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Manufacturing, economic growth, and real exchange rate: Empirical evidence in panel data and input-output multipliers

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Abstract:

This paper investigates the effects of manufacturing and of the real exchange rate (RER) on real per capita income growth. We use dynamic panel models and the calculation of output and employment multipliers for a diversified sample of countries from 1990 to 2011. Three important results can be highlighted. First, we provide new evidence that manufacturing is the most important tradable sector for achieving greater real per capita income growth for developing countries. Second, the greater a country's gap in relation to the technological frontier, the greater the positive effect of an undervalued RER on the real per capita income growth rate. Finally, the manufacturing industry's output multipliers and employment multipliers in the developing countries are higher than those in in developed ones, in all years analyzed.

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This paper investigates the effects of manufacturing and the real exchange rate (RER) on the per capita income growth by using dynamic panel model estimations considering different technological gap levels for different group of countries, and by calculating the output and employment multipliers, which provide complementary results for the econometric

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estimations in terms of the relative importance of each sector. There is a gap in the literature regarding the effects of the manufacturing industry and the RER on economic growth when a proxy of the technological gap is considered.[1] The contribution of this paper to the literature is twofold. First, we run a series of econometric models in which a proxy for the technological gap is included in order to control for the effects of this variable over the relation between the RER and economic growth. Indeed, the literature on the RER and economic growth (see Rodrik, 2008; Missio et al., 2015) neglected the effect of the technological gap over economic growth, which can result in under-estimation of the positive effect of the RER over GDP growth. Since the technological gap is a proxy for non-price competitiveness of a country in international markets, the higher this gap is, the lower will be the non-price competitiveness of the country, thus requiring an increase in the price competitiveness (a higher RER undervaluation) in order to sustain a high growth rate of exports, which is the true source of autonomous demand in open economies (Thirwall, 2002, p. 83) and hence the engine of economic growth. The paper's second contribution is the calculation of the sectorial output and employment multipliers in order to shed more light on the issue of the role of composition of output and employment – and, more specifically, the role of the manufacturing industry – on economic growth. These calculations show that the share of manufacturing industry matters for long-run growth. It is important to emphasize that econometric estimations and input-output (IO) analysis are complementary since they offer results that contemplate different characteristics of the role of manufacturing in the productive structure and economic growth.

This paper is divided into five sections besides this introduction. Section 1 presents the theoretical background concerning the relationship between the composition of productive structure and economic growth. Section 2 presents the baseline empirical model, data sources, and all variables to be used in the empirical analysis. Section 3 presents an analysis through the dynamic panel method of the generalized method of moments (GMM) for a sample of 84 countries in order to test the relationship of the per capita income growth rate and manufacturing industries among different levels of technological gaps and considering the effects of RER over economic growth, taking into account a set of control variables. Section 4 complements the econometric results by the calculation of the output and employment multipliers of 40 countries split into two groups: developed and developing countries. To do so, we use data from the World Input-Output Database (WIOD) for the years 1995, 2000, 2005 and 2010. Finally, in Section 5 some conclusions are drawn.

1. Productive structure and economic growth

The central role of the manufacturing industry regarding economic growth and the technological catch-up process is highlighted in Szirmai (2012), Thirlwall (2005), and Tregenna (2009), among others, through stylized facts and empirical analysis.[2] They show that economic growth depends on the composition of the productive structure and, especially for developing economies, on the share of the manufacturing industry. According to Rodrik (2015), manufacturing tends to experience relatively stronger productivity growth and technological progress over the medium to longer term. Therefore, premature

[1] In sections 2 and 3 we will return in this topic.
[2] For an analysis of different theoretical strands on development regarding the importance of the manufacturing industry for economic growth, see Rocha (2018).

deindustrialization closes off the main channel to achieve fast economic convergence in low- and middle-income countries.[3] It was the industrialization process, according to Rodrik (2015, p. 2), that permitted catch-up and convergence with the West by non-Western nations, such as Japan in the late 19th century and South Korea, Taiwan, and China, among other countries, in the 20th century. Rodrik (2009, 2015) highlights that the rapid economic growth of developing economies since the 1960s is associated with the largest transfer of productive resources (labor and capital) to the most modern industries. The structural shift toward industrial activities drives economic growth.

Szirmai (2012) presents a series of empirical and theoretical arguments about the role of the manufacturing industry as the "engine of growth" in developing economies. Basically, productivity in manufacturing is higher than in agriculture because the transfer of resources from this sector to manufacturing provides a "structural change bonus." This bonus comes as a result of the transfer of work from economic activities with low productivity to those with high productivity. This automatically raises the overall productivity of the economy. However, the pattern of structural change also directs resources to the services sector. Therefore, the countries begin to experience a "burden" in relation to this structural change because productivity growth in this sector is usually lower than in the industrial one.

The manufacturing sector offers special opportunities for productivity growth due to economies of scale, which are less available in agriculture or in the services sector, according to Szirmai (2012). Moreover, the manufacturing sector offers greater opportunities for the development of technologies incorporated in the goods and presents a greater technological diffusion capacity than do other sectors. Part of this dynamic occurs because of the so-called productive linkages and spillover effects, which are stronger within manufacturing industries[4] (Szirmai et al., 2013, p. 70; Gabriel and Ribeiro, 2019).

Felipe et al. (2009) used the Kaldorian theoretical framework to analyze Asian performance from a structural change perspective.[5] According to them, the economic growth verified in a panel of countries was strongly associated with the increasing industrial share in the economies studied (Kaldor's "first law"). More specifically, in Felipe et al. (2009), the sector with the greatest economic growth elasticity, after controlling for other variables and exogenous shocks, was the industrial sector as a whole, followed by the service sector, and then manufacturing industries. The higher income elasticity of the industrial sector relative to the manufacturing sector was due to the forward and backward linkages of the activities related to electricity and economic infrastructure. Moreover, this feature of the industry is based on the fact that the accumulation of capital and technical progress had been stronger in this sector, having important spillover effects to the rest of the economy in the sample of countries.

According to Rowthorn and Ramaswamy (1997), the path of economic growth depends on the composition of productive structure, and at different stages of development, certain sectors are dominant in terms of their influence on the per capita income growth rate. However, the role of manufacturing as the "engine of growth" depends on the level of the technological gap and the RER, which influence its competitiveness. The non-price competitiveness of a tradable

[3] In Oreiro et al. (2018), for instance, we can see that for the Brazilian economic performance, the reduction of the investment share in the economy was the result of the existing imbalances of macroeconomic prices (mainly an overvalued real exchange rate and exchange rate/wage ratio), which caused a premature deindustrialization, with negative effects on investment opportunities. Therefore, economic growth was harmed.

[4] In this work, the term "industry" refers to divisions 10-45 of the International Standard Industrial Classification (ISIC); when referring to manufacturing industries, it relates to divisions 15-37 of the ISIC.

[5] The authors conducted an analysis for 17 developing countries in Asia for the period 1980 to 2004.

sector depends largely on the technology gap (among other factors). The greater is the gap of a country relative to the technological frontier, the lower will be technological cumulativeness (i.e., technological learning capabilities) and thus the lower will be non-price competitiveness (quality, durability, embedded technologies, and so on).[6] Moreover, the price competitiveness of these products depends on the RER level, since overvalued RERs leads to a progressive reduction in the share of the manufacturing industry and induce an increasing transference of production activities to other countries.[7]

Classical development economists, such as Rosenstein-Rodan (1943), Nurkse (1953), Lewis (1954), Hirschman (1958) and Prebisch (1963) have consistently argued that economic growth is intrinsically linked to structural change. This process can be understood as the reallocation of labor from low- to high-productivity activities. As a complex process, the effects of this structural change on economic growth (and employment) can be seen from econometric models that assume partial equilibrium (see section 3), from input-output models based on a general equilibrium approach (see section 4), or from growth accounting.[8]

In the early stages of economic development, the agricultural sector is dominant both in terms of employment and value-added share. However, as per capita income grows, the industrial sector becomes the one with the highest relative share. Rowthorn and Ramaswamy (1997) highlighted two factors that explain this change: (i) the effect of Engel's Law, i.e., the proportion of income spent on goods from the agricultural sector declines, while per capita income increases, causing a change in the pattern of demand from agricultural products toward industrial goods and services; and (ii) on the supply side, the fast growth of labor productivity in agriculture reduces the need for workers, moving them to services activities and, in the early stages of industrialization, to the industrial sector especially. This last factor is called by Szirmai and Verspagen (2011, 2015), Szirmai (2012) and Syrquin (1984, 1988) the "structural change bonus". This effect is temporary, lasting only while the share of manufacturing industry is increasing. The transfer of resources from manufacturing industries to services activities generates a "burden" related to structural change, known in economic literature as Baumol disease (Baumol, 1967), in which, with the growth of services activities, the growth rate of income per capita tends to decline. The combined effect of these two factors highlighted by Rowthorn and Ramaswamy (1997) generates a decrease both in absolute and in relative terms of employment and value added of the agricultural sector relative to industry. Then, after a certain level of economic development, industry begins to decline, i.e., there is a process of deindustrialization.

