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Measuring the technological backwardness of middle- and low-income countries: The employment quality gap and its relationship with the per capita income gap

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Abstract:

The aim of the present article is to further develop the line of research initiated by Oreiro et al. (2019) by expanding the database used to calculate the EQI and the EQG, but also to control the effects of variables other than the EQG, such as the amount of capital per worker, over the PCIG and to assess the impact of the determinants of the EQG, considering both price and non-price factors. Following Tregenna and Andreoni (2020), the EQI will be redefined as the ratio between the share of the workforce in the sectors of high technological intensity with respect to the share of the workforce in the sectors of medium and low technological intensity. The EQG will then be used as an independent variable to explain the behavior of the PCIG of a sample of 47 developing countries in Latin America, the Caribbean, the Middle East, Africa, and Asia from 2001 to 2014.

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In the last 40 years, many developing economies are increasingly concentrated in activities that combine low added value per capita and low and/or medium-low technological intensity due to premature deindustrialization. This is the main reason for the so-called "middle-income trap" of many developing countries, mainly in Latin America, according to the New-Developmentalist Theory (Oreiro at al., 2020b). This regressive structural change had profound impacts on the structure of employment in these countries, which moves towards activities with lower technological intensity, widening the technological gap with developed economies.

A large literature on structural change and premature industrialization was developed to analyse the forces that drive this process in different countries. The first issue concerns the role of the manufacturing industry in the long-term growth of GDP per capita. Regarding this issue, there is an increasing consensus that premature deindustrialization – which can be defined as a reduction of the share of the manufacturing industry in employment and GDP before a given economy reaches the "Lewis point" – had a harmful effect on the long-term growth of GDP per capita (see Gabriel et al., 2020, and Oreiro at al., 2020b). The second issue concerns the causes of premature deindustrialization. The literature shows that the adoption of the macroeconomic policies prescribed by the Washington Consensus (Palma, 2005; Bresser-Pereira et al., 2015; Oreiro et al., 2021), more precisely growth with the foreign savings model, had resulted in a high interest rate-overvalued exchange rate trap that resulted in a reduction of external competitiveness of the manufacturing industries of these countries and hence in premature deindustrialization.

One common criticism against these arguments is that premature deindustrialization is thought to be exclusively the result of exchange-rate overvaluation. Oreiro et al. (2020a) had shown, however, that only 40% of Brazilian deindustrialization in the last two decades can be attributed to overvaluation of the exchange rate and that 60% was due to the increase in the technological gap of the Brazilian manufacturing industry. Non-price competitiveness also matters for premature industrialization and the "middle-income trap".

(i) The reasoning above shows that both structural change and the technological gap are important for explaining the low macroeconomic performance of many developing economies. But how does one measure the contribution of both factors in explaining the increasing gap in the level of per-capita income between developed and developing economies?[1] Our hypothesis is that the growing per-capita income gap between developing and developed countries can be largely explained by differences in quality of employment. This idea was presented by Oreiro et al. (2019) in a seminal paper published in Portuguese. This article developed the so-called employment quality index (EQI), defined as the ratio between the share of the workforce in the sectors of high technological intensity with respect to the share of the workforce in the sectors of medium and low technological intensity. This index allows one to build the so-called employment quality gap (EQG), which is defined as the ratio between EQI in the country and EQI in the country at the technological frontier (that was assumed to be the USA, as it is done by Fagerberg, 1988) which is the benchmark.

This index was constructed for a sample of 19 countries for the year 2014. The index was constituted from the database extracted from socioeconomic accounts that contain industry-level data on employment, capital stocks, gross production and added value, at current and constant prices, available in the World Input-Output Database (WIOD). Once the EQI of each sample country was calculated, an employment quality gap (EQG) was created, defined as the ratio between the EQI of the United States (considered the technological frontier in the sample) and the EQG of each of the other countries. Finally, they constructed a per capita income gap (PCIG) indicator, defined as the ratio between the per capita income of the United States and the per capita income of each of the other countries in the sample. The income data were analysed by purchasing power parity, extracted from World Bank data.

The main result of the article is to show the existence of a strong positive relationship between the EQG and the PCIG; that is, those countries that have the greatest gap in quality of

[1] Regarding such differences, see Ros (2013, chapter 1).

employment with respect to the reference country (in this case, the United States) also tend to have a greater PCIG measured in purchasing power parity.

The aim of the present article is to further develop the line of research initiated by Oreiro et al. (2019) by expanding the database used to calculate the EQI and the EQG, but also to control the effects of variables other than the EQG, such as the amount of capital per worker, over the PCIG and to assess the impact of the determinants of the EQG, considering both price and non-price factors. Following Tregenna and Andreoni (2020), the EQI will be redefined as the ratio between the share of the workforce in the sectors of high technological intensity with respect to the share of the workforce in the sectors of medium and low technological intensity.

The present article is structured as follows. In addition to this introductory section, there are four more sections. Section 1 highlights the theoretical framework on economic growth, dual economies, and the share of the manufacturing industry in economies; section 2 describes the methodology, the construction of indicators and the data source; section 3 addresses the econometric diagnosis and empirical analysis; and section 4 presents the conclusions and final considerations.

1. Theoretical framework

1.1. About industry, productivity and employment

Observing the process of development of nations and the manufacturing industry, Verdoorn (1949, 1956 and 1980) and Kaldor (1957, 1967, 1975, 1977 and 1978) established the theoretical basis for an important empirical relationship that is observed between the growth rate of industrial output and the growth rate of average labor productivity. Verdoorn (1949)[2] comments that one of the difficulties of long-term planning is to estimate the future level of labor productivity. However, he comments that there is a constant relationship, given by the statistical correlation, between the growth in output per worker and the growth in the volume of total production, which in turn reflects the increasing returns to scale of the economies that adopted the strategy of expanding industrial output. As a result of industrialization, the faster the manufacturing industry grows in a country, the faster will be the rate of growth in labor productivity and real income.

