fact that our previous estimates may have an endogeneity bias. This is because, for example, GDP tends to affect productivity at the same time as it is affected by it. To tackle this problem, we ran a dynamic panel data with the Generalized Method of Moments in the form proposed by Arellano and Bond (1991). In their paper the authors argue that it is possible to get around the problem of endogeneity between the dependent variable and the control variables by introducing the dependent variable with a lag. Thus, equation 2 can be changed to:

$$r_{ij} = a + \mu r_{ij(t-1)} + \alpha y_i + \beta (I/VA)_{ij} + e_{ij} \quad (3)$$

[13] It should be remarked that this model is somewhat limited due to the few observations available for the innovation variable.

The result of the estimation of the dynamic model is shown in Table 3[14]. The difference between the result of equation (3) and the estimates from equation (2) is the inclusion of a lagged productivity term (the last line in Table 3) as an explanatory variable, and the exclusion of the innovation variable in the dynamic model, since, as mentioned earlier, this variable is only available for a few years. As in the estimation of the static model, GDP growth was the main explanatory variable of productivity growth in the dynamic model. Investment ratio, though, was not significant.

Table 3: Labour productivity determinants – The dynamic model

y_t	2.15*** (4.71)
$(I/VA)_{it}$	-0.047 (-1.17)
a	-0.19** (-2.44)
$r_{i\,(t-1)}$	-0.18** (-2.22)

Note: t test in brackets, *** significant at 1%, ** significant at 5% and * significant at 10%

This is an unexpected result, as according to the literature, productivity should respond well to investment. In order to interpret this outcome, we should bring into the discussion arguments relating to the macroeconomic environment that prevailed in the 2000s and that might have affected the performance of investment decisions, which are highly dependent on the state of expectations. That is to say that a macroeconomic environment of high volatility in the main macroeconomic prices, such as exchange rate, interest rate, wage rate, fiscal rules and so on, does not favour a long-term commitment of resources.

Although the Brazilian economy performed relatively better in the 2000-2008 period (3.72 per cent per year), in relation to the previous years, the macroeconomic agenda changed from a liberal orientation in the beginning of the 2000s to a pro-growth agenda from 2007 on. Actually, during the 2003-2006 period, corresponding to the first mandate of President Lula da Silva, the liberal and pro-stability conventions to growth conflicted with a pro-growth agenda (Nassif and Feijo, 2013), which means that entrepreneurial uncertainty might have been rather high during this period. Although growth rates resumed from 2004 onwards, this was due to a great extent to the boom in foreign trade and the improvement in the terms of trade. So, the relatively good performance of Brazilian growth rates from the mid-2000s onwards was to a great deal the result of exceptional and occasional favourable external conditions. The boom in international trade at that time reinforced the trend towards the increase in the relative weight of natural resources- based industries in the manufacturing sector, and the decrease in the importance of more technological industrial segments. In short, the good performance of the economy from 2004 onwards was the result of extraordinary

[14] In equation (3), μ is a parameter term that means the lagged labour productivity.

external conditions, which did not last long, and was followed by a structural change in the manufacturing sector towards less dynamic industries.

In relation to the investment behaviour in the manufacturing sector, a recent study by Bielschowsky *et al* (2014) analyses the investment data presented by Miguez *et al* (2014) according to five types of investment, in other words, classifying the type of investment according to its own determinant logic.[15] This sort of information helps us to evaluate the impact of investment on industrial productivity, since this impact should be higher when investment is concentrated in more technologically dynamic sectors. Table 4 shows the growth rate in gross capital formation for selected periods for each type of investment.

Table 4: Gross capital formation - Real average growth rates (2000-2008 – in percentage)

	2000-03	2003-05	2005-08	2000-08
Infrastructure	-3.9	7.3	21.2	7.8
Families	1.2	0.8	5.9	2.8
Natural Resources	0.3	9.1	10.7	6.3
Mass Consumption	-8.0	6.2	13.2	3.1
Capital Goods and Intermediate Goods Industries	-8.6	16.3	8.6	3.5
Total Economy	-3.2	6.4	12.4	4.8

Source: Bielschowsky *et al (*2014), Table 2

Investment in capital goods and intermediate goods industries and in mass consumption industries, both of which are most induced by domestic conditions, were the ones to show the worst performance relatively, concerning the manufacturing sectors only. Investment in natural resources-based industries, which also include industries linked to agribusiness, was the one to show better performance. It should also be mentioned that in the 2000-03 period mass consumption and capital goods and intermediate goods industries were the ones with the largest decrease in investment. This last piece of evidence shows that although investment in fixed assets in the manufacturing industry had increased in the period, it actually started recuperating from a severe contraction after 2003.