Rowthorn and Ramaswamy (1997) formalized the economic growth process, in which there is an increase in the industrial sector share in the early stages of economic development and in the later stages de-industrialization and a transition to an economy where the services sector is dominant. Thus, the authors demonstrate that "deindustrialization" may occur as a result of successful economic development. Similarly, Rowthorn and Wells (1987) also explain that this process may be related to a higher stage of development where the level of per capita income is, as a rule, higher.

Kaldor (1966) noticed this phenomenon between 1950 and 1965 in the UK economy, which grew more slowly than that of other advanced economies. The main reason was related to the level of "maturity" of the British economy at the time. This "maturity" was related to the

[6] We recommend Verspagen (1993) and McCombie and Thirlwall (1994) for further discussion.
[7] See Palma (2005), Bresser-Pereira (2008), and Gabriel and Missio (2018) for examples of this process.
[8] It is not our goal in this work to use this last method.

high level of per capita income in the period and the lack of labor reserves in low-productivity sectors (such as agriculture) that could be transferred to the industrial sector. The economic growth rate was reduced due to the slowdown in the manufacturing industry.

The decreasing share of the manufacturing industry in developed economies was observed mainly in the late 1960s and throughout the 1970s, as analyzed in Rowthorn and Ramaswamy (1997) and Szirmai (2012). However, it was not linked to a change in the aggregate consumption pattern from the industrial sector to the services sector or the pattern of North-South international trade. Rather, it reflected largely the impact of differential productivity growth (and technological progress) between manufacturing and services. This productivity increased consistently faster in manufacturing. Then, the services sector absorbed a greater proportion of employment just to keep its output rising (Rowthorn and Ramaswamy, 1997, p. 12; Rodrik, 2015, p. 3).

According to Szirmai and Verspagen (2011, 2015) and Szirmai (2012), after World War II, industry (and manufacturing, in particular) emerged as the main economic activity of many developing countries, shaping a new international trade structure and productive specialization. Some developing countries experienced a rapid process of catching up and increasing income, which was linked to the industrialization process that began. This view is in line with economic growth in the Kaldorian tradition, where the manufacturing industry presents greater opportunities for capital accumulation, static and dynamic economies of scale, more intense technological progress, and spillover effects (Kaldor, 1966, 1967).

For several Latin American countries, the increasing industry share in the economy arose by import substitution industrialization (ISI) as a necessary first step to build a local production base, essential for the countries' insertion in the international markets. Some Asian countries, such as South Korea, pursued a growth strategy led by exports (i.e., export-led strategies) (see Esfahani et al., 2010). Also, undervalued RER, according to Woo (2004) and Gala (2008), was critical to the highest rates of economic growth observed in Asian countries. Over the past 30 years, while Latin American countries, in general, were focused on an inward industrialization, Asian countries (such as South Korea and Taiwan) pursued a growth strategy led by exports, with heavy incentives for exporters and industry and competitive RERs (Gala, 2008, p. 286; Rodrik, 2006, p. 20).

In Latin America the decline of industry share has happened at a lower level of per capita income than in Europe and Asia. Moreover, over the past decades the reduction of manufacturing and industry share in these economies was due to a number of causes, such as persistent exchange rate misalignment (overvalued), technological asymmetries (i.e., high technological gap), financial openness and terms of trade appreciation (Palma, 2005; Bresser-Pereira, 2008).[9]

Rodrik (2015, p. 4) points out that, as these economies opened to international trade without a strong comparative advantage in manufacturing, they became net importers, reversing a long process of ISI.[10] Moreover, most developing countries "imported"

[9] For a thorough analysis of the causes of deindustrialization processes at the international level, see Rowthorn and Coutts (2004) and Palma (2005). Although the "early" deindustrialization is discussed briefly here, the main focus is on industry (especially manufacturing) as a dynamic sector and driver of economic growth, as highlighted in the literature on this subject in this section.

[10] According to Rodrik (2015), after ISI reached its limits, most Latin American economies opened up to international trade without conditions to compete with advanced economies and Asian countries (with advantage in manufactures). Countries such as Brazil and Argentina became net importers of goods with greater technological content, e.g., manufactured products. For a further discussion about this topic, see Esfahani et al. (2010).

deindustrialization from advanced countries as they became exposed to the relative price trends produced in the latter. This decline in the relative prices in the advanced economies leads to a profit squeeze on manufacturing in developing economies, mainly in countries with a greater technological gap. Hence, it leads to a reduction in the employment and value-added share of this sector in developing countries (Rodrik, 2015).

This reduction in the manufacturing share at lower levels of economic development in Latin America and other developing economies has long-term consequences on their growth potential, as well as on reducing technological asymmetries. Technological catch-up and income convergence are diminished or become unsustainable (falling-behind situation). This is because the transfer of resources and labor from manufacturing sectors to lower-productivity activities (such as to lower-skilled services) can produce a smaller growth rate of per capita income, as well as a lower level of productive sophistication, as measured by Hausmann et al. (2011).[11]

2. Empirical evidence, baseline model

As already mentioned, the contribution of manufacturing to economic growth can be measured using growth accounting, econometric analysis (Szirmai et al., 2013, p. 56) and input-output models (Gabriel and Ribeiro, 2019, p. 57). The first method analyzes what proportion of growth stems from each sector (Jones and Olken, 2008; Timmer and Vries, 2008).[12] However, this method tends to underestimate the contributions of structural change and the emergence of dynamic sectors because they do not take into consideration external effects and intersectoral spillovers (Szirmai and Verspagen, 2010, pp. 12-13). Moreover, econometric analysis is more able to take into consideration exogenous and endogenous factors that may contribute positively or hinder economic growth.

Concerning the last method, Fagerberg and Verspagen (1999, 2002), Rodrik (2009), Tregenna (2009), and Szirmai and Verspagen (2010, 2011) found mixed results for different periods and different estimation techniques. These mixed results, as highlighted by Szirmai and Verspagen (2010, p. 13), are a consequence of manufacturing industries tending to be the driver of growth in developing countries mainly in the period 1950-1973 but not in greater intensity after 1973. According to Szirmai and Verspagen (2010), after 1973, information and communications technology became more important as a source of productivity growth. Moreover, these technologies were not explored only in the manufacturing industries. This fact gave rise to a service-led period of growth, as in India (Dasgupta and Singh, 2005).

Jones and Olken (2008) as well as Johnson et al. (2006) investigate cases of accelerated economic growth (above 2% per year) and their relationship with manufacturing share. These authors found a positive and statistically significant relationship in the sample of developing

[11] Hausman et al. (2011) developed a measure of economic complexity whereby diversity and ubiquity are approximations of the variety of capabilities available in an economy. While more diversified and less ubiquitous products, such as aircraft, tend to demand large quantities of capability and knowledge, more ubiquitous products, such as cloths, or less ubiquitous products based on scarcity, such as niobium (and other natural resources), reflect the need of less capability and knowledge.

[12] Jones and Olken (2008) found large transfers of labor into manufacturing during high-growth periods and large transfers out of manufacturing during growth decelerations. Timmer and Vries's (2008) findings indicate that growth accelerations are largely explained by productivity increases within sectors, services and manufacturing being major contributors during accelerations and services appearing to be the most important source.

countries. The inflection points of the economic growth rates are associated with the decrease of manufacturing share in the economy.

Pieper's (2007) findings show that industrial performance correlates with the overall performance of an economy and therefore is the key sector in explaining the sustainability of different regional patterns in overall productivity as well as economic and employment growth. Rodrik (2013a) lists all cases of high and sustained growth in the 19th and 20th centuries. The author defines "high" growth as the cases in which per capita income grows at least 4.5% per person in the year and "sustained" growth as the cases in which this pace remains for at least three decades. The author's conclusion is that in all cases the process of industrialization as well as the export of manufactured goods is a great driver for this process. According to Rodrik (2013a, 2013b) this occurred because, unlike the other sectors, manufacturing industries exhibit strong unconditional convergence in labor productivity. Rodrik's results are highly robust to changes in the sample and specification, even when controlling for variables like human capital and institutional quality.

In recent literature following Rodrik's (2008) findings, the RER presents a close connection to economic performance (Razmi et al., 2012; Missio et al., 2015). The first channel of this connection presents that an undervalued RER promotes resource reallocation from the non-tradable to the tradable sector, mainly in the modern tradable sector, which is an important locus of learning-by-doing externalities and technological spillovers (Missio et al., 2015, p. 687). The other explanation emphasizes the role of competitive RER in relaxing the foreign exchange constraint on growth (Rodrik, 2008) or the balance-of-payments constraint to growth (Gabriel et al., 2019).

Particularly regarding this last argument, Razmi et al. (2012) showed that investment growth has implications for the balance of payments and it requires an undervalued RER in order to be sustainable.

Based on these findings, we estimate an expanded version of the baseline empirical model of Szirmai and Verspagen (2010, 2011, 2015), considering different groups of countries divided by technological gap levels. To the best of our knowledge, there are no works that consider Verspagen's (1993) proxy for different technological gap levels, sectorial composition and RER at the same time in order to test if the distance from the technological frontier affects the achievement of a greater real per capita income growth rate for developing countries.

Szirmai and Verspagen (2010) estimate panel regression models with fixed, random, and between effects for different samples between 1950 and 2005, using five-year periods, for groups of countries for Asia, Latin America, and Africa. Their dependent variable is the growth of GDP per capita and the covariates are the manufacturing and services shares. The control variables are GDP per capita in the US and education levels. In Szirmai and Verspagen (2011, 2015), the control variables were proxies for human capital at the beginning of each five-year period, the log of the population size, climate zone, and the degree of openness.

