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Sectorial specialization and growth implications

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Abstract

Sectorial specialization and growth implications Charlotte Guillard University of Strasbourg and UNU-MERIT Enrollment: 2011 / Expected final date: 2016 \texttt{guillard@merit.unu.edu}} Economic growth has been a recurrent topic of interest in economics since the seminal work of Adam Smith. Sustained economic growth is pursued by most countries as it is believed to be the main root of wealth and development. However, the source growth and recession still remain relatively unclear. The accumulation of production factors such as human and physical capital along with technological progress have long been considered as being the main determinants of growth. More recently, part of the research on growth has focused on the structural aspects of the productive structure of countries in order to understand growth. In this framework, changes in the productive structure has made it possible for countries to grow by shifting part of the resources from a traditional sector towards a more productive sector in terms of value added (Pasinetti, 1981). However, the literature is unclear about the direction structural change should take. Fagerberg (2000) demonstrate empirically that the manufacturing sector still plays a role as an engine of growth in the developing world. Szirmai and Verspagen (2011) find that the effect of manufacturing on growth is relatively weak and that the effect changes with the income gap and education level. As argued by Malerba (2002), the type of knowledge differs across sectors and production also follows disparate dynamics. For this reason, accounting only for the aggregate effect of the manufacturing industry can hide heterogeneities. As in Hidalgo et al. (2007), I use export data from the COMTRADE database cleaned by Feenstra et al. (2005) for the period 1962 to 2000 in order to construct the network of products. By applying the Infomap community detection algorithm (Rosvall, 2008 and Rosvall, 2010), I first find that the production network has a modular structure. I obtain a several communities composed of a set of products corresponding to different industries. I use this classification instead of an ad-hoc one, such as SITC, because it is endogenously determined by the link structure of the product space. It reflects the fact that goods in the same community share more common knowledge than with the rest of the products. Based on this structure, I construct a measure of fitness following Tacchella et al. (2013) in order to measure not only the effect of knowledge intensity but also of different knowledge types embedded in products. In addition, by breaking down the measure, it is possible to discern the effect of different manufacturing sectors. Using panel regression methods, I find that high fitness in sectors such as textile and metallurgy (excluding iron) have a negative influence on growth while it is positive for the electronics sector. Furthermore, I analyze this effect accounting for the level of development of the country. The interaction terms do have a significant effect for several sectors. High fitness levels in the textile and chemical products industries

influence growth positively before reaching a certain threshold of GDP per capita, and after this point the effect becomes negative. However, other sectors such as electronics, machinery, iron metallurgy and petroleum depict a U-curve relationship of the effect of fitness on growth relative to income per capita. Therefore, this study illustrates the fact that estimating the overall effect of the manufacturing sector on growth veils the heterogeneous effect of its different parts and can lead to erroneous policy implications. References

Fagerberg, J. and B. Verspagen (2000). Productivity, r&d spillovers and trade. In Productivity, technology and economic growth, pp. 345-360. Springer. Feenstra, R. C., R. E. Lipsey, H. Deng, A. C. Ma, and H. Mo (2005). World trade flows: 1962-2000. Technical report, National Bureau of Economic Research. Hidalgo, C. A., B. Klinger, A.-L. Barabási, and R. Hausmann (2007). The product space conditions the development of nations. Science 317 (5837), 482-487. Malerba, F. (2002). Sectoral systems of innovation and production. Research policy 31 (2), 247-264. Pasinetti, L. L. (1981). Structural Change and Economic Growth. Cambridge University Press. Rosvall, M., D. Axelsson, and C. T. Bergstrom (2010). The map equation. The European Physical Journal Special Topics 178 (1), 13-23. Rosvall, M. and C. T. Bergstrom (2008). Maps of information flow reveal community structure in complex networks. PNAS 105 (4), 1118-1123. Szirmai, A. and B. Verspagen (2011). Manufacturing and economic growth in developing countries, 1950-2005. Tacchella, A., M. Cristelli, G. Caldarelli, A. Gabrielli, and L. Pietronero (2013). Economic complexity: Conceptual grounding of a new metrics for global competitiveness. Journal of Economic Dynamics and Control 37 (8), 1683-1691.