According to Kaldor (1977), the divide between rich and poor countries is known in the post-Keynesian literature as the cumulative result of differences in compound growth rates of output over time, something that emerged only with modern industrial capitalism, the so-called Industrial Revolution, which began in England in the eighteenth century. Kaldor sometimes, in his writings (1957, 1967, 1975 and 1977), takes positions and makes assertions about economic growth, with narratives that compare countries with agricultural areas,

[2] From the analysis of the historical series for the industry and individual industrial sectors, in several countries, Verdoorn (1949, table 2.1.) found the average value of the elasticity of labor productivity with respect to the level of production of approximately 0.45 (with limits of 0.41 and 0.57). Thus, over the period, a change in the volume of production, say of around 10%, is associated with an average increase in labor productivity of 4.5%. Under the normal assumptions of long-term analysis, elasticity, within reasonable limits, is constant and independent of variations in economic factors. In the long run, the value of the elasticity of labor productivity gives a rough idea of how much industrial production must expand to absorb a certain availability of labor. But this method allows for separate calculations only for the industrial sectors, since there are differences in technical and economic conditions existing between the various industrial sectors (for example, differences in the production function and the elasticity of labor supply).

industrial and commercial centers. Kaldor comments that regions with more developed industrial hubs supply the material needs of agricultural and/or commercial countries, causing any industrial hub installed in these countries to lose market share to countries with a large manufacturing sector. Furthermore, the system described by Prebisch (1949) as center-periphery will be used by countries that have not adopted the strategy of industrialization, without any compensatory advantage in the form of increased production and agricultural prices.

The fast economic growth in rich countries was largely, if not exclusively, the result of concentration on manufacturing activities. And still these countries became large industrial centers endowed with fixed capital, almost exclusively, such as machinery, equipment, and factories. Also, they became endowed with human capital, resulting from continuing education. Mass production was a reality in rich countries, where the skills of workers, over time, were improved by the growth rate of industrial production, combined with developments in science, technology, and their uses (learning-by-doing). Capital accumulation resulted from industrial development, and this helped the economic development of nations that had such a strategy, improving the population’s living standards.

At this point, the specialization in the production of certain products enabled the emergence of industrial clusters (Myrdal, 1957, and Hirschman, 1958), making a product manufactured by an industry need inputs from the industrial sector or other sectors. And this core becomes the manufacturing industry, which adds value in the production of a new product, even if using another input already processed, in agriculture or mining. And the industrialized region gains an advantage through economic growth and will tend to sustain it through the process of increasing returns that growth itself induces, the so-called Verdoorn effect (1949).

Kaldor and Verdoorn’s arguments inspired Dixon and Thirlwall (1975) to format a model to examine equilibrium growth in a region, making assumptions implicit in the hypothesis that regional per capita incomes and/or growth rates may diverge and that they can then be easily seen empirically. The long-term consequences of the introduction of manufacturing industries led to a tremendous acceleration of technical progress in countries that had such technology. And in the same way, they raised the level of human capital with more quality, technical and scientific education (Schultz, 1961). The manufacturing industry is usually associated with greater productivity of human capital (Ros, 2013), due to changes that occur over time, in terms of complexity and new technological movements, leaving previously revolutionary techniques in manufacturing obsolete.

Furthermore, the failure to keep up with the growth of modern technology leads countries to remain in a poverty trap. Even a rich country that does not keep up with the growth of modern technology can fall behind in technological terms and become a middle-income or poor country in later periods (Oreiro et al., 2020a). Or a country that began to industrialize ends up, for various political and strategic reasons, , over decades, that ceases to be sophisticated and retreats.

Many developing economies are increasingly concentrating on activities that combine low value added per capita and low and/or medium-low technological intensity due to premature deindustrialization (Rodrik, 2016). This is the main reason for the so-called “middle income trap” in many developing countries, especially in Latin America, according to the New Developmentalism Theory (see Oreiro et al., 2020b).

This regressive structural change in underdeveloped economies had profound impacts on the employment structure of these countries, which is shifting towards less technologically intensive activities. Even though developed countries also exhibit some deindustrialization (Rodrik, 2016; Palma, 2005, 2008), there is a widening of the technological gap between developed and developing economies. This is reflected in increasing social inequality, great differences in per capita income, and a potential decline in the capacity of underdeveloped economies to innovate. These developing and underdeveloped economies have been deindustrializing for decades, a trend that is particularly visible when one observes the participation of the manufacturing industry in total employment.

According to Veugelers (2013), when researching the European industry, most of the investment in research and development (R&D) and in patent creation originates in the manufacturing industry. Manufacturing is a technologically dynamic sector. According to Rodrik (2013), manufacturing sectors show unconditional convergence of labor productivity; it is a sector that produces tradable goods across borders (international market), absorbs significant amounts of unskilled labor in boom periods of business cycles, and can expand and absorb workers even if the rest of the economy remains technologically stagnant. Together, these dynamisms make the manufacturing industrial sector the driver of economic growth (Rodrik, 2014). Therefore, combinations of technology in products and trade shocks, for example, through exports seen in the current account of the balance of payments, help to explain the heterogeneity between poor and rich countries. Economic and labor market conditions are very heterogeneous. In particular, the structural characteristics of the labor market, its levels of technological sophistication and human capital, are quite different between developed, developing and underdeveloped countries (see Gala et al., 2018).

1.2. Productive duality, labor productivity and technical progress

In classical development theory, there is a distinction between dual and mature economies (Lewis, 1954). In a dual economy, there are two sectors where people can work: a modern capitalist sector and a subsistence or traditional sector. The traditional sector employs labor with low labor productivity, and wages are determined by the average labor product. Due to the lack of capital, wages are kept at the subsistence level. In the modern sector, modern capital and techniques are used, notably developed in high-income countries, where many technological innovations come from the role of the State, with massive public investments, for example, in scientific research and development. And labor productivity in the modern sector is high compared to the traditional sector. The modern sector pays an additional premium above the wage of the traditional sector, but it will remain constant over time as soon as there is excess labor in the subsistence sector.