In section 3 we will use dynamic panel data models (GMM), which allow us to control for individual unobserved characteristics of the sample that affect the dependent variable and the probable endogeneity of independent variables. Furthermore, as opposed to the above-mentioned empirical works, we test the effects of RER, sectorial shares, and new control variables, considering different technological gaps for the period 1990-2011 (n = 84 and T = 22, in section 3).[13]

[13] The estimators for dynamic panels of Arellano and Bond (1991) are efficient estimators called generalized method of moment (GMM), widely used in empirical research in cases where, according to Roodman (2009), the following

Given these estimator features and the objectives of the next section, the standard Arellano and Bond (1991) procedure is used for the dynamic panel data estimation:

$$GDPpcg_{it} = \beta_0 + \xi GDPpcg_{it-1} + \beta_1 \text{misxrate}_{it} + \beta_2 \text{misxrate}_{it-1} + \beta_3 \text{gaptec}_{it} + \beta_4 \text{vamanu}_{it} + \beta_5 \text{vaprim}_{it} + \beta_6 \text{vaserv}_{it} + \sum_{J=6}^{K} \beta_j Z_{i,tj} + c_i + u_{it} \quad (1)$$

where i = 1, ..., N; t = 1, ..., T; and j = 6, ..., K. In (1) β_j and ξ are the parameters to be estimated, u_{it} is the random disturbance, which captures the unobserved factors on the independent variable, and c_i is a random variable that captures the unobserved characteristics or heterogeneity of each country that affects the per capita income growth rate. $GDPpcg_{it}$ is the real per capita GDP growth, *misxrate* represents the RER adjusted by the Balassa-Samuelson effect according to Rodrik (2008), $gaptec_{it}$ is the technological gap defined by Verspagen (1993), $vamanu_{it}$ is the manufacturing industry share for each country, $vaprim_{it}$ is the primary sector share for each country, and $vaserv_{it}$ is the service sector share for each country (see table 1 for more details for each variable). $Z_{i,tj}$ represents the set of control variables, which for all specifications is 6.[14] In addition, we used a robust estimation for heteroscedasticity using the Arellano and Bond robust covariance matrix (robust vce) and Windmeijer (2005) standard errors.

The technological gap (*gaptec*) is defined following the methodology used by Verspagen (1991, 1993). The technological leader is considered to be the United States and its per capita GDP is a proxy for productivity. Thus, the technological gap is measured by the ratio of US per capita GDP compared to other country per capita GDPs. A negative coefficient for *gaptec* is expected. This indicates that countries with a larger gap relative to the US can grow more rapidly than countries with a smaller gap.

The assumption behind this measure is related to the way the evolutionary approach works with the idea of a technological gap. This approach relates the technological level of each productive system with its innovative activities: a high level of innovative activity means a greater share of 'new' products in relation to GDP and a further extension of the use of 'new' techniques in the production process. Since these new goods and techniques involve a higher level of prices and productivity, respectively, it follows that countries with higher levels of innovative activities tend to display higher value added per worker or per capita income than others.

Originally, Verspagen (1993, p. 96) use this measure as a way of evaluating the relation between growth rates and technology in the world, by trying to detect some regularities in growth performance across countries. His work analyzed 114 countries in the period between 1960 and 1986. The dynamics of real per capita GDP was used as a rough indicator of technological level. The value of per capita GDP for the United States was taken as the productivity of the technological leader in the definition of the technology gap.

are observed: i) periods (T) smaller than the number of individual units (n); ii) linear functions; iii) lagged dynamic variables, i.e., influenced by their own past values; iv) independent variables that are not strictly exogenous and can be correlated with their past values and possibly current realizations of the error term; v) individual fixed effects; vi) heteroscedasticity and within autocorrelation; vii) some variables can be predetermined but are not strictly exogenous, so they may be influenced by their past values; viii) the possibility of "internal" instruments, i.e., based on their own lagged variables or "external" instruments. A potential disadvantage for this class of estimators is that they can easily generate invalid estimates depending on model specifications, as Roodman (2009) explains.

[14] The control variables are: inflation rate (*infla*), a measure of human capital (*humank*), government spending (*govexp*), terms of trade (*ttrade*), and aggregate investment (*ainv*). A brief discussion and sources will be discussed later.

Verspagen's (1993, p. 97) results showed that countries close to the technological frontier (as measured by the performance of the US) exhibited smaller growth rate differentials relative to this frontier than those further away from it. The main conclusion about this result is that the catching-up hypothesis does not occur automatically between developed and less developed countries. However, the catching-up tendency was valid only within the group of developed countries.

In this context, Verspagen's (1993) results explain that countries with relatively low levels of learning capabilities and a large technological gap can fall even further behind.[15] Notwithstanding, countries with relatively high levels of learning capabilities that are close to a technological frontier are more likely to catch up to the leader.

The use of value-added for the tradable and non-tradable sectors is particularly important when we need to test whether industry presents the properties of an "engine of growth." According to Tregenna (2009, pp. 439-441):

(i) the effects of industry on growth through forward and backward linkages are more strongly linked to its economic effect in terms of value added: even if this economic sector lowers its employment share, it can increase the value-added share and increase the demand for capital goods and the amount of raw materials in the upstream sector, besides promoting incentives to reduce costs in downstream sectors;

(ii) the effects of economies of scale and learning-by-doing (stronger in this sector) on industry growth in terms of value added and increased production are compatible with lower employment levels, so the sector can increase its share in terms of value added without necessarily having a constant or increasing share of workers. As technical progress and innovation are particularly important in this sector, it follows that they are also compatible with the expansion of the manufacturing industry in terms of production and value added while reducing the share of workers employed.

The variable *misxrate* follows Rodrik's (2008) methodology. This methodology allows several comparisons with the relevant literature among panels of countries over time. This variable is essentially the RER adjusted by the Balassa-Samuelson effect, that is, an RER adjusted by the relative prices for the tradable sectors in relation to non-tradable sectors. So the *misxrate* variable represents an indicator of undervaluation (*misxrate*) (see Balassa, 1964; Samuelson, 1964).

The variable *misxrate* is computed in three steps. First, the nominal exchange rates from each country ($XRAT_{it}$) and the conversion factor of purchasing power parity (PPP_{it}) are used to estimate the real exchange rate (RER_{it}):

$$lnRER_{it} = ln(XRAT_{it}/PPP_{it}) \tag{2}$$

where the index *i* is the 84 countries in the sample and *t* the time index, which in this work is 22 years (1990-2011). The variables $XRAT_{it}$ and PPP_{it} are expressed in terms of dollars. RER values above one indicate that the value of the national currency is more undervalued than indicated by the purchasing power parity (PPP_{it}). However, the non-tradable sector is also cheaper in poorer countries (through the Balassa-Samuelson effect), which requires an

[15] Verspagen (1991, p. 362; 1993, p. 129) explains that, for a given technological gap, a country's learning capability varies with its intrinsic learning capability, which is determined by a mixture of social factors, such as education of the workforce, the quality of the infrastructure, and the level of mechanization of the economy. This intrinsic learning capability is very important to the technology spill-over absorption from other countries. The latter is defined in Verspagen (1991), essentially, as a process of adoption of new techniques, i.e., the assimilation of foreign technological knowledge. For a further discussion, see section 3.1 in Verspagen (1991) and chapter 5 in Verspagen (1993).

adjustment. Thus, in the second step this effect is considered by regressing RER_{it} to per capita GDP:

$$lnRER_{it} = \alpha + \beta ln\,(GDPpc_{it}) + f_t + u_{it} \qquad (3)$$

where f_t is the fixed effect for the period of time and u_{it} is the error term. Using a robust estimation of equation [3] $\hat{\beta}$ is –0.21 (t = –21.55), with a p value of 0.00, i.e., statistically significant and very close to the Balassa-Samuelson effect calculated by Rodrik (2008).

Finally, in order to calculate Rodrik's (2008) $misxrate_{it}$ indicator, the following equation is used:

$$ln(misxrate_{it}) = lnRER_{it} - ln\widehat{RER}_{it} \qquad (4)$$

Defined in this way, the variable $misxrate_{it}$ is comparable among panels of countries over time. When $misxrate_{it}$ is above the unit, the RER is set so that the domestically produced goods are relatively cheaper in terms of dollars, that is, the exchange rate is undervalued. Conversely, when $misxrate_{it}$ is below the unit, the RER is overvalued. Therefore, this variable is centered at zero.

To assure the robustness of the empirical estimations in section 3, we use a set of different control variables.[16] They are divided between structural and macroeconomic variables. In the latter case, the following variables are taken into consideration: the inflation rate (*infla*), which is a proxy for price stability; gross fixed capital formation (*ainv*), a proxy for the aggregate investment in the economy; and the government consumption share (*govexp*). A negative sign is expected for *infla*[17] and a positive sign for the variable *ainv*. Regarding the *govexp*, a negative sign is expected, suggesting that countries with a higher share of government in the final consumption have lower per capita growth rates.

