Estimating Kaldor-Verdoorn's law across countries in different stages of development

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This paper estimates Kaldor-Verdoorn's law (the long-term relationship between faster growth of production and growth of productivity) across developed and developing countries to evaluate those sectors capable of providing more rapid productivity growth. We test empirically this law for countries in different stages of development to understand why some developing countries were able to reduce the income gap to developed economies, and others were not. This analysis permits an evaluation of the sectors able to boost productivity growth according to countries' income per capita and give support to industrial policies focused on specific sectors.

Key words: Kaldor-Verdoorn's law, Cumulative Causation, Stages of Development

Este artigo estima a Lei de Kaldor-Verdoorn (a relação de longo prazo entre o mais rápido crescimento da produção e da produtividade) para países desenvolvidos e em desenvolvimento a fim de avaliar quais setores são capazes de promover o crescimento mais rápido da produtividade. Testa-se empiricamente essa lei para países em diferentes níveis de desenvolvimento com o intuito de compreender por qual razão alguns países em desenvolvimento foram capazes de reduzir o gap de renda em relação aos países desenvolvidos, enquanto outros não foram. Essa análise possibilita uma avaliação dos setores capazes de acelerar os ganhos de produtividade de acordo com a renda dos países e auxilia políticas industriais focadas em setores específicos.

Palavras-chave: Lei de Kaldor-Verdoorn, Causação Cumulativa, Estágios de Desenvolvimento

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1. Introduction

One of the most important questions in economic theory is why some developing countries were able to reduce the income gap to developed economies and others were not? Essentially, to answer this question we have to investigate the reason why growth rates differ between countries and regions in different stages of development. In this paper, we adopt a Kaldorian approach, which stress the existence of increasing returns to scale in some sectors, to tackle this issue. Sectors have different degrees of increasing returns according to countries' development stage, and thus some countries grow faster than others due to their sectoral structure of production. Thereby, we estimate Kaldor-Verdoorn's law (the long-term relationship between faster growth of production and growth of productivity) across countries to evaluate those sectors capable of providing more rapid productivity growth according to countries' income level.

Neoclassical models (Solow, 1956; Swan, 1956) assert that once economies have access to foreign capital and foreign markets, countries' income gap tends to reduce in the long run. Due to the assumption of constant returns to scale (and thus decreasing returns to capital), poor countries present higher marginal productivity of capital than the rich ones, which brings the notion of unconditional convergence among countries. In these models, only technological changes could explain the difference between countries' long-run growth rates. However, once they treat the determinants of technological changes as exogenous, neoclassical models did not provide enough contribution to explain the differences in growth rates between countries, as well as why countries' income has not converged (McCombie, 2006).

In the late 1980s, Romer (1986, 1990) and Lucas (1988) criticized these "old" growth models arguing against the constant returns to scale assumption. This critique was the basis for the "new" growth models, which assumes that productivity growth is determined endogenously[2]. This assumption has shifted the focus of the neoclassical models from exogenous technological changes to the externalities generated by the process of capital accumulation. Consequently, in contrast to "old" generation models, the "new" growth models might explain the historical divergence in countries' income. In a more complex model, Barro & Sala-i-Martin (1997) develop the idea of conditional convergence combining endogenous growth models with the notion of imitation. In this model, the relatively low costs of imitation enable developing economies to grow faster than developed economies. However, in the long run, all economies grow at the rate of discovery, and thus the rate of discovery plays the same role in this model as exogenous rate of technical change plays in neoclassical model.

Although these changes have been essential to bring the countries' growth back to debate in mainstream economics, the "new" growth models have provided limited contributions to the knowledge about the relations between economic growth and sectoral structure. According to Palma (2007), in spite of being activity-specific, these models are sector-indifferent. Essentially, countries' growth rates are explained by the existence of increasing returns on activities, such as R&D, but it is not associated with the size of one specific sector[3]. Furthermore, according to McCombie (2002) and Dutt (2006), endogenous

[2] There are two basic types of "endogenous growth models". The AK models (Romer, 1986) consider that capital is not subject to diminishing returns, and so shocks are able to modify the growth rate in the steady state. The Schumpeterian models (Lucas, 1988; Romer, 1990) consider that production stimulates other activities, such as R&D, which present increasing returns to scale. Barro & Sala-i-Martin (1995) present a detailed review of these models.

[3] Only in the last few years, some studies based on the neoclassical growth approach have focused on the sectoral composition of production to explain countries' growth rates differences. Rodrick (2013) argues that the neoclassical model's convergence does not occurs for the economy as a whole, but in manufacturing. According to him, manufacturing industries can be rapidly be integrated into global production networks, facilitating technology transfer and absorption (even when they produce only for domestic markets).

growth theory, besides ignoring the role played by different sectors in the economy, neglect the importance of factors determining the growth of demand. Consequently, they have to consider the output elasticity of capital to be exactly equal to unity; otherwise, the model predicts ever-increasing growth rates.

In contrast to neoclassical and "new" growth models, many heterodox economists, such as Hirschman, Prebisch and Kaldor, have attempted for the importance of sectoral structure of production on explaining the differences between countries' growth rates. Kaldor (1966) emphasised three reasons why manufacturing growth might explain countries' growth rate differences. He argued this sector is important because a faster growth of manufacturing (1) boosts the growth rate of GDP, (2) promotes a faster growth of productivity of the sector itself (owing to static and dynamic increasing returns to scale), and (3) stimulates the transfer of labour from primary sectors (which presents diminishing returns) to manufacturing. These relations between manufacturing and growth are known as Kaldor's laws[4].

In this paper, we focus on his second explanation, which is knew as Kaldor-Verdoorn's law[5]. Essentially, this law states that the faster the growth rate of manufacturing, the faster will be the growth rate of labour productivity, because manufacturing presents static and dynamic increasing returns to scale. The rationale behind the existence of increasing returns is that technological progress is not exogenously given, but induced by output growth[6]. This statement is on the heart of the cumulative causation models. As production grows due to the increase of the extent of markets, the scope for specialisation increases, and it stimulates the growth of productivity (due to division of labour). Thereby, in circular process that involves both the supply and demand sides, productivity growth increases output via market extension, which stimulates the productivity growth (McCombie, 2002).