The dual economic structure, described by Lewis (1954), Prebisch (1949, 1959, 1963), Prebisch and Cabañas (1949) and Furtado (1964), helps to explain the high heterogeneity in many developing countries, which nowadays manifests itself differently from that observed by the classical school of economic development.[3] Dualism today expresses itself by the increase in the service sector, generally unsophisticated, which expands its share of GDP.

[3] In some Latin American countries such as Brazil, Argentina, Uruguay, Chile, and Mexico, for example, there are: a small modern industrial sector, with a trend decreasing share of the manufacturing industry in GDP (Oreiro and D'Agostini, 2017; Oreiro et al., 2020a); an agricultural sector with some technological sophistication; and a service sector, generally unsophisticated, with low labor productivity (Gala et al., 2018). The composition of such sectors in

The increase in labor productivity makes possible the persistent rise in real wages, once the so-called "Lewis point" is overcome; that is, once the labor employed in traditional sectors (usually agriculture) has been fully transferred to modern or capitalist sectors (Lewis, 1954). At this point, the unlimited supply of labor characteristic of Phase I of capitalism (Kaldor, 1977) runs out, resulting in the continuous increase in labor demand from the expansion of the level of economic activity, allowing for a gradual rise in real wages at a rate roughly equal to labor productivity growth. The growth of real wages, in turn, is what makes it possible to increase the population's standard of living.

According to Oreiro et al. (2019), technical progress allows, on the one hand, an increase in production efficiency, that is, the same goods and services are produced using a smaller amount of inputs, especially labor; on the other hand, technical progress leads to the development of increasingly sophisticated or complex products and services, that is, products that incorporate not only a greater amount but also a more diversified amount of technical and scientific knowledge.

According to Hidalgo (2015, chapter 10), technical and scientific knowledge is embedded in people (human capital), in machines and equipment (physical capital), and in people's ability to connect and thus exchange information (social capital). In this way, what an economy produces and exports reveals the sophistication or complexity of its productive capabilities. Gala et al. (2018) comment that more sophisticated or complex products are produced by highly skilled workers in companies that operate at or near the technological frontier, which is why such products have greater added value per unit of work employed. Thus, technical progress stems from the advance of the "state of the arts" and also through a process of structural change, in which productive resources and workers are transferred from activities with lower added value per employed worker (less sophisticated or complex sectors) to activities with higher added value per employed worker (more sophisticated or complex sectors).

Although the high value added per unit of work employed can also be seen in high technology intensive services and agriculture, recent empirical evidence presented by Gabriel et al. (2020, p. 63), shows that a greater share of the primary sector in the added value is associated with lower growth rates of GDP per capita, even after controlling for the level of the technological gap. Thus, for developing countries, a greater share of the service sector is also associated with a lower GDP growth rate. Therefore, the composition of output is important for long-term growth.

Complementarily, for Oreiro et al. (2019), the sectoral composition or productive structure of a country matters; it influences labor productivity and affects the level of per capita income. It is not possible to measure the so-called total productivity of production factors without looking at the employment structure, the structure of technological domain, and the share of sectors in GDP (industry, agriculture and services). These ideas are fundamental propositions of the New-Developmentalist School, as described in Bresser-Pereira et al. (2015) and Gala (2017). The low growth of undeveloped and some developing economies is a result of the production structure, since there is an increase in the share of the output in the less dynamic sectors and with less technological intensity in the added value generated in the economy.

GDP today is similar to the rural subsistence economies described by Lewis (1954), with the difference that there is now an unsophisticated and uncomplex service sector that replaces the traditional Lewis sector.

1.3. Productive structure, structural change, and premature deindustrialization

One of the main objectives of development economics is to assess the components that lead to structural change. This analysis focuses on the movement of industrial employment and the mobility of resources across sectors of the economy. The manufacturing industry plays a prominent role in economic growth and its expansion generates increasing returns to scale and an improvement in productivity in the economy (Furtado, 1964; Kaldor, 1966).

Developing economies suffer from the concentration of output in sectors with low and medium-low technological intensities, which is often the result of premature deindustrialization. Deindustrialization can be caused by internal or external effects (Rowthorn, 1994; Rowthorn and Ramaswany, 1997, 1999). Regarding internal effects, two must be emphasized: the income elasticity of goods and the industrial productivity gap with respect to the service sector.

In industrialized countries, the service sector concentrates efforts to meet the demands of the manufacturing industry. In this configuration, the service sector is diversified, has a greater share of labor force, and generates high added value in the economy. The deindustrialization process of mature economies is inevitable, since the income elasticity of services becomes greater than those of industrial goods after some critical level of per-capita income is reached. This deindustrialization is, so to speak, "natural" (Oreiro and Feijó, 2010). In many developing economies, however, this process occurred prematurely, that is, they did not reach the maximum per-capita income that economic development can provide. This fact triggers the process of premature deindustrialization and the "middle income trap" (Oreiro et al., 2020b).

Rodrik (2016) comments that deindustrialization reflects on the quality and decline of employment. It is low-skilled workers who bear most of the impact of recent changes in commerce and technology in the manufacturing industry. Countries that have had a strong comparative advantage in manufacturing products using new technologies have avoided the steady decline in manufacturing jobs over the past few decades as a proportion of total employment. Using data from the World Input-Output Database (WIOD), which provides a division of industrial employment into three types of workers (low, medium and high skilled), looking at 40 countries between the years 1995 to 2009, Rodrik (2016, figure 4) shows that the reduction in employment occurred in the sector with low technological qualifications (four percentage points). The decline in medium-skilled employment was small, while industry's share of high-skilled employment increased slightly.