Regarding the structural variables, we use the following proxies. The variable *humank* for human capital.[18] This variable must be considered from an evolutionary perspective, i.e., as a proxy for learning ability in a broad sense, including technology. In other words, it is a proxy for human capital at the macroeconomic level. A positive sign is expected, indicating that the higher the learning ability, the greater the impact on the explained variable (income per capita growth rate). The variable *pop* captures the effects of the population growth rate on the explanatory variable. In this case, a negative sign is expected.[19] Finally, *ttrade* represents the international terms of trade for the sample of countries. A worsening of the terms of trade tends to undervalue RER, which can boost economic growth.

For the broad sample, the panel estimation is unbalanced, with random missing data covering 84 countries (n = 84) in 22 years of analysis (T = 22), where 18 are developed countries and 66 are developing countries. Table A1 shows the groups of countries. Table 1 presents the abbreviations, a brief description of the variables used in the econometric models, and their sources.

[16] In this case we are following Gala (2006). A comprehensive analysis for potential control variables for the economic growth literature can be seen in Bhalla (2012).
[17] According to Motley (1998), inflation creates distortions in economic decisions concerning consumption, saving and investment. Moreover, high inflation is generally associated with high volatility of price levels over time, hurting economic growth. For a further discussion on this topic, see Motley (1998).
[18] This variable represents the percentage of the population of each country in higher education, regardless of age. In table 2 we present the description of the variables used in the models, their measures, and sources.
[19] If the population growth ratio is higher than the per capita income rate of growth, the country is becoming poorer in the long run (for this metric).

Table 1 – *Description of the variables used in the models, their measures, and sources*

Abbreviation	Brief variable description	Source
GDPpc	Per capita GDP in real terms (US$ dollars - 2005)	IMF (IFS dataset)
GDPpcg	Real per capita GDP growth rate	IMF (IFS dataset)
vamanu	Manufacturing sector share to GDP (value added, in %), 15-37 divisions from the ISIC*	World Bank (WDI dataset)
vaprim	Primary sector share to GDP (value added, in %), 1-5 divisions from the ISIC*	World Bank (WDI dataset)
vaserv	Services sector share to GDP (value added, in %), 50-99 divisions from the ISIC*	World Bank (WDI dataset)
gaptec	Technological gap between countries from Verspargen (1991, 1993) methodology	based on PWT 8.0 (GGDC)
misxrate	RER adjusted by the Balassa-Samuelson effect according to Rodrik (2008) – undervaluation measure	based on PWT 8.0 (GGDC)
ppp	Purchasing power parity in relation to GDP (in domestic monetary units for American dollars)	PWT 8.0 (GGDC)
xrat	Nominal exchange rate for each country in terms of US dollars	PWT 8.0 (GGDC)
rer	*Xrat* adjusted by the purchasing power parity (PPP)	based on PWT 8.0 (GGDC)
infla	Annual inflation rate (from the *Consumer Price Index* – CPI, for each country)	World Bank (WDI dataset)
ainv	Gross fixed capital formation as a proportion of annual GDP	World Bank (WDI dataset)
govexp	Government consumption in terms of goods and services in relation to GDP in real terms	World Bank (WDI dataset)
humank	Percentage of the population of each country in higher education regardless of age	World Bank (WDI dataset)
pop	Population growth rate	World Bank (WDI dataset)
ttrade	Terms of trade: index calculated as the percentage ratio of the unit export value index in relation to the unit import value index, base year 2000	World Bank (WDI dataset)
eci	Hausmann et al. (2011) complexity indicator: calculated based on ubiquity and diversity of the products in each country export basket	MIT (*The Observatory of Economic Complexity* dataset)

Notes: * Revision 3.0 of the ISIC for economic activities of the United Nations Statistics Division (UNSD); value added is the net product of the economic sector after adding the gross value of the entire product and subtracting the intermediate goods involved in the production process. It was calculated without taking into account deductions for depreciation, depletion, and degradation of natural resources. Relative participation (%) is calculated at constant prices in terms of 2005 dollars. IMF – International Monetary Fund; IFS – International Financial Statistics (one of the IMF's main datasets); WDI – *World Development Indicators* (World Bank's compilation of cross-country comparable data on development); PWT – *Penn World Tables* 8.0 (see Feenstra et al., 2015), available at the Groningen Growth and Development Center (GGDC); MIT – Massachusetts Institute of Technology.

3. Manufacturing industries and economic growth: a dynamic

Table 2 shows the results of the dynamic panel data model (1) considering different technological gap levels (*gaptec*) and the service sector (sixth and seventh columns). For the sample used in these estimates, the *gaptec* has an average of 40.28 and a standard deviation of 1.42 (within countries). It was considered in these econometric exercises that countries at the technological frontier have a technological gap of less than 1.5 (table A1 presents the sample of countries with these criteria). The panel "between" standard deviation, i.e., between countries, was 57.72, with a minimum of 0.68 and a maximum of 311.78.

Table 2 reports the estimations for the sample of 84 countries, dividing the sample of countries in terms of technological gap magnitudes: intermediate technological gap, $1.5 < gaptec \leq 57.72$; high technology gap, $57.72 < gaptec \leq 115.44$; and very high technology gap, $gaptec > 115.44$. Furthermore, in the second, sixth and seventh columns, dynamic panel estimations are estimated for the broad samples of developing countries.

It can be observed in table 2 that the effect of real undervalued RER is positive and statistically significant with a lag for all the technological gap levels considered, increasing its effect over the per capita income growth rate when the technological gap measure is higher (for each group of countries).[20] The greater effect of undervalued RER on the per capita growth rate is thus conditional on the technological gap level considered: the greater the gap of the sample of countries in relation to the technological frontier, the greater the effect of the undervalued RER on the per capita income growth rate. This positive and statistically significant result was also found in the broad sample for developing countries with all sectors considered (sixth column) and with the addition of the *eci* in the estimation (seventh column). This last variable was not statistically significant, though positive.

The variable *misxrate* is not statistically significant without lags in the panel of countries with an intermediate, a high, or a very high technological gap, as well as in the broad sample; while it is found to be negative and significant for the broad samples of developing countries (sixth and seventh columns). This result suggests that the *misxrate* variable affects only the per capita income growth rate in a non-contemporary way when considering economic activities (such as in the specification model in this work).

The variable related to the manufacturing share of GDP is positive and significant for all levels of technological gap considered, as well as in the broad samples of developing countries (sixth and seventh columns). Furthermore, it presents significant differences in magnitude at different levels of the technological gap. This result suggests that the degree of technological gap of each sample of countries influences the manufacturing positive (and significant) effect on the per capita income growth rate.

The primary sector share to GDP negatively influences the per capita income growth rate in all technological gap levels considered, but with statistical significance only in the case of intermediate and high technological gaps, as well as in the broad samples (sixth and seventh columns for developing countries and second column for all countries). This result implies that, even for the sample of countries considered to be less developed and with a higher technological gap, the primary sector share to GDP does not positively influence the per capita income growth rate.

In all estimations, the technological gap variable has a negative and statistically significantly effect on the per capita income growth rate, as expected. The *humank* control variable does not present the expected sign for all estimations. The *infla* control variable is negative and significant only in the broad sample (second column) and for countries with the high or very high technological gap level. In relation to the *ainv* control variable, we can see that it has the expected sign for all samples, and it is statistically significant in all estimations.

[20] As can be seen in table 2, *misxrate* does not have a positive and contemporaneous effect on the dependent variable. Therefore, two lagged *misxrate* were tested and presented a positive and statistically significant impact on the dependent variable. In order to keep all the robustness checks and a parsimonious model, just one lag is presented in table 2.

Table 2 – *Dynamic panel estimations (GMM): Arellano and Bond (Diff GMM – two steps robust) with Windmeijer (2005) standard errors, 1990-2011*