Although Kaldor (1966) argued that UK, a developed economy, was de-industrializing because it suffers from "premature maturity", which has exhausted its potential for fast growth, the author extend his argument for countries in early stages of development. Nevertheless, the extension of his argument depends on the consideration that different industries inside manufacturing, such as capital goods, might have different degrees of increasing returns according to countries' stage of development. Because individual industries take different advantages of production and demand factors, such as market extension, skilled labour and innovation, we cannot expect in these industries the same degree of increasing returns in countries in different stages of development. Based on this assumption, we analyse the sectors in terms of their dynamic increasing returns to scale (Kaldor-Verdoorn's law) across countries controlling for their income per capita. We seek to identify those sectors that present higher degree of increasing returns and thus which are able to boost economic growth both for developing and developed countries. This analysis aims to demonstrate the importance of the sectoral structure to productivity growth and thus to economic growth in the long run.

Several studies have analysed the existence of increasing returns across manufacturing sectors, for example: McCombie & Ridden (1984), McCombie (1985), Bernat (1996), Leon-Ledesma (2000), McCombie, Pugno & Soro (2002), and Angeriz,

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Consequently, the lack of convergence between poor and rich countries is due to specific circumstances that influence the speed of structural reallocation to industrial sectors.

[4] A good systematization and discussion of the Kaldor's laws can be found in Thirlwall (1983) and McCombie (1983).

[5] Verdoorn (1949) have emphasised it before Kaldor and showed such empirical relation for a cross-section of countries. However, Kaldor (1966) brings this relation back to the debate.

[6] The "new economic geography" (Krugman, 1991; 1998) provides the micro-foundation for Kaldor's aggregate approach. The author stresses the importance of Marshallian sources of external economies, such as market-size effects (backward and forward linkages), a thick local labour market, especially for specialized skills, and information spillovers.

McCombie & Roberts (2009). Essentially, they found evidence of high increasing returns to scale in the industry level, especially when the specification attempts for dynamic increasing returns. However, they considered a specific country or a group of selected countries (usually developed countries), e.g., states of the USA or regions of the European Union, and thus we cannot infer any conclusion about the importance of these sectors according to countries' stages of development. Although we use these studies for the purposes of comparison, the aim of this paper is to analyse the degree of increasing return for both developed and developing countries in the industry level. Therefore, we estimate Kaldor-Verdoorn's law across a range of countries, including those with high-income levels and those with low and middle-income levels in order to contrast them, and, consequently provide an explanation for the convergence (or divergence) across countries based on sectoral specialisation.

The main results are that low-tech manufacturing sectors and consumption goods present high degree of increasing returns for low-income countries, and low increasing returns for middle- and high-income countries. On the other hand, high-tech manufacturing sectors and capital goods present low increasing returns for low-income countries, and high increasing returns for middle- and high-income countries. Furthermore, natural resource manufacturing sectors do not present significant variation in the degree of increasing returns according to countries' stage of development.

These findings can explain why some developing countries were able to reduce the income gap by promoting structural changes, and many others were unable to promote sustainable high growth rates. According to the results, countries have to stimulate low-tech manufacturing sectors and consumption goods in the early stages of development, and move to high-tech manufacturing sectors and capital goods in the later stages (between US$ 5,000 and US$ 10,000 per capita).

This paper is organised as follow. The next section presents methods and data used for estimation. Section III presents the results and the robustness checks. Section IV discusses the consequence of this paper's findings for the Kaldorian literature and provides the concluding remarks.

2. Methods and data

2.1. Estimation methods: supply- and demand-side specifications

The Kaldor-Verdoorn's law is the relationship between productivity growth and output growth. Thus, in principle, the estimation of this law should be obtained by a simple regression of these two variables:

$$p = \lambda + b\, q \qquad (2.1)$$

where p is the productivity growth, q is the output growth, λ is the rate of technical progress and b is the Verdoorn's coefficient.

Many estimations of Kaldor-Verdoorn's law were based on this equation and found a statistically significant value for b different from zero, suggesting that a faster growth of output is positively related to a faster growth of productivity[7]. However, according to McCombie (1985) and McCombie & Ridden (1984), the specification of Verdoorn's law must account for the fact that growth is essentially demand and not supply constrained. Hence, the simple regression presented in 2.1 is unable to estimate correctly the degree of increasing returns once growth of capital is endogenous to the model and it is a function of

[7] McCombie, Pugno & Soro (2002) presents a review of the many of these estimations.

output growth, and thus this estimation is not consistent, once it is only a spurious relationship between these two variables[8].

Because in the long run capital accumulation is a function of output growth, the specification must include controls for the level of physical capital stock. In order to do it, however, we have to make some assumptions about the production functions. Based on Angeliz, McCombie & Roberts (2008), we assume a Cobb-Douglas function[9] for total output

$$Q = Ae^{\lambda}K^{a}L^{(1-a)} \qquad (2.2)$$

where λ is the rate of technical progress, Q, K, and L are the level of output, capital and labour, and a is the production function parameter.

We can re-write it in a linearised form taking the logarithm of 2.2:

$$q = \lambda + ak + (1-a)l \qquad (2.3)$$

where lower cases mean growth rates.

According to Kaldor-Verdoorn's law, the rate of technical progress is endogenous determined. Although many authors have emphasised the existence of induced technical progress, such as Arrow (1962), which stressed the importance of learning-by-doing in the firm level, and Young (1928), which focused on increasing returns on the macro level, we consider induced technical progress in a Kaldorian line, in which it takes place in the industry level. Thus, the rate of technical progress is given by

$$\lambda = \bar{\lambda} + \pi[ak + (1-a)l] \qquad (2.4)$$

where $\bar{\lambda}$ is the exogenous technical progress, and π is the elasticity of induced technical progress in respect to inputs.

Replacing (2.4) in (2.3) and re-arranging we have

$$q = \bar{\lambda} + v[ak + (1-a)l] \qquad (2.5)$$

where v is the degree of increasing returns. In this equation, the importance of factors accumulation for economic growth become explicit. In contrast with equation 2.3, where we only can see explicitly the direct impact of factors accumulation on output growth, here we can see that accumulation of capital and labour increases output growth by stimulating endogenous technical progress if the degree of increasing returns, v, is greater than the unity.