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Industrial specialization and growth

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1 Introduction

Sustained economic growth is pursued by most countries as it is believed to be the main root of wealth and development. Since the industrial revolution, some countries have experienced periods of rapid growth driven by the shift of economic resources from a traditional to a modern sector, that is structural change. However, structural change does not always imply growth because the direction of this change matter. According to Salter (1960), structural change can imply improved growth rates because of the heterogeneous rates of technological progress across industries. Cornwall (1977) argues that structural change towards the manufacturing sector would improve growth through dynamic scale economies (learning by doing) and important backward linkages to other sectors. In addition, the prices of manufacturing goods are less prone to external shocks and they are less affected by a degradation of the terms of trade relative to agricultural products and commodities. The degradation increases the risk of falling into a low-development trap as explained in Prebisch (1950) and Singer (1950). Changes in the structure of an economy have been quantified in different ways in the literature. Several authors have intended to empirically assess the effect of the growth rate or share of manufacturing value added in GDP on growth and found that this effect was not always significant (Cornwall, 1977; Fagerberg and Verspagen, 1999;Fagerberg and Verspagen, 2002; Szirmai, 2012; Szirmai and Verspagen, 2015). As argued by Saviotti and Frenken (2008), the identification of the key directions require looking at a fairly desegregated level of the production to understand where the dynamics occur. Aggregating the value of the goods produced by an economy leads to a loss of information that may be critical to understand the underlying dynamics of structural change and their effect on growth. According to the structuralist view, the sector an economy transitions to has different dynamics than the one it comes from. This is true between the agricultural and the manufacturing sectors but also between sub-sectors inside the manufacturing sector. The focus on the manufacturing sector as a whole, induces omitting the heterogeneity of sub-sectors in terms of their technological content, spillovers due to linkages, opportunities for capital accumulation and technological progress and demand elasticity to income. In addition, the overall value does not distinguish between different degrees of diversification and the level of technology involved in the production of a country. Finally, if the effect of structural change is tightly linked to technological change the way knowledge, embodied in different products, is quantified is crucial to understand the mechanism of development. The aim of this paper is to understand the effect of different sectors by accounting for both the amount and type of knowledge embodied in the productive structure of countries. After reviewing the literature on structural change, I first propose a new way to quantify knowledge in order to account for both knowledge accumulation and diversity (different types of knowledge) based on the export structure of the world. In the following section, I use the constructed measures in an econometric regression to assess the effect of each sector on growth. Furthermore, I analyze these effect conditional on the income level and the level of integration in a given sector. I also study the effect of these measures by limiting the sample to countries having experienced sustainable growth. Finally, I conclude in the last section.

2 Review of the literature

2.1 Structural change, knowledge and growth

Structural change implies an improvement in the rate of technological change in the sector towards which part of the resources are transferred. In this section, I review the literature on the effect of structural change on growth. In particular, I focus on the way structural change has been measured. The most common way to quantify structural change in the literature is by looking at the relative share of the value added from the manufacturing sector in GDP. Fagerberg and Verspagen (1999) demonstrate empirically that the manufacturing sector still plays a role as an engine of growth in the developing world only by looking at the effect of growth rate of manufacturing value added on growth for the period 1973 to 1989 and 67 countries.