	Primary and manufacturing				All sectors	
GDPpcg	**Broad sample**	**Intermediate technological gap**	**High technological gap**	**Very high technological gap**	**Developing countries**	
l.GDPpcg	0.0120	-0.0202	0.146	-0.266	-0.00585	-0.0713
	(0.36)	(-0.49)	(1.81)	(-0.64)	(-0.15)	(-1.70)
l.misxrate	7.103***	6.404***	6.681*	7.538*	5.558***	7.662***
	(5.44)	(4.34)	(2.55)	(2.48)	(3.78)	(4.48)
misxrate	-4.038	-4.160	-1.342	-0.803	-3.624*	-5.231**
	(-0.56)	(-0.79)	(-0.40)	(-0.28)	(-2.36)	(-2.83)
gaptec	-0.0520*	-0.0494**	-0.165***	-0.0330*	-0.0616**	-0.0936***
	(-2.56)	(-2.87)	(-3.58)	(-2.02)	(-2.90)	(-3.78)
vaserv					-0.156*	-0.109*
					(-2.10)	(-2.03)
vamanu	0.214**	0.661**	0.223**	0.198**	0.112**	0.0868**
	(2.94)	(2.71)	(2.63)	(2.69)	(2.82)	(2.65)
vaprim	-0.115*	-0.0810**	-0.0630**	-0.0369	-0.312***	-0.210**
	(-2.04)	(-2.72)	(-2.92)	(-0.74)	(-4.40)	(-2.60)
humank	-0.0152	-0.0285	0.0829	0.0749	-0.0263	-0.0342
	(-0.55)	(-1.12)	(0.53)	(0.29)	(-0.81)	(-1.03)
infla	-0.00249**	0.000307	-0.131**	-0.0352***	-0.00153	0.000332
	(-3.39)	(0.10)	(-2.62)	(-3.81)	(-0.37)	(0.09)
ainv	0.261***	0.342***	0.0304***	0.253***	0.200***	0.265***
	(6.84)	(7.53)	(4.70)	(4.15)	(5.24)	(6.72)
govexp	-0.444***	-0.489***	-0.0910*	-0.233*	-0.376***	-0.269**
	(-5.15)	(-4.01)	(-2.57)	(-2.45)	(-4.25)	(-2.84)
ttrade	-0.00999	-0.00381	-0.0422**	-0.000792	-0.00999	-0.00171
	(-1.13)	(-0.35)	(-3.12)	(-0.06)	(-1.07)	(-0.15)
pop	-0.944**	-1.414***	-0.146**	-0.686**	-0.692*	-1.207**
	(-2.76)	(-3.33)	(-2.81)	(-2.92)	(-1.99)	(-2.90)
eci						0.0149
						(0.12)
Temporal dummy	Yes	Yes	Yes	Yes	Yes	Yes
Arellano and Bond's test for AR(1) – *A*	z = -14.14 Pr > z = 0.000	z = -10.04 Pr > z = 0.000	z = -13.34 Pr > z = 0.000	z = -9.02 Pr > z = 0.000	z = -10.58 Pr > z = 0.000	z = -11.17 Pr > z = 0.000
Arellano and Bond's test for AR(2) – *A*	z = -0.32 Pr > z = 0.752	z = -1.53 Pr > z = 0.126	z = 0.07 Pr > z = 0.942	z = 1.43 Pr > z = 0.154	z = 1.77 Pr > z = 0.176	z = -0.99 Pr > z = 0.323
Sargan's test for over-identified restrictions – *B*	Prob > chi2 = 0.571	Prob > chi2 = 0.231	Prob > chi2 = 0.113	Prob > chi2 = 0.757	Prob > chi2 = 0.571	Prob > chi2 = 0.205
N	1256	673	181	135	987	778

Notes: *t* (s) statistics in brackets; * p<0.05, ** p<0.01, *** p<0.001. In *A* – the null hypothesis: there is no "n" order correlation in the residues. In *B* – the null hypothesis: the model is correctly specified, and all over-identifications are correct. Results are generated using the xtabond2 command in Stata and assume exogeneity of time dummies (see Roodman, 2009).

The control variable *govexp* has the expected sign and is statistically significant in all estimations. For the *ttrade* variable, we can see that it has a negative sign and is statistically significant only in the case of a high technological gap, though negative in other estimations. The *pop* control variable was negative and statistically significant for all estimations. The main hypothesis which explains the negative result for the primary and service sectors is that, for these samples of countries (mainly developing ones), the majority of the activities within these sectors present lower productivity, value added per worker, and/or less skilled labor.[21]

In all estimations reported in table 2, the null hypothesis that over-identified restrictions are valid at the 1% level of significance is not rejected.[22] Similarly, the null hypothesis that there is no autocorrelation for higher order than AR is not rejected. Furthermore, with the two-step estimations, efficient and robust parameters were obtained for any level of heteroscedasticity, whereas, for Windmeijer's (2005) standard errors, the downward bias for the standard errors in the estimators was avoided.

In conclusion, our econometric results support the "engine of growth" hypothesis concerning manufacturing industry presented in section 2 for the period 1990-2011, even though we had expected a positive sign for the primary sector parameter, at least for higher technological gaps, and this was not verified.

However, according to Gabriel and Ribeiro (2019, p. 6), "econometric models may not capture the direct and indirect effects of the different economic sectors" in a multisectoral perspective. In this regard, the input-output (IO) multipliers provide complementary results to the econometric estimations. As opposed to the econometric models, which assume partial equilibrium, IO models are based on a general equilibrium approach. All economic agents of the model, i.e., industries, households, government, investors, exporters and importers, are interconnected through intersectoral trade.

4. Input-output multipliers: an analysis

The IO model allows the representation of the most diverse relationships between sectors of a given economy, which contributes to economic planning (Miller and Blair, 2009). The IO technique is a linear model of production in which the economy is represented in a simplified way from intersectoral tables of flows of goods and services, which allows the identification of sectorial interrelations between the different economic agents (Prado, 1981). The IO model assumes constant returns to scale, perfectly elastic supply, and invariability of technical coefficients, i.e., price changes or technological advances are not considered. In addition, it is assumed that system disturbances derive from exogenous changes in final demand (Miller and Blair, 2009). However, even with these limitations, the IO model is fundamental for sectorial

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[21] For further analyses of these features in developing countries within these sectors, see Su and Yao (2016), Rodrik (2008, 2009, 2015), and Marconi (2015).

[22] Whenever there is heteroscedasticity, the Sargan (1958) test of over-identifying constraints usually rejects the null hypothesis (which is that they are valid). This means that there may be the presence of heteroscedasticity, poor model specification, or even inadequate use of the number of instruments, cf. Roodman (2009). In addition to the Sargan test (1958), there is the Hansen test (1982). The two tests have good asymptotic properties in the absence of heteroscedasticity and autocorrelation, as in the case of the panels estimated in table 2. However, if the residues present any of these uncorrected problems, the Hansen test (1982) presents superior statistical properties, having only the problem of loss of power when the number of instruments used is high.

policy planning and especially for economic development, as it provides analysis mechanisms for efficient allocation of economic resources in underdeveloped regions or countries.

In this section we calculate IO multipliers of 40 countries for the years 1995, 2000, 2005 and 2010. To do so, we use data from the WIOD (Timmer et al., 2015) to calculate the output and employment multipliers. It is important to highlight that this sample of countries is different from the one used in the previous section. However, 25 countries, or 62.5% of the sample, are the same as those of the previous sections. The exceptions are the following countries: Belgium, Canada, Czech Republic, Estonia, Hungary, Ireland, Luxembourg, Portugal, Slovak, Slovenia, Cyprus, Malta, Poland, Romania, and Taiwan.

The WIOD data for the period 1995-2011 has 35 sectors. For this paper, we use the aggregation proposed by Gabriel and Ribeiro (2019), i.e.: agriculture, hunting, forestry and fishing; mining and quarrying; manufacturing; electricity, gas and water supply; construction; trade; and services.

Following Miller and Blair's (2009) notation, the IO model can be defined by $x = Lf$, where: x is the total output; $L = [l_{ij}] = (I - A)^{-1}$ is the Leontief Inverse matrix; and f is the final demand vector. The simple output multiplier for sector *j* is specified as $m(o)_j \sum_{i=1}^{n} l_{ij}$. The simple employment multiplier for sector j is $m(h)_j \sum_{i=1}^{n} a_{n+1}, il_{ij}$, where a_{n+1} is the employment coefficient, i.e., the employment of sector *j* divided *per* the output of sector *j*. It is important to highlight that both multipliers consider households as exogenous.

Moreover, we split the data into two groups of countries: 28 developed countries and 12 developing countries. Table 4 shows the results of output multipliers. In general, the output multipliers' average of developing countries is higher than the developed countries for the following sectors: manufacturing, electricity, gas and water supply, and construction. For each $1.00 of final demand variation in the manufacturing industry of developing countries in 2010, on average, the whole economy of this group of countries needs to increase its production by $1.90 in order to meet this final demand variation.

The Chinese manufacturing output multiplier in 2010 was the highest, at 2.8, which is in line with the argument of industry as the "engine of growth" (Szirmai, 2012; Rodrik, 2015). This sector in developing countries is more dynamic than in developed countries, i.e., the increase in production in order to meet this final demand variation, on average, is stronger, mainly in Brazil, China, India, Russia, and Turkey.

In 1995, the China's manufacturing industry share in total employment, for instance, was 16% and in 2010 it increased to 20%, indicating a process of strong industrialization, which reflected a value-added share of 33% in the same year. In 1995, India's manufacturing industry share in total employment was 11% and in 2010 it increased to 13%, which reflected a value-added share of 15%. In 1995, the Turkey's manufacturing industry share in total employment was 15% and in 2010 it increased to 19%, which reflected a value-added share of 19%. However, a decrease was verified in Russia; in 1995 its manufacturing industry share in total employment was 17% and in 2010 it decreased to 13%, which reflected a value-added share of 15%. In 1995, Brazil's manufacturing industry share in total employment was 13% and in 2010 it decreased to 12%, which reflected a value-added share of 17%.

On the other hand, the output multiplier of agriculture, hunting, forestry and fishing is higher in developed countries, which could indicate a more capital-intensive, and therefore a more productive, sector. The top five highest output multipliers in agriculture, hunting, forestry and fishing are from Canada (1.96), United States (1.94), China (1.91), Japan (1.90) and Czech Republic (1.87). However, China's agriculture share in total employment in 2010 was 36%, against 5%, on average, for the developed countries (see table 3). This kind of structure is similar to that of other countries, i.e., the agriculture of developed countries has a low share in total employment and agriculture of developing countries has a higher share (see table 3).