The observed differences in the income elasticities of demand for exports and imports reflect the non-price characteristics of goods and, therefore, the structure of production (Thirlwall, 1997). Several other authors claim that structural changes can affect the income elasticities of imports or exports in constrained balance-of-payments models (Setterfield, 1997; McCombie and Roberts, 2002; Palley, 2002). An important contribution to demand-oriented theories of output growth is the structural economic dynamics approach developed by Pasinetti (1983, 1993). For Pasinetti, changes in the production structure led to changes in the output growth rate, due, for example, to different sectoral demand growth rates that could be produced by differences in sectoral income elasticities. And yet, structural change impacts human learning.

The international diffusion of technology and the relationship with human learning are slow and uneven across countries (Prebisch, 1949). A few countries take the lead in innovation and technology, while the vast majority lag behind, being just innovation takers, without learning and appropriating the invention. As technical change is closely associated with structural change and the emergence of new sectors, goods and skills, the productive structure of a few countries diversifies, undergoing major transformations, while those of most other countries remain stagnant or even decline, as a result, for example, of under-accumulation of human capital. Thus, most countries end up specializing in a few sectors, generally traditional sectors, which generate low-quality employment.

Sectors with low or negligible technological intensity maintain a high share of workers employed and exhibit extreme difficulty in generating good-quality jobs, which should be reflected in higher wages. In the literature on economic growth, the problem of asymmetry generated by the concept of technological gap between rich and poor countries emerges. The question here is whether it is still relevant to discuss the role of the manufacturing sector in the process of economic development.

1.4. Composition of the manufacturing sector and its impacts on economic growth

According to List (1841), what a country produces matters. According to Hirschman (1958), Prebisch (1959), Thirlwall (2002) and Szirmai (2012), the manufacturing sector is the engine of growth for two specific reasons. First, the productivity growth rate that occurs in the manufacturing sector is comparatively high, and, secondly, productivity growth gains are transferred to wages at a higher speed. Furthermore, the composition of the manufacturing sector is very important (Szirmai and Foster-McGregor, 2017); that is, it is important to expand the composition of the high-tech manufacturing sector compared to the low- and medium-technology sectors. In fact, there is growing evidence of the gap between wages and productivity across sectors (Berlingieri et al., 2017). Technical change and the division of labor within factories represented a turning point for the general process of economic development and, since then, manufacturing has represented the locus of capacity accumulation, learning by doing, and dynamic returns with technological innovations (see Arrow, 1962; Kaldor, 1967; Abramovitz, 1986; Cimoli and Dosi, 1995).

Dosi et al (2021), noting the heterogeneity between sectors, comment that the manufacturing sector with higher technological intensity is the engine of output growth because it generates positive side effects in the economy in terms of: (i) indirect multiplier jobs created in other sectors, such as knowledge-intensive services; (ii) wage effects, through Kaldorian virtuous circles (Kaldor, 1967); and (iii) employment created through the supply chain, the so-called forward and backward linkage effect.

By the way, Pavitt (1984) identifies heterogeneity, separating manufacturing into four classes: supplier-dominated industries, intensive scale industries, specialized supplier industries, and science-based industries. The industrial classifications of the OECD by technological intensity (OECD, 1984, 1995), evaluated by spending on research and development as a percentage of production value, are usual criteria for ordering industrial sectors according to technological groups. And in 2016, the OECD updated the classification to five technological intensity categories (high, medium-high, medium, low-medium, and low-tech) and included other sectors of economic activity, due to the more active role of non-manufacturing sectors in the technological development in recent decades (see Galindo-Rueda and Verger, 2016).

Lall (2001) builds a taxonomy distinguishing group of products that are generated in different sectors of the economy, produced by resource-based manufacturers and low, medium and high technology manufactures. Shumpeterians, neo-Schumpeterians and evolutionaries, such as Schumpeter (1942), Nelson and Winter (1982), Rosenberg (1982), Dosi et al. (1990), Dosi et al. (1994), and Lee (2013), describe different perspectives within manufacturing, particularly in relation to heterogeneity between companies.

Of course, given the heterogeneity among the subsectors, a country that has a manufacturing industry that produces something equivalent to packaged baked bananas is quite different from an industry that produces high-precision processors, cell phone microchips, and sophisticated devices. There is a brutal difference in learning, in innovation, in the process of accumulating capacities, in sophistication and, therefore, in the complexity of a specific industrial subsector. Returns are dramatically different across subsectors.

Dosi et al. (1990), Fagerberg (1987) and Lee and Malerba (2017) comment on the historical patterns of industrialization in each country and the patterns of specialization and sectorial diversification; for these reasons there are great differences in the process of economic growth and in the levels of per capita income observed. Researchers using balance of payments constrained growth models (BOPC) point out that the ratio of foreign trade income elasticities reflects the nonprice competitiveness of the economy. According to Gouvêa and Lima (2010, 2013) and Romero and McCombie (2016), competitiveness not related to prices is, to a large extent, determined by the diversification and complexity of the productive structure.

Economic diversification is conditioned by the composition of the existing productive structure (Hidalgo et al., 2007; Alshamsi et al., 2018). It is important to note the role played by technological specialization in countries (Fagerberg, 1988; Cimoli and Porcile, 2014) and the changes in the sectoral composition of the economy (Araújo and Lima, 2007; Nishi, 2016).

Tregenna and Andreoni (2020) analyzed the dynamics of premature deindustrialization and the heterogeneity of deindustrialization experiences. They show the high degree of heterogeneity within manufacturing, between low-, medium-, and high-tech manufacturing and also within each of these categories. As a stylized fact of deindustrialization, the relationship between GDP, the share of manufacturing industry in GDP, and employment generally follows a U pattern relation, as written by Rowthorn (1994) and Rowthorn and Ramaswamy (1997), between countries and over time. Significantly, not all manufacturing subsectors exhibit an inverted U pattern. The greater the technological intensity of a manufacturing activity, the less concave is its pattern of development, becoming a monotonically rising line and even a convex curve for high-tech subsectors.

According to Tregenna and Andreoni (2020), less than 20 countries control nearly 90 percent of the world's manufacturing value-added. Many low- and middle-income countries are not part of this group of industrialized countries. And many of the countries that managed to achieve middle-income status show signs of premature deindustrialization. Countries that are traditionally classified in the group of middle-income countries are highly heterogeneous in terms of their sectoral composition and, therefore, also their deindustrialization experiences.