Subtracting vq from both sides, rearranging and defining the total factor productivity growth as the difference between output growth and the weighted growth of labour and capital, $tfp = q - ak - (1-a)l$, we can re-specify equation (2.5) as

$$tfp = \frac{\bar{\lambda}}{v} + (1 - \frac{1}{v})q \qquad (2.6).$$

The aim of this study is to obtain the degree of increasing returns, v, however, we have to estimate first the tfp. Following Angeliz, McCombie & Roberts (2008) we can estimate it considering a as the contribution of capital for the total output, and $1-a$ as the

[8] Under the assumption of constant capital-output ratio in the long run, a stylised fact showed by Kaldor (1961), Kaldor-Verdoorn's law can be reduced to equation 2.1. However, we do not assume it in this paper, because short-term variations in capital-output ratio can affect the estimation of Verdoorn's coefficient.

[9] There is no need to assume a Cobb-Douglas function. However, it is one of the simple ways to estimate Kaldor-Verdoorn's law, once we can obtain a linearised form only taking the logarithm of the function.

contribution of wages for the total output, which is given by the wage share, and thus calculate tfp based on this:

$$tfp = q - ak - (1-a)l \qquad (2.7)$$

where $= 1 - \frac{W}{Q}$.

Another possible way of obtaining tfp is to estimate it as a residual. Rearranging its original equation as following

$$p = a(k - l) + tfp \qquad (2.8)$$

where $p = q - l$ is the labour productivity growth, we obtain an alternative estimation. This method, however, is based on the assumption that $k - l$ is exogenous in relation to p, which is a strong assumption, as the accumulation of capital is related to the market extend and it is related to productivity growth.

After estimating the tfp we can finally regress it in q, as suggested by equation (2.6), to obtain the degree of increasing returns to scale (and the Verdoorn's coefficient). This two-step methodology is important because it considers that output growth is exogenous to the growth of total factor productivity. It implies that demand factors are the main driven of accumulation process.

Alternatively, in order to obtain v we can define $tfi = ak + (1-a)l$ as the total factor inputs, and estimate it from

$$q = \bar{\lambda} + v\, tfi \qquad (2.9)$$[10].

The difference between (2.6) and (2.9) is that in (2.9) the growth of production factors (inputs) is considered to be exogenous, so it is the supply-side specification of Kaldor-Verdoorn's law, whilst in (2.6) output growth is the exogenous variable, which characterises the demand-side specification of Kaldor-Verdoorn's law[11].

2.2. Human capital augmented specification

As we are estimating this law for countries in different stages of development, it is important to consider that human capital stocks differ significantly across countries. Mankiw, Romer & Weil (1992), for example, show that Solow's model augmented with human capital can explain more precisely countries' growth path during the post-war period. Therefore, in order to consider that labour differs among countries, our specification needs to control for each country's human capital stock.

Assuming a Cobb-Douglas function for total output as (2.10) instead of (2.2)

$$Q = Ae^{\lambda}K^{a}(H)^{(1-a)} \qquad (2.10)$$

where H is the stock of human capital. Defining $tfp = q - ak - (1-a)h$ as the total factor productivity growth, and also that the rate of technical progress is endogenous determined by (2.11) instead of (2.4)

[10] In the original paper, Angeriz, McCombie & Roberts (2009), it is specified as $tfp = \bar{\lambda} + (v-1)tfi$. However, it does not change the estimation of v.

[11] Rowthorn (1975a, 1975b) and Kaldor (1975) discuss the implication of each specification to estimate Kaldor-Verdoorn's law. Angeriz, McCombie & Roberts (2008) present a systematization of this debate, testing both specifications. They conclude that only the degree of increasing returns estimated by the demand-side specification is significantly different from the unity.

$$\lambda = \bar{\lambda} + \pi[ak + (1-a)h] \qquad (2.11),$$

we can re-specify equation (2.7) as

$$tfp = q - ak - (1-a)h \qquad (2.12),$$

and then proceed exactly as before, estimating (2.6) or (2.9).

2.3. Macro and micro increasing returns

In order to estimate Kaldor-Verdoorn's law, it is also important to consider that economic growth may affect individual industries, and thus Kaldor-Verdoorn's law specification should control for the existence of macro increasing returns to scale. Based on McCombie (2002), we can estimate micro and macro increasing returns as follow.

Assuming a Cobb-Douglas function for total output as (2.13) instead of (2.2)

$$Q_j = Ae^{\lambda_j} K_j^{a_j} L_j^{(1-a_j)} Q^{\xi_j} \qquad (2.13)$$

where j refers to the analysed sector, and ξ is the degree of macro increasing returns.

The growth rate of this sector output is given, thus, by

$$q_j = \bar{\lambda}_j + v_j[a_j k_j + (1-a_j)l_j] + \xi_j q \qquad (2.14)$$

where v is the degree of micro increasing returns.

Defining $tfp_j = q_j - a_j k_j - (1-a_j)l_j$ as the total factor productivity growth, we can respecify equation (2.5) as

$$tfp_j = \frac{\bar{\lambda}_j}{v_j} + (1 - \frac{1}{v_j})q_j + \frac{\xi_j}{v_j} q_j \qquad (2.15),$$

and we can define $tfi_j = a_j k_j + (1-a_j)l_j$ as the total factor inputs, re-specifying equation (2.9) as

$$q = \bar{\lambda}_j + v_j\, tfi_j + \xi_j q \qquad (2.16).$$

Similarly, we can proceed with the same estimations for (2.6) and (2.9) to obtain the micro increasing returns from the supply- and demand-side specifications.

2.4. Data and sectoral aggregation

To estimate Kaldor-Verdoorn's law we use panel data on the countries considered between 1963 and 2009. Data for employees, output, and value added are available in the UNIDO Industrial Statistics Database at the 2-digit level of the International Standard Industrial Classification (ISIC), Rev. 3. Data for output and value added, however, are only available in nominal prices (US current prices or the various national currencies), and it is therefore necessary to deflate them before conducting the econometric tests. Although countries' price indices by sector should be used to deflate the output data, these indices are not available for most of the countries we intend to analyse. Therefore, in the absence of the ideal deflator, we replace it with the output, consumption and investment deflators for each country. These deflators are available in the Penn World Table (PWT 7.1).

Another relevant issue is that data on fixed capital stocks are not available. This variable is estimated using data on gross fixed capital formation (GFCF), also available in the UNIDO database, across countries and sectors at the ISIC 2-digit level. Following the approach adopted in Angeliz, McCombie & Roberts (2008), we apply GFCF data, combined with approximations of probable average asset lives, to estimate gross fixed capital stocks.