It is well-known in the literature that the service sector becomes relatively more important, in terms of share of employment and value added, in countries with higher levels of development (Rowthorn and Ramaswamy, 1997); this can be seen in table 3. The sectorial share of services in total value added and total employment of developed countries (59.3% and 55.6%, respectively) is higher than that of developing countries (47.2% and 39%, respectively).

We can see in table 4 that the output multipliers' average of the trade sector was higher in developed countries than in developing ones but, for the services sector, these indicators were slightly higher in developing countries (the only exception is in 2005). However, for both groups of countries, these indicators are lower than what is verified for the manufacturing industry, for electricity, gas and water supply, and for construction. This is an expected result in an IO framework, because the services sector has few linkages in the economy compared to industrial activities, as pointed out by Gabriel and Ribeiro (2019).

In order to evaluate the behavior of the labor force within sectors, it is interesting to evaluate the employment multiplier over time, as shown in table 5. In general, the employment multipliers' average of developing countries is higher than that of developed countries for all sectors and all analyzed years. This is an expected result because developing countries employ more labor-intensive technologies.

For each US $1,000,000 of final demand variation in agriculture, hunting, forestry and fishing of developing countries in 2010, on average, the whole economy created, directly and indirectly, 205 new jobs. This same indicator for developed countries was 31 new jobs. It is important to note that agriculture tends to create low-skill jobs, especially in developing countries, as shown by Couto and Ribeiro (2017) for Brazil.

On the other hand, the manufacturing industry, especially, creates high-skill jobs; therefore, it is important to relativize its smaller employment multiplier when comparing the industry to agriculture, hunting, forestry and fishing, for instance.

As we can see in table 3, in 2010 on average, agriculture's share in total employment in developing countries and in developed countries was 21.4% and 5.1%, respectively. In 1995, the China's and India's employment multipliers were 1,920 and 2,357, respectively. After 15 years, the same indicators of these two countries, which have the largest populations in the world, decreased to 352 and 837, respectively. In 1995 and 2010, the China's agriculture accounted for 56% and 36% of total employment, respectively, which could suggest a process of sectorial mechanization.

Table 3 – *Descriptive statistics: sectorial share in total employment and total value added, 2010* (%)

	Sector	Employment				Value added			
		Average	Standard deviation	Min	Max	Average	Standard deviation	Min	Max
Developed countries (N = 28)	Agriculture, hunting, forestry and fishing	5.1	3.8	1.0	18.0	2.2	1.1	0.0	5.0
	Mining and quarrying	0.2	0.5	0.0	2.0	1.3	2.5	0.0	12.0
	Industry	14.6	4.1	9.0	25.0	16.2	5.6	6.0	30.0
	Electricity, gas and water supply	0.9	0.6	0.0	2.0	2.9	1.1	1.0	6.0
	Construction	8.1	2.1	5.0	15.0	6.1	1.6	4.0	10.0
	Trade	15.3	2.4	12.0	22.0	12.0	2.1	9.0	17.0
	Services	55.6	7.8	39.0	68.0	59.2	6.4	45.0	75.0
Developing countries (N = 12)	Agriculture, hunting, forestry and fishing	21.4	15.3	3.0	52.0	6.8	5.0	2.0	17.0
	Mining and quarrying	0.6	0.5	0.0	1.0	3.9	4.3	0.0	13.0
	Industry	15.6	4.9	9.0	27.0	18.3	6.4	7.0	33.0
	Electricity, gas and water supply	0.7	0.8	0.0	2.0	2.7	1.4	1.0	6.0
	Construction	7.7	1.7	5.0	11.0	7.4	2.0	4.0	11.0
	Trade	14.8	2.9	8.0	18.0	13.9	3.7	9.0	21.0
	Services	39.0	13.0	17.0	62.0	47.2	12.1	27.0	68.0

Source: data from WIOD.

It is worth mentioning that there are not great differences in the averages of employment multipliers among manufacturing Industry, construction, trade and services for the analyzed years when considering the same group of countries (developing or developed). Notwithstanding, there are great differences among the averages of developing and developed countries in these sectors, even when China, India and Indonesia are excluded from the calculations. These results suggest high differences in productivity between the two groups of countries, which can be explained by differences in human capital and the technological gap.[23]

[23] Certainly, the supply of labor influences the level of employment multipliers. However, it is not our goal here to explain how much each factor influences the employment multiplier result.

Table 4 – *Output multipliers* (*1995, 2000, 2005, and 2010*)

	Country	Agriculture, hunting, forestry and fishing				Mining and quarrying				Manufacturing industry				Electricity, gas and water supply				Construction				Trade				Services			
		1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
Developed countries	Australia	1.78	1.75	1.68	1.69	1.58	1.62	1.56	1.56	2.02	2.03	2.02	2.02	1.61	1.74	1.72	1.73	2.10	2.19	2.23	2.25	1.81	1.86	1.78	1.78	1.67	1.68	1.65	1,65
	Austria	1.53	1.55	1.58	1.66	1.49	1.48	1.42	1.48	1.61	1.52	1.51	1.61	1.64	1.53	1.90	2.41	1.52	1.50	1.52	1.65	1.42	1.42	1.44	1.45	1.39	1.41	1.45	1,48
	Belgiun	1.60	1.57	1.63	1.58	1.40	1.52	1.48	1.52	1.51	1.54	1.49	1.46	1.37	1.36	1.42	1.44	1.79	1.76	1.82	1.86	1.56	1.61	1.57	1.54	1.45	1.48	1.50	1,47
	Bulgaria	1.78	1.81	1.90	1.84	1.79	1.66	1.78	1.60	1.81	1.58	1.88	1.88	1.62	1.46	1.76	1.79	1.67	1.62	1.93	2.00	1.64	1.67	1.87	1.86	1.43	1.43	1.63	1,66
	Canada	1.76	1.80	1.87	1.96	1.41	1.39	1.34	1.37	1.66	1.65	1.71	1.87	1.22	1.31	1.32	1.35	1.62	1.61	1.68	1.78	1.38	1.44	1.45	1.48	1.42	1.48	1.49	1,52
	Czech Republic	1.83	1.74	1.70	1.87	1.77	1.68	1.66	1.72	1.94	1.74	1.69	1.67	2.11	1.97	1.65	1.70	2.12	2.07	2.11	2.06	1.76	1.59	1.66	1.76	1.66	1.69	1.72	1,70
	Denmark	1.60	1.62	1.70	1.69	1.40	1.15	1.13	1.18	1.63	1.58	1.59	1.61	1.30	1.33	1.41	1.58	1.65	1.59	1.59	1.58	1.47	1.46	1.47	1.47	1.41	1.41	1.42	1,43
	Estonia	1.85	1.59	1.68	1.66	1.47	1.43	1.41	1.37	1.71	1.56	1.64	1.66	1.64	1.65	1.53	1.57	1.53	1.60	1.66	1.61	1.49	1.57	1.55	1.53	1.51	1.56	1.58	1,53
	Finland	1.64	1.63	1.68	1.63	1.71	1.79	1.77	1.77	1.82	1.77	1.71	1.79	1.42	1.49	1.42	1.52	1.81	1.83	1.81	1.87	1.57	1.58	1.56	1.67	1.49	1.50	1.52	1,55
	France	1.74	1.73	1.77	1.82	1.86	1.77	1.79	1.81	1.93	1.86	1.87	1.94	1.78	1.72	1.74	1.87	1.81	1.80	1.80	1.79	1.62	1.61	1.64	1.64	1.50	1.50	1.50	1,45
	Germany	1.68	1.63	1.69	1.68	1.75	1.76	1.79	1.65	1.77	1.73	1.70	1.69	1.61	1.59	1.57	1.61	1.73	1.73	1.69	1.68	1.53	1.51	1.52	1.51	1.46	1.48	1.47	1,47
	Greece	1.54	1.47	1.46	1.44	1.44	1.40	1.52	1.47	1.87	1.66	1.67	1.53	1.32	1.37	1.43	1.42	1.77	1.64	1.61	1.63	1.36	1.31	1.36	1.33	1.41	1.33	1.33	1,30
	Ireland	1.56	1.48	1.59	1.59	1.51	1.54	1.59	1.53	1.48	1.33	1.38	1.41	1.37	1.38	1.51	1.58	1.67	1.64	1.71	1.69	1.39	1.32	1.41	1.37	1.49	1.42	1.40	1,38
	Italy	1.52	1.54	1.59	1.67	1.44	1.57	1.68	1.55	1.97	1.99	2.00	1.94	1.52	1.62	1.62	1.35	1.94	1.97	1.93	1.85	1.70	1.82	1.85	1.85	1.49	1.55	1.56	1,53
	Japan	1.81	1.77	1.83	1.90	1.90	1.84	1.81	1.86	2.19	2.15	2.15	2.21	1.71	1.69	1.71	1.76	1.99	1.94	1.94	1.93	1.61	1.61	1.61	1.56	1.59	1.59	1.59	1,59
	Latvia	1.67	1.69	1.68	1.74	1.40	1.60	1.47	1.58	1.62	1.67	1.67	1.75	1.28	1.56	1.58	1.68	1.59	1.64	1.88	1.99	1.61	1.63	1.51	1.57	1.44	1.53	1.53	1,58
	Lithuania	1.72	1.54	1.58	1.70	1.52	1.39	1.42	1.42	1.62	1.42	1.37	1.40	1.69	1.35	1.41	1.44	1.51	1.42	1.44	1.47	1.37	1.32	1.29	1.34	1.42	1.33	1.34	1,37
	Luxembourg	1.24	1.25	1.26	1.33	1.24	1.29	1.30	1.50	1.20	1.26	1.27	1.34	1.10	1.10	1.25	1.39	1.30	1.38	1.36	1.41	1.28	1.32	1.32	1.40	1.26	1.32	1.35	1,31
	Malta	1.39	1.38	1.44	1.51	1.57	1.43	1.48	1.42	1.28	1.24	1.38	1.35	1.44	1.40	1.47	1.44	1.39	1.45	1.49	1.43	1.26	1.29	1.37	1.42	1.25	1.26	1.43	1,52
	Netherlands	1.60	1.57	1.57	1.57	1.24	1.23	1.23	1.19	1.57	1.53	1.52	1.47	1.75	1.70	1.61	1.60	1.69	1.71	1.69	1.65	1.41	1.42	1.42	1.41	1.44	1.46	1.45	1,45
	Portugal	1.54	1.60	1.66	1.72	1.58	1.61	1.68	1.63	1.85	1.74	1.71	1.79	1.87	1.88	1.95	2.18	2.01	1.97	2.02	2.04	1.54	1.56	1.56	1.53	1.48	1.48	1.49	1,51
	Slovak	1.97	1.84	1.61	1.56	1.64	1.57	1.46	1.47	1.85	1.68	1.48	1.56	1.93	2.52	1.88	1.94	2.04	1.86	1.84	1.83	1.80	1.72	1.52	1.51	1.61	1.55	1.47	1,54
	Slovenia	1.62	1.57	1.50	1.52	1.43	1.47	1.44	1.54	1.61	1.59	1.51	1.57	1.73	1.55	1.50	1.59	1.82	1.80	1.79	1.86	1.60	1.57	1.51	1.56	1.48	1.48	1.43	1,47
	South Korea	1.47	1.53	1.62	1.79	1.46	1.46	1.60	1.66	2.06	2.01	2.12	2.17	1.60	1.58	1.56	1.79	1.91	1.94	1.97	2.08	1.57	1.56	1.63	1.65	1.56	1.58	1.59	1,63
	Spain	1.58	1.54	1.58	1.61	1.80	1.70	1.77	1.86	1.97	1.84	1.90	1.91	1.73	1.63	1.70	1.83	2.10	1.97	2.19	2.11	1.58	1.51	1.59	1.58	1.56	1.51	1.54	1,52
	Sweden	1.38	1.43	1.53	1.43	1.64	1.65	1.47	1.39	1.69	1.65	1.64	1.68	1.32	1.38	1.36	1.33	1.64	1.61	1.59	1.59	1.46	1.43	1.45	1.47	1.56	1.55	1.54	1,54
	United Kingdom	1.73	1.77	1.68	1.61	1.50	1.36	1.35	1.31	1.75	1.74	1.75	1.65	1.89	2.04	1.85	1.72	1.98	1.94	1.92	1.90	1.60	1.66	1.64	1.62	1.55	1.59	1.62	1,59
	United States	2.10	2.07	1.98	1.94	1.66	1.71	1.71	1.60	2.12	2.06	1.98	1.89	1.43	1.72	1.54	1.30	1.93	1.84	1.80	1.72	1.48	1.46	1.47	1.47	1.58	1.63	1.62	1,59
	Average	**1,65**	**1.62**	**1.64**	**1.67**	**1.56**	**1.54**	**1.54**	**1.54**	**1.75**	**1.68**	**1.69**	**1.71**	**1.57**	**1.59**	**1.59**	**1.64**	**1.77**	**1.75**	**1.79**	**1.80**	**1.53**	**1.53**	**1.54**	**1.55**	**1.48**	**1.49**	**1.51**	**1.51**