According to Tregenna and Andreoni (2020), Structuralist, Shumpeterian and Evolutionary literature have recognized the importance of heterogeneity within manufacturing (and in other sectors) to varying degrees, including differences in technological intensity. The fact that, even within the manufacturing sector, subsectors are characterized by different degrees of technological intensity, different speeds of technological change, different levels of scale efficiency, different degrees of commercialization, etc., has led several scholars to develop multi-sector models of economic growth and various types of sectoral classifications and taxonomies. The high degree of heterogeneity in technological intensity within manufacturing highlights the importance of sub-sector analysis by levels of technological intensity.

In fact, this entire theoretical framework shows that such developments in the manufacturing sector are fundamental and mandatory for developing countries to reach advanced economies and reduce the per capita income gap (see, for example, Bell and Pavitt, 1993; Lall, 1996; Fagerberg, 2000; Hobday, 2003; and Tassey, 2010). According to Tregenna and Andreoni (2020) and Oreiro et al. (2020b), innovation and technological progress are important to avoid the middle-income trap.

In line with structuralism (see Prebisch and Cabanãs, 1949; Furtado, 1964), developing economies persist in presenting some chronic problems, such as a low stock of capital per worker, low labor productivity, poorly diversified production, with a low level of endogenization of technical progress, and a heterogeneous productive structure. For the most part, a dual structure still prevails, in which there are traditional and modern sectors, keeping a considerable share of the workforce in low-productivity activities. Thus, an underdeveloped (developing) structure does not efficiently use its capital to absorb the labor force at the level of productivity that is found in the more dynamic sector (Furtado, 1964).

As these developing economies can be considered small and open, as well as lacking convertible currencies, unlike developed countries, the only component of autonomous demand that provides sustained long-term growth is exports. This component can be affected by the income elasticity of exports, which is linked to the composition of the exports (productive structure) and the growth of external income (Dixon and Thirlwall, 1975; Gouvêa and Lima, 2010). However, for this export-led growth to be sustainable over time, imports must not generate persistent trade deficits; that is, the long-term growth rate must be compatible with a balanced balance of payments.

In this way, asymmetric productive structures can generate uneven growth, affecting external growth restriction (Thirlwall, 1979; McCombie and Thirlwall, 1994). In other words, the productive structure matters in determining elasticities. Therefore, a structural shift towards more technology intensive (industrial) sectors tends to relax the external constraint on growth.

An additional step is to connect the relationship between the exchange rate, the production structure, and income elasticities of demand and growth. The argument is that the level of exchange rate has effects on the growth rate of output as it affects productive heterogeneity, technological progress, and the manufacturing industry's share of output. In this case, it is assumed that a moderate devaluation of the real exchange rate can lead to a structural change in the economy in the sense of expanding (decreasing) the participation of technology-intensive/industrial sectors in exports (imports).

Complementarily, in structuralist development macroeconomics, the actual level of exchange rate must be compared to the industrial equilibrium exchange rate, which is defined as the level of exchange rate that is compatible with a constant share of manufacturing industry in GDP for a given level of technological gap (Oreiro, 2020; Oreiro et al., 2020a). When the first is below the value found by the industrial equilibrium exchange rate, there is a process of premature deindustrialization (Rodrik, 2016) and re-primarization of exports (Palma, 2005 and 2008). On the other hand, when the current exchange rate is slightly above the industrial equilibrium exchange rate, it will ensure a trend increase in the manufacturing share.

2. Methodology

This section presents the methodological steps required to: (i) calculate a measure of the quality gap of the employment structure; (ii) relate it to the per capita income gap between the developed and the middle and low-income economies, controlling for other variables that could also explain the per capita income gap in order to isolate the effect of the employment quality gap over the per capita income gap; and (iii) evaluate the effects of price and non-price competitiveness factors over the employment quality gap in order to determine the importance of the real exchange rate over the employment quality gap and hence over the per capita income gap. For this, we adopted the following steps:

(i) Classifying the industry into several subsectors by technological intensity (low, medium and high), according to the classification described in Tregenna and Andreoni (2020, table 1).

(ii) Building the *Employment Quality Index*,[4] $\mathrm{EQI}_{i,t}$, by country, i, and by period, t, defined as the ratio between the sum of the share of the workforce in the high technological intensity sectors, $HT_{h,i,t}$, and the sum of the share of the workforce in the low and medium technological intensity sectors, $LT_{l,i,t}$ *and* $MT_{m,i,t}$, according to equation (1), below:

$$\mathrm{EQI}_{i,t} = \left[\frac{\sum_{h=1}^{n} HT_{h,i,t}}{\left(\sum_{l=1}^{p} LT_{l,i,t} + \sum_{m=1}^{q} MT_{m,i,t}\right)}\right] \quad (1)$$

where:

- $t = 1, 2, \dots, T$; $l = 0, 1, 2, \dots, p$; $h = 0,1,2, \dots, n$; $m = 0,1,2, \dots, q$ e $i = 1, 2, \dots, I$; where t is the time; l, m *and* h are, respectively, the number of subsectors of low, medium and high technological intensity; i is the number of countries;
- $N = n + q + p$, where N is the total number of sectors; n, q and p represent, respectively, the total number of high, medium and low technological intensity sectors;
- The denominator of $\mathrm{EQI}_{i,t}$ must be greater than zero, $\left(\sum_{l=1}^{p} LT_{l,i,t} + \sum_{m=1}^{q} MT_{m,i,t}\right) > 0$, and indicates that at least a fraction of the workforce of the national productive structure employed in at least one of the sub-sectors, of low or medium technological intensity, is needed.