Pasinetti (1981) explains structural change by a productivity increase that leads to demand saturation. In this case, adding new activities and products to the economic system is the only way to use remaining resources. Fagerberg (2000) uses a sample of 39 countries and 24 industries from the UNIDO database between

1973 and 1990 and decomposes the effect of productivity growth as a consequence of structural change (change in productivity due to labor reallocation between industries), productivity change within industries and the interaction of both. He shows that productivity change within industries is the main cause of productivity growth while structural change has almost no effect. He then regresses the share of electrical machinery in total employment on productivity growth, limited the sample to countries with high productivity growth. Estimation results show that productivity growth can be attributed to productivity growth variation within the electrical machinery industry and to spillovers to other industries. This industry is also the one benefitting from the highest average productivity growth over the period. Similarly, Saviotti and Frenken (2008) rely on the hypothesis that both productivity and growth of variety are drivers of growth. However, they argue economic growth cannot be driven only by structural change (unrelated variety) but also qualitative change including change at lower levels of aggregation than sectors (related variety). Unrelated and related variety growth have different effects on growth and are complementary. On the one hand, specializing in similar products offers the possibility for agglomeration economies due to spillovers within sectors through labor market pooling, the creation of specialized suppliers, and knowledge spillovers. On the other hand, the existence of a large unrelated variety of exports enables knowledge recombination leading to Jacobs externalities. However, as stressed in Frenken et al. (2007), knowledge spillovers are possible only if the sectors are complementary and involve sets of knowledge that are not too far from each other for their recombination to be feasible. Importantly enough, these two effects lead to different outcomes. Agglomeration economies steer incremental and process innovation inducing productivity rises while Jacobs externalities are more responsible for radical and product innovations. Third, variety is also a risk-sharing tool to assimilate sector specific shocks. The way the relative prevalence of these three effects affects future growth prospects depends on the productive structure of the country. Saviotti and Frenken (2008) demonstrate empirically that related variety leads to short term growth while unrelated variety has positive effects in the long term. However, the set of sectors used to compute variety matters. These measures do not account for the differences in the amount of embodied knowledge between products and thereby sectors. This problem is limited in their analysis because the sample only includes a few developed countries that have a fairly homogenous productive structure. In other words, it amounts to compare quantities that are not comparable because products are not linearly related to each other Hidalgo and Hausmann (2009).

Hidalgo and Hausmann (2009) construct a measure of the extent of knowledge and capabilities present economy accounting for their asymmetric amount embedded in goods. In other words, their measure of product variety is weighted by their complexity. Some products such as garment do not require as much knowledge and capabilities as it is needed for a car. In Hidalgo and Hausmann (2009), product complexity, i.e. amount of knowledge and capabilities, is derived from the network of exports.[1] Formally, the bipartite network is defined as (C,P,W), where C is the country subset, P is the product subset and W are the weights linking C and P. The incidence matrix of the export network, $M_{c,q}$, is based on the revealed comparative advantage of country c in the export of product p(Balassa, 1965) and is defined as follows :

$$M_{cp} = \begin{cases} 1, & \text{if } RCA_{cp} > 1. \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

with

$$RCA_{cp} = \frac{W_{cp} / \sum_{p} W_{cp}}{\sum_{c} W_{cp} / \sum_{cp} W_{cp}} \tag{2}$$

The measure of country and product complexity is the result of the iteration of equations 3 and 4. The complexity of a country depends on the complexity of the products it exports which in turns depends on the complexity of the countries exporting these products, controlling for the ubiquity of the given products.

$$k_c^{(N)} = \frac{1}{k_c^0} \sum_{p=1}^{P} M_{cp} k_p^{(N-1)} \tag{3}$$

$$k_p^{(N)} = \frac{1}{k_p^0} \sum_{c=1}^{C} M_{cp} k_c^{(N-1)} \tag{4}$$

In Hidalgo and Hausmann (2009), the relationship between country and product complexity is linear. However, Tacchella et al. (2013) show that this mathematical configuration does not follow the capability theory. They argue that the average fitness of countries producing a given good is not representative of the level of fitness one needs to produce it, but it is overestimated. The logic behind this argument is that complex countries will be able to produce this good but also much more complex ones. Thereby, parts of the capabilities needed for more complex goods are diluted in the average fitness of other goods although they are