(continues)

(continued)

	Country	Agriculture, hunting, forestry and fishing				Mining and quarrying				Manufacturing industry				Electricity, gas and water supply				Construction				Trade				Services			
		1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
Developing countries	Brazil	1.50	1.58	1.70	1.61	1.88	1.73	1.80	1.81	2.01	2.03	2.11	2.03	1.59	1.66	1.64	1.66	1.77	1.78	1.75	1.74	1.35	1.41	1.42	1.39	1.49	1.51	1.53	1,50
	China	1.75	1.82	1.82	1.91	2.03	1.91	1.99	2.21	2.49	2.47	2.50	2.80	2.11	2.06	2.37	2.65	2.59	2.60	2.65	2.90	2.05	1.96	1.82	1.84	1.95	1.99	1.96	2,06
	Cyprus	1.35	1.37	1.42	1.48	1.33	1.34	1.38	1.40	1.45	1.44	1.57	1.72	1.07	1.04	1.03	1.08	1.38	1.41	1.50	1.61	1.26	1.30	1.35	1.42	1.22	1.24	1.29	1,34
	Hungary	1.83	1.71	1.66	1.64	1.62	1.55	1.58	1.59	1.88	1.52	1.50	1.48	1.48	1.33	1.43	1.44	1.75	1.52	1.57	1.55	1.66	1.59	1.60	1.58	1.45	1.40	1.43	1,43
	India	1.37	1.35	1.36	1.32	1.45	1.35	1.37	1.36	2.25	2.08	2.02	2.04	2.08	2.03	2.03	2.00	2.01	1.91	1.90	1.95	1.35	1.26	1.20	1.16	1.52	1.52	1.49	1,46
	Indonesia	1.23	1.28	1.28	1.32	1.16	1.14	1.17	1.20	1.83	1.74	1.70	1.80	1.66	1.73	1.77	1.90	1.87	1.74	1.73	1.82	1.36	1.45	1.55	1.60	1.50	1.53	1.56	1,63
	Mexico	1.48	1.44	1.51	1.49	1.22	1.19	1.20	1.19	1.74	1.62	1.64	1.63	1.61	1.66	1.76	1.74	1.66	1.57	1.58	1.56	1.31	1.27	1.27	1.26	1.33	1.29	1.29	1,29
	Poland	1.93	1.85	1.74	1.74	1.56	1.53	1.44	1.45	1.98	1.85	1.81	1.79	1.80	1.77	1.70	1.62	1.88	1.78	1.83	1.86	1.65	1.61	1.56	1.51	1.58	1.54	1.53	1,52
	Romania	1.82	1.70	1.67	1.68	1.83	1.62	1.62	1.72	2.01	1.79	1.67	1.71	2.28	2.01	1.74	2.01	1.85	1.65	1.61	1.70	1.44	1.39	1.44	1.49	1.57	1.47	1.46	1,53
	Russia	1.81	1.64	1.69	1.82	1.63	1.72	1.56	1.56	2.03	1.84	2.02	2.17	1.87	1.73	2.01	2.24	1.80	1.71	1.87	1.95	1.41	1.38	1.56	1.61	1.65	1.61	1.65	1,70
	Taiwan	1.61	1.84	1.61	1.56	1.46	1.57	1.46	1.47	1.48	1.68	1.48	1.56	1.88	2.52	1.88	1.94	1.84	1.86	1.84	1.83	1.52	1.72	1.52	1.51	1.47	1.55	1.47	1,54
	Turkey	1.46	1.46	1.45	1.49	1.25	1.47	1.49	1.56	1.70	1.86	1.92	2.02	1.28	1.65	1.57	2.19	1.74	1.77	1.75	1.77	1.33	1.39	1.47	1.48	1.39	1.50	1.52	1,52
	Average	**1.60**	**1.59**	**1.58**	**1.59**	**1.54**	**1.51**	**1.50**	**1.54**	**1.90**	**1.83**	**1.83**	**1.90**	**1.73**	**1.77**	**1.75**	**1.87**	**1.85**	**1.78**	**1.80**	**1.85**	**1.47**	**1.48**	**1.48**	**1.49**	**1.51**	**1.51**	**1.51**	**1.54**

Source: author's elaboration, using data from WIOD.