(iii) Building the *Employment Quality Gap*,[5] $\mathrm{EQG}_{i,t}$, by country, i, and by period, t, defined as the ratio of the EQI of the country considered as the benchmark, $\mathrm{EQI}_{benchmark,t}$, with respect to a country that has low or middle income, $\mathrm{EQI}_{i,t}$:

$$\mathrm{EQG}_{i,t} = \frac{\mathrm{EQI}_{benchmark,t}}{\mathrm{EQI}_{i,t}}, \text{ com } \mathrm{EQG}_{i,t} > 0 \quad (2)$$

(iv) Estimating the *per capita income gap*, $\mathrm{PCIG}_{i,t}$, as a function of the conditional convergence of per capita income, $CCINC_{i,t}$, employment quality gaps, $\mathrm{EQG}_{i,t}$, and the capital stock per capita, $CSG_{i,t}$, according to the following linear stochastic model:

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[4] In its original format, elaborated by Oreiro et. al. (2019), the EQI measures the ratio between the sum of jobs in the high, medium-high, and medium technological intensity sectors over the sum of jobs in the medium-low and low technological intensity sectors of each country.

[5] The EQG_i, equation shows that no country has complete specialization only in the high technological intensity subsector; that is, even if the country is at the technological frontier, at least a fraction of the workforce will be employed in at least one subsector, which is of low or medium technological intensity.

$$\text{PCIG}_{i,t} = \alpha_i + \beta_1 CCINC_{i,t} + \beta_2 \text{EQG}_{i,t} + \beta_3 CSG_{i,t} + \varepsilon_{i,t} \quad (3)$$

(v) Estimating the *employment quality gap*, $\text{EQG}_{i,t}$, as a function of the human capital index, $HC_{i,t}$, of the economic complexity index, $\text{ECI}_{i,t}$, and the bilateral real exchange rate, $BEER_{i,t}$, according to the following linear stochastic model:

$$\text{EQG}_{i,t} = \alpha_i + \beta_1 HC_{i,t} + \beta_2 \text{ECI}_{i,t} + \beta_3 BEER_{i,t} + \varepsilon_{i,t} \quad (4)$$

To estimate the per capita income gap, $\text{PCIG}_{i,t}$, and the employment quality gap, $\text{EQG}_{i,t}$, described by equations (3) and (4), we used the method of generalized moments (GMM) applied to panel data, according to Arellano and Bover (1995) and Blundell and Bond (1998). In equation (3), the robust fixed effects (FE) method was also used, in which all independent variables are considered exogenous (Pesaran, 2015). In addition, the GMM system dynamic panel model will be used to correct the endogenous variable bias. Furthermore, according to Arellano and Bover (1995) and Blundell and Bond (1998), the use of the GMM system estimator captures the difference of the endogenous variable in time and serves as an instrument for the level equation. In the GMM system method, regressors can be level-correlated with the specific effects of everyone. However, the instrumentalized variables, taking the first difference, may not be correlated.

(vi) Elaborating the decomposition of the variance of the dependent variables of equations (3) and (4), from the analysis of the principal components of the independent variables.

(vii) Carrying out the validation tests of the GMM estimators, suggested by Roodman (2009), to assess the model specification and the robustness of its instruments, namely: (a) a joint exogeneity test of the instruments used in the GMM, through Hansen's method, and (b) a test of residuals autocorrelation, by the Arellano-Bond method for second order correlation (AR (2)).

3. Economic and empirical analysis

To estimate the determinants of the per capita income gap, equation (3), and the determinants of the employment gap, equation (4), the following databases were used: World Bank (WB), United Nations Industrial Development Organization (UNIDO), Penn World Table (PWT version 10.0), Global Change Data Lab (GCDL) and Observatory of Economic Complexity (OEC).[6] The period of analysis was from 2001 to 2014, which is the period of the “commodities boom”, for a sample of 47 developing countries.[7] We use the United States[8] as a benchmark for developed countries, $\text{EQI}_{benchmark,t}$, to find the employment quality gap, $EQG_{i,t}$.

Variables were collapsed into their mean, with 2-year time windows.[9] The variables that were considered endogenous in the GMM system model were as follows: (i) $CCINC_{i,t}$ and $EQG_{i,t}$ in equation (3); (ii) $HC_{i,t}$ in equation (4).

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[6] See the set of variables used and data sources in the appendix, table A1. In addition, the ranking for EQI and EQG variables is in the appendix, table A2.

[7] See the table of countries reviewed in the appendix, table A3. The criterion used to select the sample of 47 developing countries was the absence of missing values in all the variables used.

[8] When Fagerberg (1988) defines the technological gap, he places the USA as a technological frontier.

[9] The calculation is performed by applying the average of two observations over time, according to the following generic formula: $\frac{V_t+V_{t+1}}{2}$; that is, a typical simple arithmetic mean equation.

In the model corresponding to equation (3), the independent variables were analyzed considering strictly exogenous (FE) and considering the possibility of endogenousity (GMM system) between the per capita income and the variables, conditional convergence of per capita income and employment quality gap. This procedure was performed to give robustness to the model.

On the other hand, in the model that corresponds to equation (4), human capital is considered endogenous to the model, due to the following argument: a supply of good jobs generates incentives to invest in human capital or jobs are good because of their quality.