We can draw two conclusions from the evidence in Table 4. The first is that as investment growth was less strong in more technologically dynamic sectors, its impact on productivity could also be less strong. The other conclusion is that the

[15] The authors define five types of investment. Investment in infrastructure, which depends on long-term political decisions and is greatly determined by the State; investment by families, which is concentrated in real estate; investment in natural resources activities (includes agribusiness and oil and gas) which depend mostly on foreign demand; investment in mass consumption industries, which depend on the performance of the domestic market; and finally investment in the production of capital and intermediate goods, which are determined by the behaviour of the economy.

recovery in the investment growth rates in the manufacturing sector might not have been enough to promote the catching up of the industrial productivity. This follows from the evidence that in the 2000-03 period growth rates were highly negative for the capital and intermediate industries and mass consumption industries. If these interpretations are correct, then we have a clue for the low significance of investment to explain productivity growth.

In short, a rather high degree of entrepreneurial uncertainty in relation to the macroeconomic environment and a relatively short period of ' bonanza' to recover the growth rates of the economy might explain why investment in fixed assets still does not show significance to explain labour productivity.

4. Conclusion and policy implications

There has been a "*cliché*" to evaluate the low economic growth rates in the 2000s as a result of low labour productivity growth rates in the Brazilian economy. In the 2000-2008 period (which covers the analysis of this paper), while the average real GDP growth was 3.72 per cent per year, the labour productivity had a negative variation of -0.95 per cent per year. However, according to the so-called Kaldor-Verdoorn Law, the reciprocal could also be true: the low growth rates of labour productivity in Brazil could be an effect of the low growth rates of the real GDP. This means that it is not enough to diagnose that the labour productivity in Brazil was low in the 2000s. It is necessary to go further and identify the main determinants of the labour productivity in order to explain why this indicator was so low in that period in Brazil. By estimating econometrically the main explanatory variables of the labour productivity of the Brazilian manufacturing industries in the 2000s, we tried to contribute to the debate on the subject.

In this paper, we used a modified version of León-Ledesma's (2002) model for explaining the main determinants of labour productivity in the Brazilian manufacturing industries in the 2000s. First of all, it is important to remember that, due to the lack of data for all variables of our model, the empirical research only covers a short period of time (nine years referring to the 2000-2008 period). Then, in principle, the results must be cautiously analysed. However, it is important to stress that, by applying the model to 21 industries in the Brazilian manufacturing sector, the size of the sample is significantly increased. Even so, our econometric results seem robust when they are compared with some descriptive statistics on the manufacturing sector in Brazil during the period under analysis.

In the several econometric models we ran, the real GDP growth was the most significant variable to explain the behaviour of labour productivity in the manufacturing industries in Brazil in the 2000s. This result suggests that the larger and more sustainable the real GDP growth in Brazil is, the greater will be its labour productivity growth rates. This result is also consistent with the Kaldor-Verdoorn Law, according to which the labour productivity growth is highly dependent on the growth rates of the economy as a whole.

In most models we ran, the gross investment was not significant to explain the behaviour of the labour productivity in the manufacturing industries in Brazil throughout the 2000s. The investment only showed to be significant when it was included into the model with a lag of one period and when innovation was incorporated as one of the explanatory variables of the labour productivity. Although this result seems to be consistent with theoretical expectations, it must be carefully analysed because, as innovation data is available for only few years, the number of observations is too few to make the empirical conclusion robust.

In relation to the gross investment, specifically, although the literature suggests that labour productivity growth should respond positively to increasing gross investment, this latter explanatory variable was not significant in most models we ran, as already stated. Even so, this unexpected result is consistent with some descriptive statistics on the behaviour of gross investment by sector of economic activity in Brazil between 2000 and 2008. In fact, while gross capital formation grew at 7.8 per cent and 6.3 per cent, respectively, in infrastructure and natural resources-based sectors (this latter includes agribusiness), in the 2000-2008 period, growth of investment in the mass consumption and capital goods and intermediate goods sectors were only 3.1 per cent and 3.5 per cent, respectively, in the same period. Indeed, between 2000 and 2003, gross capital formation grew at negative rates in the most dynamic sectors of the Brazilian economy.