Table 5 – *Employment multipliers (1995, 2000, 2005, and 2010)*

	Country	Agriculture, hunting, forestry and fishing				Mining and quarrying				Manufacturing industry				Electricity, gas and water supply				Construction				Trade				Services			
		1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
Developed countries	Australia	25	25	15	9	9	9	5	3	18	19	11	7	10	11	7	5	20	24	14	9	28	29	18	11	20	21	13	9
	Austria	38	55	38	27	10	11	6	5	13	14	8	7	6	7	4	3	13	17	10	9	16	21	13	12	14	18	12	10
	Belgium	14	18	14	10	7	10	7	5	7	9	6	4	5	6	4	3	11	14	9	7	13	16	10	8	13	16	10	8
	Bulgaria	312	366	230	182	165	154	72	33	175	165	92	50	122	85	58	34	218	169	82	52	245	292	151	99	208	177	94	57
	Canada	26	23	16	11	10	7	4	4	15	13	10	8	8	7	5	5	21	18	12	10	33	28	19	14	23	21	15	11
	Czech Republic	92	81	38	31	71	64	25	18	66	51	22	14	40	36	14	10	84	75	35	25	95	79	39	26	71	70	33	22
	Denmark	15	18	12	9	5	2	1	1	12	13	8	6	5	6	3	3	13	15	9	9	15	19	12	10	13	16	10	8
	Estonia	184	97	45	28	105	79	34	23	118	60	29	22	87	66	25	13	94	73	32	28	138	90	36	32	126	73	35	25
	Finland	24	29	18	14	12	15	9	6	12	13	8	7	7	9	5	4	14	16	10	9	18	21	13	11	15	18	12	10
	France	17	21	15	11	10	15	9	7	13	14	9	7	6	10	6	5	15	18	11	10	16	21	13	11	14	18	11	9
	Germany	23	28	22	18	13	19	12	9	13	15	10	8	9	12	7	5	16	22	15	12	19	26	18	16	14	19	13	12
	Greece	65	79	42	45	22	21	12	12	31	30	17	13	12	15	7	5	28	28	18	23	35	39	21	21	26	26	15	13
	Hungary	121	133	50	42	109	95	38	28	67	46	20	15	48	36	15	13	79	73	36	32	80	85	38	33	71	68	30	24
	Ireland	25	31	22	16	11	11	7	5	11	7	4	3	9	10	5	3	16	14	8	18	23	22	10	9	17	15	8	7
	Italy	31	32	22	20	10	11	8	7	16	17	11	9	8	8	5	3	20	22	14	13	20	21	14	13	18	19	12	11
	Japan	36	37	36	25	8	8	7	5	12	12	11	8	6	7	7	5	13	15	15	12	13	15	15	11	11	13	13	10
	Latvia	15	233	107	43	34	124	43	23	26	99	48	28	10	57	31	17	63	86	48	34	51	104	54	40	42	91	48	32
	Lithuania	281	273	111	59	149	53	26	24	147	78	29	19	102	63	23	15	155	96	50	37	181	103	48	36	182	101	48	35
	Luxembourg	505	19	16	11	65	8	5	4	38	7	5	5	42	5	2	2	26	12	8	7	47	15	9	5	22	6	4	3
	Netherlands	15	20	13	10	3	4	1	1	10	11	7	5	5	5	3	2	14	17	10	9	19	22	14	12	16	19	12	10
	Portugal	82	113	80	64	26	32	21	15	35	37	23	18	14	14	8	7	42	48	30	25	40	44	30	24	30	33	21	18
	Slovak	73	94	39	23	35	73	29	16	34	56	22	13	17	61	15	9	38	72	34	20	38	82	41	24	34	83	38	22
	Slovenia	150	111	64	49	90	39	20	14	71	32	16	13	73	25	12	9	85	35	19	18	88	44	23	19	89	35	20	17
	South Korea	64	76	51	42	15	15	12	11	27	24	15	11	12	10	6	6	32	34	22	19	57	60	41	32	31	35	25	22
	Spain	29	36	24	18	18	21	13	10	18	21	13	10	10	10	6	5	23	29	16	11	27	34	20	16	21	25	15	12
	Sweden	17	20	15	10	11	12	6	3	11	11	7	6	5	7	4	3	14	15	10	9	18	19	12	10	16	16	11	9
	United Kingdom	24	25	18	18	8	5	3	3	17	14	10	9	8	7	4	3	25	20	14	14	28	22	15	16	25	20	13	14
	United States	22	18	13	10	10	8	6	5	15	12	8	7	7	7	4	3	18	15	12	10	19	16	13	11	17	14	11	9
	Average	**83**	**75**	**42**	**31**	**37**	**33**	**16**	**11**	**37**	**32**	**17**	**12**	**25**	**21**	**11**	**7**	**43**	**39**	**22**	**17**	**51**	**50**	**27**	**21**	**43**	**39**	**22**	**16**

(continues)

(continued)

	Country	Agriculture, hunting, forestry and fishing				Mining and quarrying				Manufacturing industry				Electricity, gas and water supply				Construction				Trade				Services			
		1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
Developing countries	Brazil	370	399	291	120	63	58	47	23	98	114	92	42	33	36	29	15	102	137	124	56	123	175	145	63	78	103	89	45
	China	1,921	1,488	912	352	514	252	125	62	616	375	208	95	374	214	105	54	664	489	245	105	644	422	261	111	680	408	236	102
	Cyprus	37	43	29	24	22	20	10	10	25	25	18	15	6	5	3	2	29	31	19	18	37	40	27	21	26	27	18	14
	India	2,357	2,178	1,620	817	378	267	152	75	713	598	381	200	331	271	178	97	664	563	355	205	621	585	358	187	524	420	281	147
	Indonesia	959	1,228	971	337	68	44	32	19	284	357	236	116	176	114	88	54	245	326	202	97	375	546	400	193	266	439	241	148
	Malta	25	29	20	17	26	30	20	14	16	14	13	10	17	15	9	8	39	44	25	22	32	36	25	21	34	31	20	16
	Mexico	308	188	169	137	18	10	9	7	75	43	36	32	55	30	24	21	105	58	53	51	88	54	48	43	87	53	45	44
	Poland	251	299	119	76	74	59	30	20	97	74	36	24	64	50	24	16	86	60	36	26	84	65	35	26	88	64	37	29
	Romania	451	889	264	196	207	146	55	36	204	222	71	43	152	119	41	29	171	163	59	43	211	205	84	76	152	143	55	38
	Russia	572	796	357	189	83	132	35	18	202	232	86	47	117	188	74	40	241	266	109	55	129	184	92	46	198	310	101	51
	Taiwan	345	561	232	125	68	131	52	27	102	282	110	74	37	177	40	27	198	403	169	83	176	448	192	105	142	335	168	101
	Turkey	273	216	111	73	54	35	23	15	58	61	39	29	30	20	9	13	74	73	41	33	67	81	53	35	59	48	31	22
Average		**656**	**693**	**425**	**205**	**131**	**99**	**49**	**27**	**207**	**200**	**111**	**61**	**116**	**103**	**52**	**31**	**218**	**218**	**120**	**66**	**216**	**237**	**143**	**77**	**194**	**198**	**110**	**63**

Source: author's elaboration on data from WIOD

5. Final remarks

The main objective of this paper was to investigate the effects of manufacturing and the RER on real per capita income growth rate, controlling for different technological gap levels, as well as to present the output and employment multipliers, which provide complementary results for the econometric estimations. According to the Kaldorian approach, the increasing returns of scale in the manufacturing industry and its technological spillovers to the rest of the economy are the driving forces behind the positive effects of this sector on the labor productivity dynamics and economic growth. The empirical analysis carried out in this article provided robust evidence that the manufacturing industry positively influences the income per capita growth rate. In other words, we have found results that confirm the “engine of growth” role of this sector and its important role for the catch-up process of developing countries between 1990 and 2011.

Even when considering the service sector in terms of its value-added share, estimations show that manufacturing still plays a positive and statistically significant role in boosting the per capita income growth rate. Therefore, the premature decrease of the manufacturing share to GDP in developing economies can reduce the level of productive sophistication, hindering the catch-up process and the achievement of higher per capita income levels (falling-behind situation).

More important empirical evidence concerns the effect of the undervalued RER on the income per capita rate of growth. The positive effect of the former on the latter was found to be conditional on the technological gap level, which is a novel result for the literature. The greater the gap of the sample countries relative to the technological frontier, the greater the effect of the undervalued RER in the income per capita growth rate. These results mean that countries below the technological frontier and thus at a great disadvantage from the point of view of non-price competitiveness need to compensate for this backwardness with some price advantage, which is represented here by an undervalued RER.

Due to the reallocation of resources to non-industrial sectors, such as activities linked to commodity production (in the primary sector), where there are decreasing returns to scale, the real overvaluation of the RER reduces the total productivity of the economy and structural change is directed towards lower value-added goods.

Finally, regarding the IO analysis, the manufacturing industry’s output multipliers and the employment multipliers of all sectors in developing countries are higher than those in developed countries in all analyzed years. This result, therefore, also reinforces this sector as an “engine of growth”.

Overall, from the use of two complementary methodologies, econometric models and input-output analysis, we can see the central role that manufacturing plays in leveraging economic growth, especially in developing countries, which to some extent captures a convergence or catch-up process.

Appendix

Table A1 – *Dynamic panel: country samples by technological gap*

Emerging or developing countries			**Developed countries**
(1) Intermediate technological gap	**(2) High technological gap**	**(3) Very high technological gap**	**(4) Technological frontier (*N* = 18)**
Argentina, Bolivia, Botswana, Brazil, Bulgaria, Cameroon, Chile, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt Arab Rep., El Salvador, Estonia, Gabon, Georgia, Indonesia, Iran. Islamic Rep., Jordan, Korea. Rep., Latvia, Lithuania, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Morocco, Namibia, Nigeria, Oman, Panama, Paraguay, Philippines, Russian Federation, Senegal, South Africa, Thailand, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Ukraine, Uruguay	Bangladesh, Ghana, India, Kenya, Mali, Mauritania, Pakistan, Sudan, Uzbekistan, Vietnam, Zambia, Zimbabwe	Ethiopia, Guinea, Liberia, Madagascar, Malawi, Mozambique, Tajikistan, Tanzania, and Uganda.	Australia, Austria, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, United Kingdom, United States.
(n = 45 and T = 22)	(n = 12 and T = 22)	(n = 9 and T = 22)	(n = 18 and T = 22)
Broad sample (1)+(2)+(3)+(4) (n = 84 and T = 22)			

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