[1] In order to ease the calculations, Hidalgo and Hausmann (2009) construct a binary country-product matrix. The threshold to determine whether a country export or not a product is based on whether it has a revealed comparative advantage in this product as defined in Balassa (1965).

not required to produce the later. The information fitter countries give in terms of capabilities is less representative than the one with lower levels of fitness. The solution to this is a weighted average of countries' fitness in which the influence of the fitness of a country decrease with its fitness level. Country fitness and product complexity are defined as:

$$\tilde{k}_c^{(N)} = \sum_{p=1}^{P} M_{cp} k_p^{(N-1)} \tag{5}$$

with

$$k_c^{(N)} = \frac{\tilde{k}_c^{(N)}}{\langle \tilde{k}_c^{(N)} \rangle} \tag{6}$$

$$k_p^{(N)} = \frac{1}{\sum_{c=1}^{C} M_{cp} (\frac{1}{k_c^{(N-1)}})} \tag{7}$$

with

$$k_p^{(N)} = \frac{\widetilde{k_p^{(N)}}}{\langle \widetilde{k_p^{(N)}} \rangle} \tag{8}$$

The renormalization is done to avoid that the iteration result in 0 or $+\infty$. By doing that, the values are restricted to the range of possible values (meaningful values).

3 Measuring industrial specialization

The determinants of growth have been widely studied. However, it is still unclear through which industries or combination of industries countries develop. In this section, I do not focus on the distinction between structural change and change within industries. I rather study the extent to which a country is specialized in a given industry and the effect this has on growth along with the effect of industrial diversity (the variety of industries a country is involved in). The analysis of countries' complexity in the economic system is important for measuring the growth potential of countries as shown in Hausmann et al. (2011). However, it gives very little information as to which patterns of development foster growth. The complexity of a country in an industry is different from the global one because of differences in specialization patterns, which implies distinct growth dynamics. As argued by Malerba (2007), the type of knowledge differs across sectors. Complexity only accounts for the intensity of knowledge but does not measure the knowledge specificities across industries, i.e. the different types of knowledge used in the production of a country. In addition, path dependence does not only rely on the accumulation process (in the sense of increasing the intensity of knowledge in general) but also on the presence of different types of knowledge. Arthur (1990), Weitzman (1998) and Arthur (2009) argue that new knowledge is created through the recombination of old knowledge. Therefore, the greater the diversity of knowledge types, the greater the possibilities of recombination leading to a positive feedback.

The measures of industrial specialization and diversity rely heavily on the product classification. Products are considered of the same industry if they share many common capabilities and knowledge compared to the rest. The theory of networks offers a wide range of methodologies to measure the similarity between elements in a system and quantify disparity, based on the structure of their interactions. One of the main methods to quantify vertex similarity is the so-called structural similarity, which assumes that two vertices are similar when the structure of their interactions is alike, i.e. when they share the same neighbors. Structural similarity can be measured by looking at structural equivalence or regular equivalence. Hausmann and Klinger (2006) and Hidalgo et al. (2007) focus on the first approach to measure product relatedness using export data[2]. It is captured by looking at the structure of the bipartite network of exports connecting products to countries, their connection being determined by the export value. The proximity between two products corresponds to the number of common neighbors divided by the maximum degree among the two products. The connection between products is positively correlated with the number of common neighbors, thereby controlling for the commonness of the products. This measure reflects the similarity between the set of capabilities and technologies required to export two different goods. The product space has a core-periphery structure and is discontinuous, i.e. the strength and density of the links between products are heterogeneous in the space. In other words, being located in distinct parts of the core or the periphery has different implications. This heterogeneity is not captured by the product variety model of Romer (1990), the quality ladders model of Grossman and Helpman (1991) or product variety measured by entropy as in Saviotti and Frenken (2008). The measure of proximity corresponding to the weights of the product space is formally described as follows:

$$P_{p_i p_j} = min\left\{P(M_{c,p_i}|M_{c,p_j}), P(M_{c,p_j}|M_{c,p_j})\right\} \tag{9}$$