The main issue with these data, however, is that they are not available for all countries in the same years and do not employ a single sectoral division. Therefore, before performing the estimates, we analyse each country separately with the aim of identifying which countries we will use and which we will discard, as well as the sectoral aggregation. Although data on employees, output or value added and gross fixed capital formation are available between 1963 and 2009 for 38 countries, most of these are developed countries, and thus exclusively using these countries will generate a relevant bias. As a result, data on other countries have to be analysed (and in some cases estimated) prior to conducting the econometric tests.

In terms of the sectoral aggregation, we group some sector to make it possible to extend the analysis for the longest time series. The groups of sectors we consider here are: food, beverages and tobacco products [Food], textiles, wearing apparel and leather products [Textiles], wood, paper and publishing [Paper], fuels, chemicals, rubber and plastic [Chemicals], non-metallic mineral products [Non-metallic], basic and fabricated metals, machinery, equipment, office and computing machinery [Metals], electrical machinery, communication, medical, precision and optical equipment [Electrical]; motor vehicles and other transport equipment [Transport], and furniture and other manufacturing products [Others].

Finally, the sectors are grouped according to their technological intensity and categories of demand to determine which sectors have the potential to guarantee higher growth rates in the long run. According to technological intensity aggregation, we group Food, Paper and Non-metallic as natural resource based manufacturing [NR], Textiles, Metals and Others as low-technology manufacturing [LT], and Chemical, Electrical and Transport as high-technology manufacturing [HT]. In terms of categories of demand the first group (NR) remains the same, and we group Textiles and Others as consumption goods chains [CG], and Metals, Electrical and Transport as capital goods chains [KG]. Because Chemicals cannot be considered neither capital nor consumption goods, we do not classify this sector in any of this groups.

The analysis also uses data for human capital stocks and GDP per capita. Regarding human capital stocks, data on the average years of total schooling (for the population aged 15 and over) are available in Barro & Lee (2012) dataset. Regarding the GDP per capita data, we also use the Penn World Table (PWT 7.1).

3. Empirical results

3.1. General results: dynamic increasing returns to scale in the industry level

We start by estimating Kaldor-Verdoorn's law for countries in general (not controlling for countries' stage of development). This estimation, as well as all other in this paper, is based on two-way fixed effects panel (countries and years)[12]. The estimated models are

$$\ln\left(TFP_j\right) = \beta_0 + \beta_1 \ln(Q_j) \quad (3.1)$$

and

$$\ln\left(TFP_j\right) = \beta_0 + \beta_1 \ln\left(Q_j\right) + \beta_2 \ln(GDPpc) \quad (3.2).$$

[12] Because we are estimating the Verdoorn's coefficient based on two-way fixed effects panel, we obtain non-biased estimations for dynamic increasing returns to scale, once it not subject to the spatial aggregation bias (McCombie & Roberts, 2007).

where the index j stands for the sectors (Food, Textiles, Paper, Chemicals, Non-metallic, Metals, Electrical, Transport, Others and Manufacturing).

The results shows that although some sectors present higher increasing returns than others, such as Food, Chemicals and Electrical, we can accept that all manufacturing sub-sectors present high degree of increasing returns. The lowest results can be seen in Textiles (around 1.34) and Non-metallic (around 1.38), whilst the higher results can be seen in Food (around 1.76) and Chemicals (around 1.76). Table 3.1 presents the results for the four estimation methods. (3.1a) does not consider human capital and it does not control for macro increasing returns, (3.1b) considers human capital, but it does not control for macro increasing returns, (3.2a) controls for macro increasing returns, but it does not considers human capital, and (3.2b) considers human capital and it controls for macro increasing returns).

Table 3.1 – Degree of increasing returns by sub-sector and manufacturing*

	(3.1a)	(3.1b)	(3.2a)	(3.2b)
Food	1.70	1.74	1.79	1.83
Textiles	1.39	1.31	1.38	1.29
Paper	1.50	1.46	1.55	1.49
Chemicals	1.72	1.75	1.78	1.80
Non-metallic	1.41	1.37	1.39	1.35
Metals	1.41	1.38	1.50	1.46
Electrical	1.44	1.43	1.77	1.77
Transport	1.47	1.44	1.54	1.52
Others	1.64	1.58	1.82	1.75
Manufacturing	1.31	1.28	1.36	1.32

(*) Here we present only the degree of increasing returns, calculated by $v_j = \frac{1}{1-\beta_1}$. For complete results and standard deviations, please contact the author.

One interesting point about these results is that all sectors in all estimations present higher increasing returns than manufacturing (except by Textiles in the fourth estimation). This result suggests that dynamic increasing returns to scale tend to be found in the individual industry level instead of macro level. Most of the other studies find similar results, such as Angeriz, McCombie & Roberts (2009). The authors find higher increasing returns for all sub-sectors than for manufacturing, with the only exception of Textiles.

3.2. Increasing returns in the industry level according to countries' GDP per capita

The existence of different degrees of increasing returns to scale among manufacturing sub-sectors for countries in different stages of development provides a good support for stimulus to industrial policies that focused on promoting inter-industry structural changes. Thereby, the estimation of increasing returns to scale according to countries' income by a heterogeneous analysis may bring some important issues for the debate of the importance of sectoral structure for countries development. Taking advantage of having a dataset with countries in different stages of development, we estimate the degree of increasing returns interacting sectoral output and GDP per capita, as follow:

$$\ln(TFP_j) = \beta_0 + \beta_1 \ln(Q_j) + \beta_2 \ln(Q_j) \ln(GDPpc) \quad (3.3)$$

and

$$\ln(TFP_j) = \beta_0 + \beta_1 \ln(Q_j) + \beta_2 \ln(Q_j) \ln(GDPpc) + \beta_3 \ln(GDPpc) \quad (3.4).$$

The degrees of increasing returns provided by these estimations are not obtained by β_1, such as in 3.1 and 3.2, but they are obtained by $\beta_1 + \beta_2 \ \ln(GDPpc)$, which means that they vary according to countries' GDP per capita. Hence, rather than one value for the degree of increasing returns, we obtain a function.

As can be seen in Table 3.2, in estimations that does not control the results for the existence of macro increasing returns (3.3a and 3.3b), countries' GDP per capita do not have an important impact on the degree of increasing returns. Even though some sectors present higher degree of increasing returns for low level of GDP per capita (such as Chemical, Electrical and Others), there is no sectors that present a positive relation between GDP per capita and degree of increasing returns.