The convergence of per capita income and the employment quality gap endogenously help to explain the behavior of the per capita income gap (equation 3), while human capital impacts and is impacted by the employment quality gap (equation 4). Tables A4 and A5 in the appendix show, respectively, the correlation matrix between the determinants of the per capita income gap and the employment quality gap. The per capita income gap, equation (3), presents: (i) a strong correlation with the convergence of per capita income and capital stock and (ii) a moderate positive correlation with the employment quality gap. Likewise, the employment quality gap, equation (4), presents: (i) a moderate negative correlation with the economic complexity index and human capital and (ii) a weak negative correlation with the bilateral real exchange rate. Estimates for the per capita income gap and the employment quality gap are presented, respectively, in tables 1 and 2. All variables were significant and with the expected sign.[10]

Table 1 – *Per capita income gap (2001-2014)*

	FE (1)	**FE (2)**	**GMM system (3)**	**GMM system (4)**
Conditional convergence of per capita income	0.93752*** (0.007)	0.90494*** (0.012)	1.11119*** (0.012)	0.92179*** (0.019)
Employment quality gap	0.16188*** (0.042)	0.17884*** (0.053)	0.16111*** (0.039)	0.27827*** (0.035)
Capital stock per worker gap	–	0.32841*** (0.087)	–	0.43615*** (0.030)
Constant	4.70697*** (0.256)	2.48063*** (0.599)	1.15347*** (0.298)	0.73135** (0.337)
Observations	328	328	328	328
Instruments	–	–	55	50
R^2 Adjusted	0.9868	0.9883	–	–
Arellano-Bond test for AR(2) in first difference (p-value)	–	–	0.2930	0.2172
Hansen test of joint validity of instruments (p-value)	–	–	0.6923	0.4955
F Test	0.0000	0.0000	–	–

Notes: All the equations are robust standard errors. Below the coefficients we report the standard errors. *** p < 0.01, ** p < 0.05, * p < 0.10. Two-step standard errors are robust to the Windmeijer (2005) heteroscedasticity correction, which greatly reduces the downward bias of the one-step standard error. All models feature balanced panel data.

[10] Time dummies were not significant; therefore, they were not incorporated into the models.

Table 2 – *Employment quality gap (2001-2014)*

	GMM system (1)	**GMM system (2)**
Human capital	-3.81643*** (1.412)	-4.14250** (1.971)
ECI	-1.41332*** (0.513)	-2.53828*** (0.816)
Bilateral real exchange rate	–	-0.00074** (0.000)
Constant	12.93186*** (3.688)	14.75638*** (5.207)
Observations	299	299
Instruments	14	30
Arellano-Bond test for AR(2) in first difference (p-value)	0.4051	0.3943
Hansen test of joint validity of instruments (p-value)	0.4737	0.2790

Notes: All the equations are robust standard errors. Below the coefficients we report the standard errors. *** p < 0.01, ** p < 0.05, * p < 0.10. Two-step standard errors are robust to the Windmeijer (2005) heteroscedasticity correction, which greatly reduces the downward bias of the one-step standard error. All models feature balanced panel data.

When performing the endogeneity control procedure in the estimates of the per capita income gap in table 1, the coefficients of the employment quality gap and of the capital stock per worker had increased. Using the fixed effect and GMM system methods, from the moment the conditional convergence variables of per capita income and the employment quality gap were endogenized, it is noted that there was an increase of the estimated coefficients for the capital stock per worker. It is important to note that the gap in the capital stock per capita had two effects in the model. The inclusion of this variable increased the coefficient of the employment quality gap; but, at the same time, the coefficient of the per capita capital stock gap was greater than the coefficient of the employment quality gap, that is, $\beta3 > \beta2$.

Likewise, in the estimation of the employment quality gap, table 2, all variables became significant from the moment when human capital was considered endogenous. It should be noted that, by adding the bilateral real exchange rate, there was an increase in the effect of human capital and the effect of the economic complexity index. The considerable effect of human capital in reducing the distance between the quality of employment in developing economies and the pattern of a developed country is highlighted. In addition, the inverse price effect was observed; that is, the devaluation of the bilateral real exchange rate induces a reduction in the employment quality gap between developing countries to the standard of developed countries.

Finally, in tables A6 and A7 of the appendix, we present the decomposition of the variance of the dependent variables, corresponding to equations (3) and (4).

The effects on the variability of the per capita income gap (table A6), from highest to lowest, are, respectively: conditional convergence of per capita income, employment quality gap, and gap in the capital stock per worker. Likewise, the variability of the employment quality gap (table A7), from highest to lowest, is, respectively: human capital, economic complexity index, and bilateral real exchange rate.

In addition, it is important to note that the employment quality gap generates greater variability in the per capita income gap than the variability generated by the capital stock gap per worker, even though the coefficient effect of the first variable is smaller than that of the second.

Non-price effects are the determinants explaining the behavior of the employment quality gap; their impact must be considered since they explain a major part of the variability of this dependent variable. Note that this topic has not yet been empirically addressed in the literature, giving originality to the paper.

4. Final remarks

The results endorse the arguments presented in the literature, according to which the quality of employment, the capital stock per worker, and together "industrial police" are fundamentals to reduce the income gap between developing economies compared with the benchmark economy, which we consider to be the United States.

It can be said that the productive structures of countries that concentrate activities with low value added per capita and low and medium-low technological intensity are factors that explain the growing delay of catching-up for low- and medium-income per capita economies relative to developed countries.

Since developing economies are more labor intensive and increasing labor productivity helps to reduce the per capita income gap, policies that encourage the growth of human capital and economic complexity in these economies will allow for a reduction in income inequality between developing and developed economies.

As policy implications, we can state that the maintenance of the exchange rate at a competitive level (the so-called industrial equilibrium level of new-developmentalist literature) is necessary but not sufficient to allow the development and expansion of firms in developing economies. It is also necessary to implement industrial, scientific and technological, and foreign trade policies that aim to: (i) gradually reduce the technological gap that separates domestic firms from their competitors in developed countries and hence to increase the economic complexity; and (ii) ensure minimum conditions of survival and expansion for domestic firms while they do not reach the technological frontier. In this context, import tariffs can even be used for a limited and defined period, as a necessary instrument to ensure isonomic conditions for domestic companies in a context in which they have a significant technological lag with respect to their competitors abroad.