[2]They use the uniformized fourth level digits COMTRADE dataset for the period 1962 to 2000 (Feenstra et al., 2005).

with

$$M_{cp} = \begin{cases} 1, & \text{if } RCA_{cp} > 1. \\ 0, & \text{otherwise.} \end{cases} \quad (10)$$

Given that equation, the weight of a given link between two products is ultimately driven by the extent to which the most common product of the two is ubiquitous. It follows that the proximity is diminished considerably if one of the two products is commonly exported. Therefore, this measure takes into account the similarity between the two products as well as the amount of capabilities they share. A pair of products will have a higher weight if they are both complex, i.e. requiring many capabilities because the overlap is drawn from a relatively large set of capabilities (the set being proportional to the ubiquitousness of the most common product). In other words, this measure captures not only the fact that many of the capabilities overlap (similarity) but also the size of the capability set of the most common product (diversity). Indeed, capturing only the similarity dimension amounts to neglecting the importance of capability diversity and accumulation, which affects the process of combinatorial evolution. By doing so the edges seize the intensity of the knowledge and capabilities flow shared by the two products. The industrial classification is determined by the structure of the product space through a community detection algorithm based on the minimum length of the path of a random walker on the network (Rosvall and Bergstrom, 2008 and Rosvall et al., 2010). This classification improves the SITC in two ways. In this setting the classification is endogenously determined by the similarity network of products in terms of knowledge. The SITC is an ad-hoc classification to partition systems into groups, which categorizes exports according to a set of benchmarks, also defined exogenously.[3] Furthermore, using a network measure enable to improve the measure of related variety by accounting for the amount of knowledge embodied in products within industries.

Because each community result in a sub-network, it is possible to account for the heterogenous localization of products in an industry as well as the diversity and export value of exports in order to quantitatively measure the integration of a product and thereby a country in an industry. This is precisely the object of this section. Furthermore, one can also quantify the distance between two communities using the edge weights between them, which was not possible to do with the SITC.

[3]This classification, constructed by the United Nations, reflects "(a) the materials used in production, (b) the processing stage, (c) market practices and uses of the products, (d) the importance of the commodities in terms of world trade, and (e) technological changes". (http://unstats.un.org/unsd/iiss/Print.aspx?Page=Standard-International-Trade-Classification)

The measure of sectoral integration relies heavily on the fragmentation of the productive structure into sectors. Considering that each product corresponds to a set of technologies, institutional and infrastructure requirements, detecting the community structure allows to uncover clusters of similar products sharing analogous characteristics that are not directly observable. On the one hand, the product space involves knowledge and capability flows. The links through which information circulates, and the speed at which it reaches one node will be affected by the size and composition of the communities. Indeed, information tends to circulate inside a cluster for a certain time before jumping to another one. These patterns are important to take into account when analyzing products and technological links. They affect the development of the productive structure and thereby the technological opportunities. On the other hand, the fabrication and export of products relies on a battery of institutional and infrastructure settings. A poor environment can hinder the extension of the export basket even when the knowledge and capabilities are present. At the same time, the quality and evolution of this setting is tightly linked to the patterns of specialization of an economy described by the network of products (the product space). The community detection algorithm I use to explore the product classification relies on the structure of these interactions [4].

I obtain in 29 communities, six of which are considered noise because the products they contain do not have apparent links and five of them are dismissed because they contain very few products. In order to limit the number of variables in the regressions, I exclude from this analysis the communities corresponding to agricultural products that is the ones classified as: "Tempered Agr. (35)", "Meat, Dairy and Cereals (29)", "Tropical Products (15)" and "Mediterranean Products (10)". [5]

[4] The use of a hierarchical algorithm for the subsequent part of the analysis could have been an option. However, in this case we are likely to find the same commodities, low-tech and high-tech classification present in the literature. Furthermore, using a highly aggregated partition, I could miss key part of the product space for which the positive effect is diluted into the aggregated whole.