Table 3.2 – Degree of increasing returns (not controlling for macro increasing returns)

	(3.3a)					(3.3b)				
	2.5	5	10	20	40	2.5	5	10	20	40
Food	1.81	1.78	1.75	1.73	1.70	1.84	1.81	1.79	1.76	1.74
Textiles	1.40	1.40	1.39	1.39	1.39	1.31	1.31	1.31	1.31	1.31
Paper	1.54	1.53	1.53	1.52	1.51	1.47	1.47	1.47	1.47	1.47
Chemicals	1.82	1.78	1.75	1.72	1.69	1.83	1.80	1.77	1.75	1.72
Non-metallic	1.39	1.39	1.40	1.40	1.41	1.35	1.35	1.36	1.36	1.37
Metals	1.49	1.48	1.46	1.44	1.43	1.44	1.43	1.42	1.41	1.40
Electrical	1.87	1.77	1.68	1.61	1.53	1.84	1.75	1.67	1.60	1.53
Transport	1.56	1.54	1.52	1.49	1.47	1.54	1.52	1.49	1.47	1.45
Others	1.90	1.81	1.73	1.66	1.59	1.81	1.74	1.67	1.60	1.55
Manufacturing	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.30	1.30	1.29

However, as shown in the following figures, once we control the estimation of the degree of increasing returns in the industry level for the existence of macro increasing returns (3.4a and 3.4b), the results for some sectors change significantly as countries' GDP per capita increases.

Figure 3.1 – Degree of increasing returns (controlling for macro increasing returns)

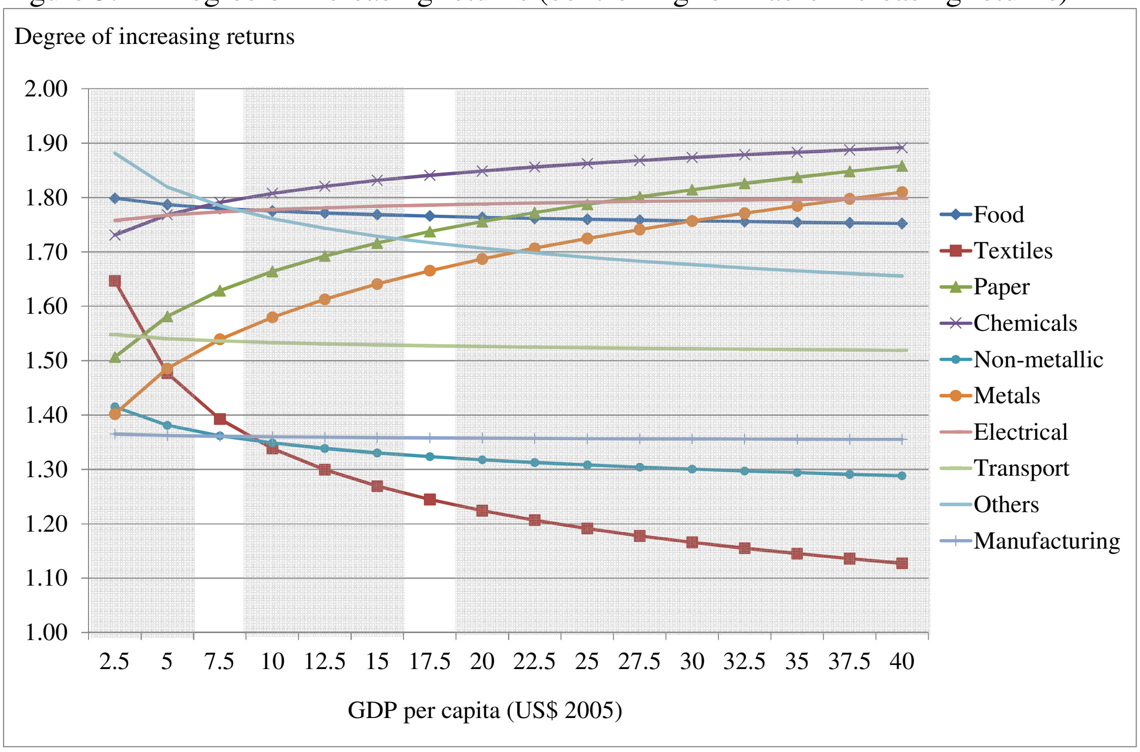
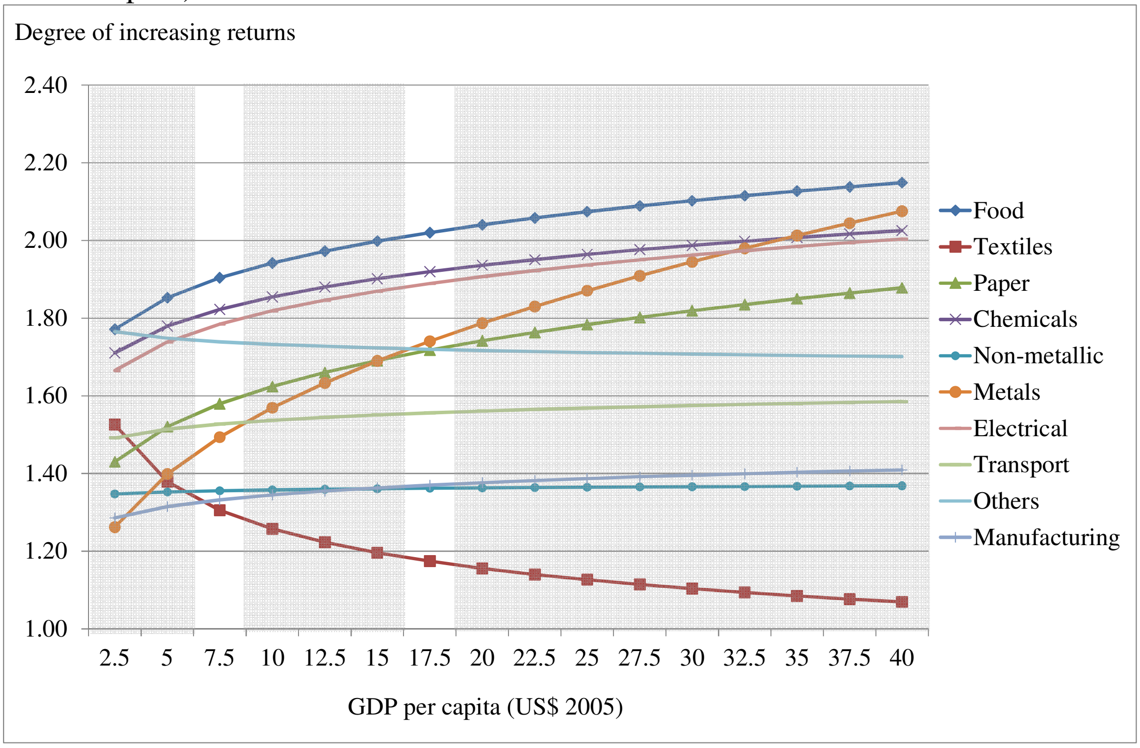