Appendix – Statistical Steps and econometric results

Table A1 – *List of variables, equations, and data source*

Variable	Description	Unit	Data Source	Equation
$\text{PCIG}_{i,t}$	Per capita income gap*	%	World Bank Open Data, available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD	$\frac{GDPpc_{t}^{USA}}{GDPpc_{i,t}}$
$CCINC_{i,t}$	Convergence condition of per capita income, with respect to 2001*	%	World Bank Open Data, available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD	$\frac{GDPpc_{2001}^{USA}}{GDPpc_{i,t}}$
$\text{EQG}_{i,t}$	Employment quality gap*	%	United Nations Industrial Development Organization (UNIDO), available at: https://stat.unido.org/database/INDSTAT%202%202020,%20ISIC%20Revision%203	$\frac{EQI_{t}^{USA}}{EQI_{i,t}}$
$CSG_{i,t}$	Capital stock per worker gap*	%	Penn World Table (PWT) 10.0, available at: https://www.rug.nl/ggdc/productivity/pwt/?lang=en	$\frac{(CS)_{t}^{USA}}{(CS)_{i,t}}$
$HC_{i,t}$	Human capital	Absolute value	Global Change Data Lab, available at: https://ourworldindata.org/grapher/mean-years-of-schooling-1?time=2017	-
$\text{ECI}_{i,t}$	Economic complex index	Index	Observatory of Economic Complexity (OEC), available at: https://legacy.oec.world/en/rankings/country/eci/	-
$BEER_{i,t}$	Bilateral real exchange rate*	Absolute value	Penn World Table (PWT) 10.0, available at: https://www.rug.nl/ggdc/productivity/pwt/?lang=en	$\frac{xr}{pl\_gdpo}$

Notes: 1) *Authors' calculation; 2) Capital stock per worker were calculated as $CS = (\frac{rnna}{emp})$ where $rnna$ is the capital stock at constant 2017 national prices (in mil. 2017 US$) and emp is the number of persons engaged (in millions); 3) Bilateral real exchange rate* was calculated as the ratio of the xr, that is, exchange rate, national currency/USD (market+estimated), with the pl_gdpo, that is, the price level output-side real GDP at current PPPs (in mil. 2017 US$). $CCINC_{i,t}$ corresponding to the convergence condition of per capita income is calculated from the initial value (2001) of the USA per capita income gap ($\text{PCIG}_{i,t}$) in relation to the incomes of the analyzed countries (i), increasing in time ($t,\ t+1,\ t+2 \ldots t+n$).

Table A2 – *Ranking of EQI and EQG (average value 2000-14)*

Country	Position	EQI	EQG
Singapore	1	1.84	0.35
South Korea	2	1.11	0.59
Malaysia	3	0.66	0.98
China	4	0.66	0.99
United States	-	0.64	1.00
Philippines	5	0.64	1.01
Russia	6	0.59	1.10
Ukraine	7	0.58	1.10
Mexico	8	0.56	1.17
Iran	9	0.51	1.26
Azerbaijan	10	0.47	1.42
South Africa	11	0.41	1.55
India	12	0.39	1.66
Thailand	13	0.36	1.81
Brazil	14	0.35	1.82
Kazakhstan	15	0.35	1.84
Turkey	16	0.28	2.31
Egypt	17	0.26	2.50
Colombia	18	0.26	2.50
Senegal	19	0.26	2.50
Saudi Arabia	20	0.26	2.59
Kuwait	21	0.25	2.66
Costa Rica	22	0.24	2.87
Georgia	23	0.21	3.13
Jordan	24	0.19	3.38
Indonesia	25	0.18	3.56
Morocco	26	0.18	3.66
Vietnam	27	0.22	3.75
Uruguay	28	0.17	3.94
United Arab Emirates	29	0.17	3.99
Chile	30	0.19	4.20
Oman	31	0.15	4.63
Ecuador	32	0.14	4.71
Moldova	33	0.13	4.93
Kenya	34	0.12	5.47
Bolivia	35	0.12	5.50
Macedonia	36	0.12	5.65
Qatar	37	0.10	7.53
Albania	38	0.09	7.62
Panama	39	0.08	8.33
Tanzania	40	0.08	8.52
Botswana	41	0.11	8.59
Ethiopia	42	0.07	8.91
Peru	43	0.07	8.91
Laos	44	0.06	10.94
Mongolia	45	0.05	13.61
Ghana	46	0.04	20.94
Yemen	47	0.02	28.06

Note: The USA has been incorporated into this country ranking table with respect to the EQI and the EQG.

Table A3 – *Country list (47 countries)*

Albania	Iran	Philippines
Azerbaijan	Jordan	Qatar
Bolivia	Kazakhstan	Russia
Botswana	Kenya	Saudi Arabia
Brazil	Korea	Senegal
Chile	Kuwait	Singapore
China	Lao People's DR	South Africa
Colombia	Macedonia	Tanzania
Costa Rica	Malaysia	Thailand
Ecuador	Mexico	Turkey
Egypt	Moldova	Ukraine
Ethiopia	Mongolia	United Arab Emirates
Georgia	Morocco	Uruguay
Ghana	Oman	Viet Nam
India	Panama	Yemen
Indonesia	Peru	–

Table A4 – *Correlation matrix of equation 3*

	Per capita income gap	**Conditional convergence**	**Employment quality gap**	**Capital stock gap per worker**
Per capita income gap	1			
Conditional convergence	0.9927	1		
Employment quality gap	0.3330	0.3173	1	
Capital stock gap per worker	0.8761	0.8329	0.1785	1

Table A5 – *Correlation matrix of equation 4*

	Employment quality gap	**Human capital**	**Bilateral real exchange rate**	**Economic complex index**
Employment quality gap	1			
Human capital	-0.3530	1		
Bilateral real exchange rate	–0.0577	–0.1086	1	
Economic complex index	-0.5714	0.5458	–0.1272	1

Table A6 – *Decomposition of variance of the employment quality gap*

	Proportion	**Cumulative**	**Eigenvalue**
Conditional convergence	0.6538	0.6538	1.9615
Employment quality gap	0.2946	0.9485	0.8839
Capital stock gap per worker	0.0515	1	0.1546

Table A7 – *Decomposition of variance of the per capita income gap*

	Proportion	Cumulative	Eigenvalue
Human capital	0.5319	0.5319	1.5958
ECI	0.3182	0.8501	0.9546
Bilateral real exchange rate	0.1499	1	0.4496

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