[5] The detection of the industrial structure is the subject of an independent paper that can be available upon request.

Table 1: Share of countries that do not export any product from a given community (in %)

	1960	1965	1970	1975	1980	1985	1990	1995	2000
Textile (142)	0.91	1.82	2.70	3.60	3.60	0.88	0.00	0.75	0.75
Machinery (132)	65.45	60.00	51.35	45.95	44.14	37.72	26.12	32.09	22.39
Electronics (102)	32.73	27.27	23.42	19.82	24.32	26.32	23.88	19.40	20.90
Natural resources (53)	25.45	22.73	21.62	17.12	22.52	19.30	17.91	14.93	16.42
Chemicals (29)	67.27	62.73	54.05	54.95	47.75	44.74	42.54	45.52	50.00
High-tech Machinery (18)	80.91	75.45	72.07	72.07	58.56	55.26	56.72	50.00	51.49
Chemicals - plastics (18)	71.82	62.73	51.35	61.26	63.06	64.91	58.96	58.96	58.96
Metallurgy - Iron (20)	63.64	57.27	54.95	48.65	47.75	40.35	32.84	34.33	32.84
Petroleum	44.55	36.36	26.13	21.62	16.22	23.68	17.16	12.69	15.67
Wood (12)	53.64	49.09	45.95	39.64	42.34	51.75	42.54	42.54	40.30

Table 2: Evolution of the average complexity of products by industry

	1960	1965	1970	1975	1980	1985	1990	1995	2000
Textile (142)	0.38	0.61	0.04	0.19	0.02	0.03	0.07	0.07	0.10
Machinery (132)	3.45	4.26	2.64	1.82	3.02	2.61	2.55	1.92	1.49
Electronics (102)	0.79	0.80	1.02	1.08	0.95	1.04	1.21	2.46	1.84
Natural resources (53)	1.17	0.65	0.76	0.52	0.37	0.54	0.32	0.29	0.49
Chemicals (29)	0.78	0.83	0.26	5.49	1.26	0.82	1.14	1.25	1.61
High-tech Machinery (18)	8.41	1.35	6.98	3.54	3.40	2.71	1.44	1.18	1.98
Chemicals - plastics (18)	2.32	0.77	0.05	3.31	2.47	4.94	3.49	2.70	2.84
Metallurgy - Iron (20)	0.82	0.60	0.02	0.00	0.16	0.19	0.13	0.41	0.28
Petroleum	0.09	0.05	4.09	2.53	0.19	0.04	0.11	0.15	0.08
Wood (12)	0.00	0.04	0.00	0.00	0.02	0.16	0.12	1.54	0.12

3.1 Method

Based on this industrial classification, I construct several variables aimed at capturing different aspects of industrial specialization and diversity.

I first construct a binary variable that measures the presence of a country in a given industry q. A country c is present in an industry q if it has a comparative advantage in exporting at least one product from this industry. It is formally defined as:

$$\boldsymbol{d}_c^q = \begin{cases} 1, & \text{if } \boldsymbol{D}_c^q \geq 1. \\ 0, & \text{otherwise.} \end{cases} \tag{11}$$

with

$$\boldsymbol{D}_c^q = \sum_{p \in q} \boldsymbol{M}_{cp}^q \tag{12}$$

However, as depicted in Table 1, because the condition of only having a presence in an industry is englobed for most industries in many countries of the sample, as shown in Table 1, this condition is likely not to be specific enough to understand the drivers of growth.

Therefore, I further introduce a measure of variety in sector q, which counts the number of products a country has a comparative advantage in.

Finally, as discussed above, variety is an incomplete measure because it does not account for the heterogeneous complexity among products. To remedy this, I weight variety by the value of the product market in sector q. This measure has also a drawback discussed above, that is the sum does not account for the different patterns of production. For instance, it does not distinguish between producing many low tech products and few high tech products.