Figure 3.1 presents the degree of increasing returns in the industry level and for manufacturing for countries according to their GDP per capita level. The data shows that some sectors present high degree of increasing returns for low-income countries and low increasing returns for medium and high-income countries, such as Textiles. Others sectors, such as Metals and Paper, present low increasing returns for low-income countries and high increasing returns for high income countries. The figure shows, however, that some sectors present high increasing returns independently of the stage of development, such as Electrical, Food and Chemicals. Only Non-metallic and Manufacturing present low increasing returns independently of the stage of development (around 1.35).

The estimation of degree of increasing returns taking into account that labour is not homogenous (controlling for human capital) show very similar results. Figure 3.2 present these results and the main difference is that the degree of increasing returns are higher in general, but specially in Food and Metal for high-income countries. Moreover, Textiles present very low degree of increasing returns (close to the unity) for high-income countries, which means that this sector has constant returns to scale for developing countries.

Figure 3.2 – Degree of increasing returns (controlling for macro increasing returns and human capital)

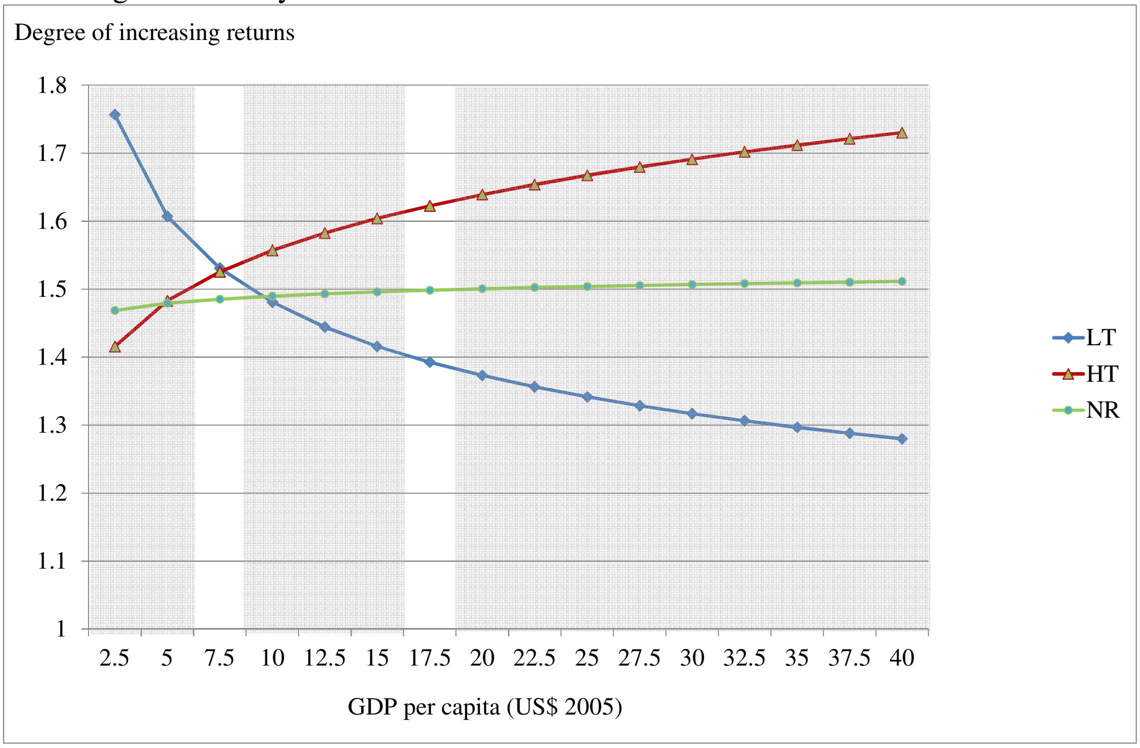


3.3. Technologic Intensity

One of the main sources of dynamic increasing returns in the industry level is technological search and knowledge diffusion. According to Fagiolo & Dosi (2003:239), "technological advances are endogenously generated through resource-expansive search undertaken by multiple agents". Thereby, we can expect higher degree of increasing returns in sectors which higher technologic intensity, once expenses in research and technological diffusion are the main drivers of productivity growth in these sectors. Moreover, we can expect higher degree of increasing returns as countries' GDP increases, once the level of GDP per capita is strictly related to expenditures in R&D and innovation activities.

In order to evaluate the degree of increasing returns among sectors with different technologic intensity, we aggregate the sectors in three groups: natural resource based manufacturing [NR], low technologic intensity sectors [LT] and high technologic intensity sectors [HT]. The same methodology used in section 3.2, which estimate the degree of dynamic increasing returns according to countries' GDP level (controlling for macro increasing returns), is applied and we obtain the following results:

Figure 3.3 – Degree of increasing returns (controlling for macro increasing returns) by technological intensity