In specific terms, between 2000 and 2008, the growth rates of gross capital formation in more knowledge-based sectors (capital goods and intermediate goods) and industries from medium to high technological sophistication (mass consumption) were less (3.5 per cent and 3.1 per cent, respectively) than those of the economy as a whole (4.8 per cent). In a few words, rather than concluding that, in general terms, gross investment is not important for boosting labour productivity in the economy, our results suggest that, in the case of Brazil in the 2000s, gross capital formation grew at very low rates – in fact, at rates lower than those of the economy as a whole – in sectors with a high capacity of technological innovation and a high capacity to spill over their gains from productivity to the economy as a whole.

These results are also consistent with several recent studies which show empirical evidence that early de-industrialisation in Brazil intensified in the 2000s.[16] Nassif, Feijó and Araújo (2013:14-15) presented empirical evidence that the technological gap (measured as the relative labour productivity in the Brazilian manufacturing industries compared with those of the United States) grew significantly in all manufacturing industries classified according to their technological intensity between the mid-1990s and 2008. Bacha (2013) showed that between 2005 and 2011 the Brazilian economy highly benefited from both the improvement in the terms of trade and the large net capital inflows, which were both responsible for the overvaluation of the Brazilian currency (the *real*) in real terms. Also according to Bacha (2013: 97-98), this short period of external "*bonanza*" explains, on the one hand, the relatively good performance of the Brazilian economy in the 2005-2011 period (a real GDP growth of 4.2 per cent per year) and, on the other hand, the strong reallocation of resources from domestic production to imports in the same period.[17]

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[16] See, for instance, Oreiro and Feijó (2010), Nassif, Feijó and Araújo (2013) and Bacha (2013).

[17] It should be mentioned that Bacha's (2013) analysis suggests that the early de-industrialisation in Brazil would have begun in the mid-2000s. However, there is strong evidence that this process

In other words, the empirical evidence suggests that Brazilian policy-makers were not able to, by taking advantage of the short period of favourable external conditions that occurred between 2004 and 2011, design and implement macroeconomic policies to boost labour productivity in industries with a major capacity for innovating and disseminating gains from productivity to the economy as a whole. Although suggestions of economic policies go further than the scope of this paper, we could conclude that any attempt for boosting labour productivity and real GDP growth rates in Brazil should include instruments that contribute to reaching three important goals: i) the reduction of the high degree of uncertainty that still prevails in the economy (at the time of finalising this paper in July 2014); ii) the decrease of the high real interest rates; and iii) the elimination of the long-term real overvaluation trend of the Brazilian *real*, a phenomenon that has been observed since the mid-1980s in Brazil.[18]

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began in the mid-1980s, continued in the 1990s and intensified in the 2000s. Most empirical studies conclude that one of the main factors responsible for this phenomenon is the overvaluation trend of the Brazilian currency in real terms, which can be observed since the mid-1980s. Episodes of depreciation of the Brazilian *real* have suddenly occurred as a response to internal or external shocks. For details, see Oreiro and Feijó (2010) and Nassif, Feijó and Araújo (2011).

[18] From the microeconomic point of view, since 2003 the Brazilian government has been making a great attempt at adopting industrial and technological policies. However, in an environment of high real interest rates and real exchange rate overvaluation, it is hard to expect good results from any industrial and technological policies. On industrial and technological policies that have been adopted in Brazil from 2003 on, see Coutinho *et.al.* (2012). On macroeconomic proposals aiming at reaching the three mentioned macroeconomic goals, see Oreiro (2014).

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Annex 1

Manufacturing industry according to technological intensity

Science, engineering and knowledge-based

Metal products
Non electrical machinery
Eletrical machinery
Motor vehicles
Scientific instruments
Chemicals

Natural resource-based

Food and beverage
Tobacco
Wood products
Paper and cellulose
Petroleum refining and oil and carbon products
Glass and other non-metallic mineral products
Iron and steel
Non ferrous metals

Labour intensive

Textile
Clothing
Leather manufactures and footwear
Furniture, pottery and other manufactured products
Paper printing
Other chemicals
Rubber products and plastic products

Source: ECLAC-PADI