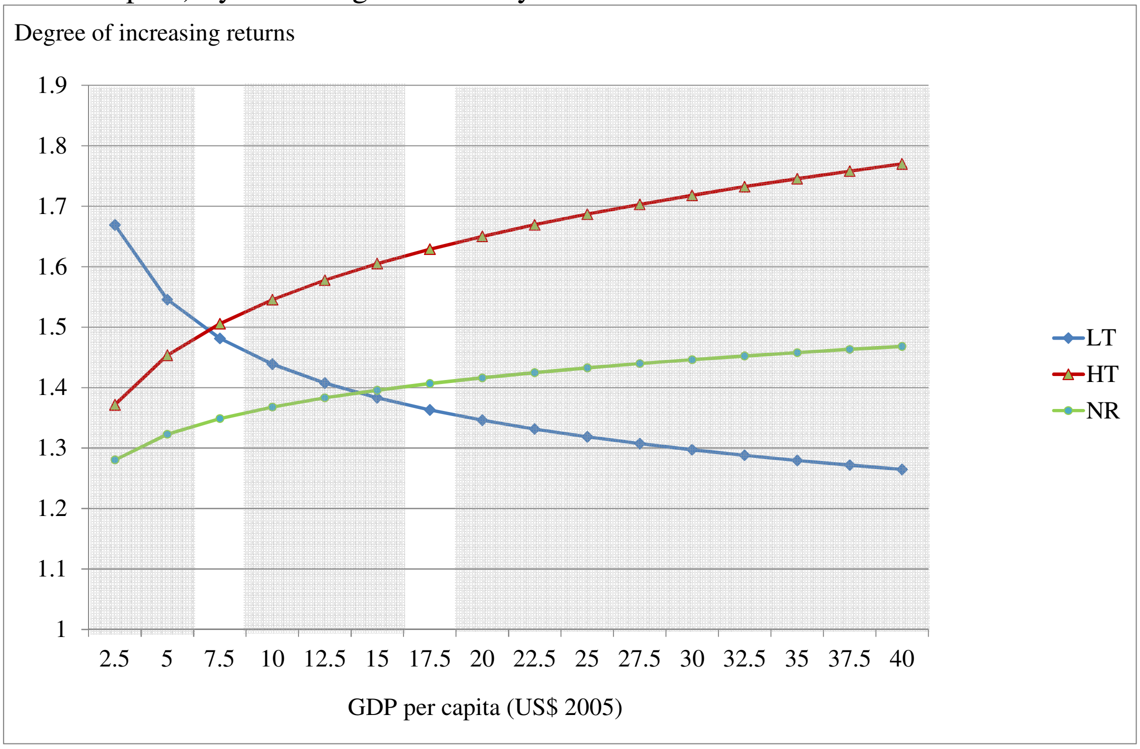


The results show that for low levels of income (lower than US$ 7,500 per capita), low technological sectors present higher degree of dynamic increasing returns, but as GDP per capita increases the degree of increasing returns fall, which means that specialization in this sectors increases the productivity of the sector itself only for low income countries. In contrast, for middle and high level countries the high technologic sectors are those capable to boost productivity growth as they present higher degree of increasing returns. Natural resource based sectors, such as food and non-minerals, present a relevant degree of increasing returns, but it does not change if countries' GDP per capita increases.

Controlling for human capital the main results do not change substantially, as can be seen from Figure 3.4.

The main difference between the results controlling for human capital is that natural resource based sectors present low degree of dynamic increasing returns for low income countries, which means that the specialization in this sectors do not increase the productivity due to output growth. The results also show that if the countries' GDP per capita is higher than US$ 10,000, they have to promote high-tech sectors to boost productivity growth, once these sectors present higher degree of increasing returns as countries achieve a higher level of development.

Figure 3.4 – Degree of increasing returns (controlling for macro increasing returns and human capital) by technological intensity



3.4. Categories of demand

An alternative approach that we can adopt to understand the origin of the difference of the degree of dynamic increasing returns is based on the categories of demand. The capital goods sectors, when associated to users, are responsible for most of innovations in the economy, and they are central in the process of technologic diffusion (Lundvall, 1988). Thereby, one can argue that productivity growth in capital goods sectors is driven by the increase of production in this sector itself when it is associated to users, whilst the increase of productivity in consumption goods it is driven by the increase of production in other sectors in the economy.

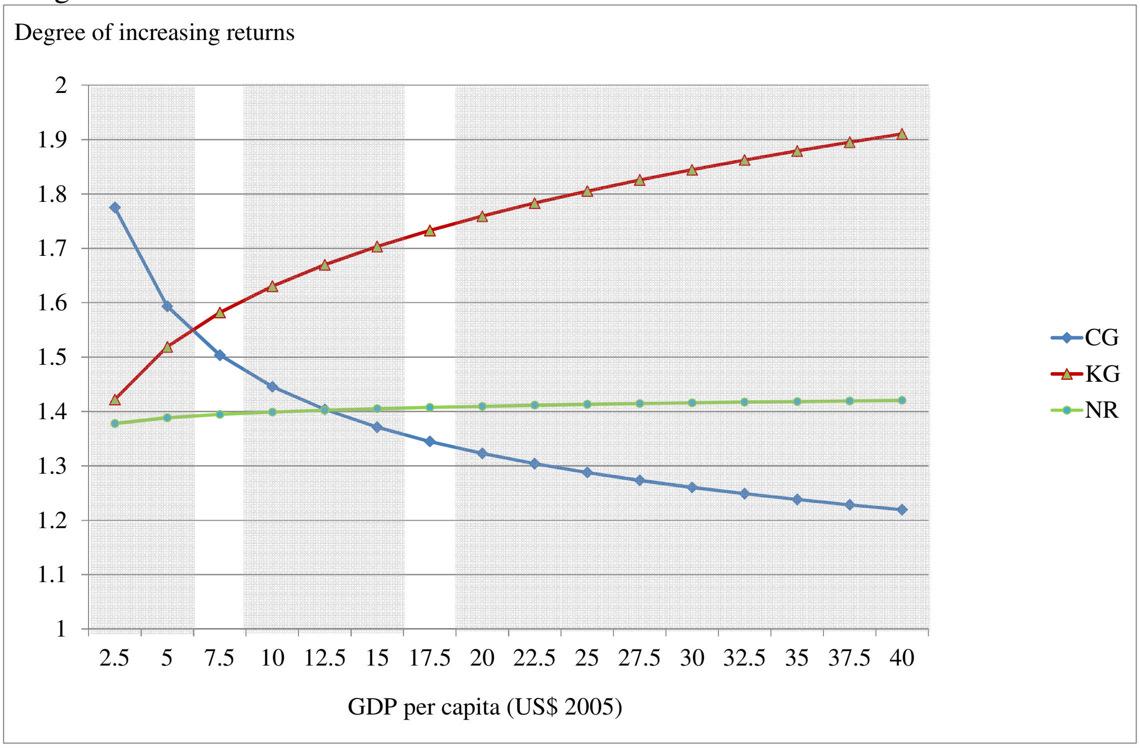
Furthermore, as stressed by Kaldor (1966, 1967), capital investment is an important source of demand for countries in the most advanced stages of development, because manufacturing generates demand for its own products. He argues that countries have to promote the import-substitution and exports of capital goods, because this sector will provide the goods on which capital expenditure is spent. Thus, the very establishment of a capital goods sector is an important source of increasing returns to scale from the demand side. Productivity growth will extend this sector's market size, and thus this sector will display a self-generating demand for capital goods, which is a central element of cumulative causation. On the other hand, if this sector is not internalised, although increases on output can increase productivity, it will not be able to promote an increase on its market, which will be a constraint for the continuity of a cumulative process[13].

In order to estimate the degree of dynamic increasing returns in these groups we aggregate sectors into three categories: natural resource based manufacturing [NR], consumption goods chains [CG] and capital goods chains [KG]. We estimate it based on the

[13] Based on this fact, Kaldor (1966, 1967) define the four stages of development: first, a country has to promote import-substitution of consumption goods, second, promote exports of these goods, third, promote import-substitution of capital goods, and, finally, in the most advanced stage, promote exports of capital goods.

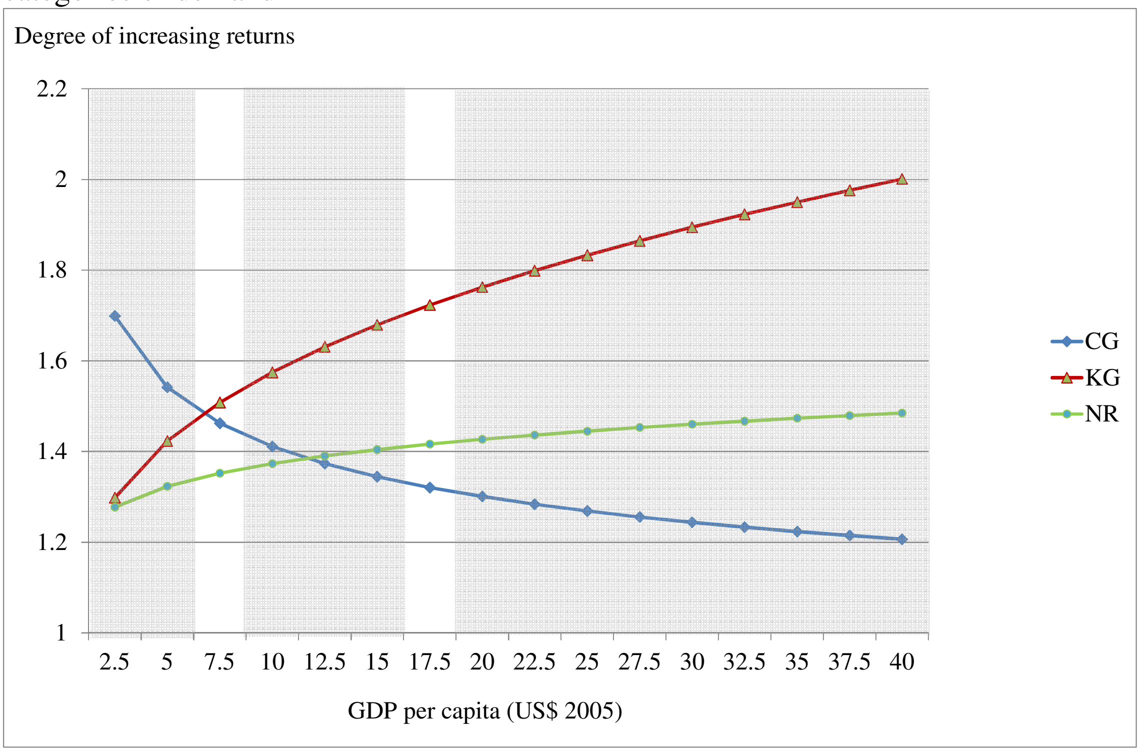
same methodology applied in section 3.2. Figure 3.5 present the degree of dynamic increasing returns for each of these categories according to countries' GDP per capita:

Figure 3.5 – Degree of increasing returns (controlling for macro increasing returns) by categories of demand



The results shows that production of consumption goods can boost the productivity of the sector itself only for low income countries, whilst the production of capital goods is an important source of dynamic increasing returns for middle and high income countries.

Figure 3.6 – Degree of increasing returns (controlling for macro increasing returns) by categories of demand



Thereby, an increase of production for low-income countries increases the productivity if the countries are specialized in consumption goods. However, as GDP per capita increases, specialization in consumption goods are not able to boost productivity any more. Countries have to specialize in the production of capital goods, instead. Natural resource based sectors present a relevant degree of increasing returns (around 1.4), but it does not present variation as countries' GDP per capita increases.

When we control the estimation for the accumulation of human capital, results are very similar to those presented before, as presented in Figure 3.6.

Although the specialization in consumption goods is an important source of dynamic increasing returns for low-income countries, as GDP per capita increases, countries have to specialize in capital goods to take advantage of higher degrees of dynamic increasing returns. Again, the main difference is that natural resource based manufacturing present low increasing returns for low-income countries, but it increases as countries' GDP increases, although it is significantly lower than high tech sectors for middle and high-income countries.

4. Concluding remarks

There is an important debate on economic theory about why some developing countries were able to achieve sustainable high growth rates and their income per capita have converged towards developed ones, and why others were not. This paper tried to assess this issue from a Kaldorian approach, which stress the importance of increasing returns to scale in some sectors. More specifically, we estimate these increasing returns according to countries' stage of development by heterogeneous regressions.

The first result corroborates the findings of previous studies, which have found that manufacturing sub-sectors present higher increasing returns than manufacturing. It suggests that dynamic increasing returns tends to be found in the industry level instead of macro level. Furthermore, we also found that the degree of increasing returns in manufacturing does not vary according to countries' GDP per capita.

In contrast to the findings for manufacturing, the data shows that some sectors, such as Textiles, present high degree of increasing returns in the early stages of development, but as countries grow the degree of increasing returns become low. Others sectors, however, such as Metals and Paper present low increasing returns for countries in the early stages of development, and high increasing returns for more developed economies. Finally, some sectors present high increasing returns independently of the stage of development, such as Electrical, Food and Chemicals, and only Non-metallic has low increasing returns independently of the stage of development.

When we aggregate sectors according to technologic intensity and categories of demand we find that countries in the early stages of development benefits from specializing in low-tech manufacturing and consumption goods because they present high degree of increasing returns for low-income countries and low increasing returns for medium and high-income countries. However, as countries reach higher stages of development, it is important to promote structural changes in favour of high-tech manufacturing sectors and capital goods. These sectors present low increasing returns for low-income countries and high increasing returns for high-income countries and thus they can boost the growth rate of countries in higher stages of development. These findings can explain why industrial policies, which promotes changes from low-tech manufacturing and consumption goods production to high-tech manufacturing and capital goods sectors, are important to reduce the income gap.

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