I first include this simple variable in order to check whether being present in a community has an effect on growth, independently of the value of exports, the number of products or the complexity of the country in a community. An alternative measure of integration is the value of exports written as: with

$$\boldsymbol{S}_c^q = \sum_{p \in q} \boldsymbol{A}_{cp}^q \tag{13}$$

with $\boldsymbol{A}$ being the incidence matrix of the original country export matrix. The entries of this variable are in current dollars. However, $\boldsymbol{S}_c^q$ does not account for the variety of products exported by a country, which reflects the variety of its capabilities. To fill this gap, I measure the diversity of a country in a community as defined in equation 12. Yet, this measure omits the overall value of the exports that potentially reflects the level of technology involved in the production of a good. The two last variables measure different aspects of integration and are complementary. Finally, I develop a measure of complexity of a country in a community. I break down the measure developed in Tacchella et al. (2013) in order to take into account the extent of capabilities a country master in a given sector.

Within measure: sectorial specialization

First, I decompose the export bipartite network into several bipartite networks, $\boldsymbol{M}_{cp}^q$, representing the product-country relationships inside each community, q. I compute the measure of country fitness, $\boldsymbol{F}_c^q$, and product complexity, $\boldsymbol{Q}_p^q$, using this matrix.

The first part of the calculation is the two asymmetric iteration processes between the country fitness and the product complexity.

$$\tilde{\boldsymbol{l}}_{c,N}^q = \boldsymbol{M}_{cp}^q \boldsymbol{l}_{p,N-1}^q \tag{14}$$

with

$$\boldsymbol{l}_{c,N}^q = \frac{\tilde{\boldsymbol{l}}_{c,N}^q}{\langle \tilde{\boldsymbol{l}}_{c,N}^q \rangle} \tag{15}$$

$$\tilde{\boldsymbol{l}}_{p,N}^q = \frac{1}{(\boldsymbol{M}_{cp}^q)^t (\boldsymbol{l}_{c,N-1}^q)^{-1}} \tag{16}$$

with

$$\boldsymbol{l}_{p,N}^q = \frac{\tilde{\boldsymbol{l}}_{p,N}^q}{\langle \tilde{\boldsymbol{l}}_{p,N}^q \rangle} \tag{17}$$

The results for the country fitness and product complexity are the fixed point of each iteration process.

The economic fitness of country c in community q, $\boldsymbol{F}_c^q$, is given by:

$$\boldsymbol{F}_c^q = \boldsymbol{l}_{c,N}^q \tag{18}$$

with

$$\boldsymbol{l}_{c,N}^q = \boldsymbol{l}_{c,N+1}^q \tag{19}$$

The complexity of a product p from community q, $\boldsymbol{Q}_p^q$, is given by:

$$\boldsymbol{Q}_p^q = \boldsymbol{l}_{p,N}^q \tag{20}$$

with

$$\boldsymbol{l}_{p,N}^q = \boldsymbol{l}_{p,N+1}^q \tag{21}$$

Because this measure is at the sectoral level, it is possible that a country is not included in a network. The set of bipartite networks constructed from the community structure of the product space implies that some countries isolated in the network as they are not linked to any product. First, I set the value of the complexity variable to 0 for those countries. However, as depicted in Table 1, not all countries export at least one product in all communities. In other words, there some cases in which a country exports none of the products of a given community. The fact that a country does not export any product of a community does not mean that its position outside the community does not matter. Countries are at different degrees of distance from a community in the same way they are at different degrees of integration inside a community. Then, I extend this measure by introducing a measure of distance quantifying the extent to which it can reach the community given its capability set. I construct a measure of distance to the community for countries that are isolated inside the community. The distance is measured by the shortest path from one product inside the community to the closest product outside the community and inside a country's export basket (minimum or average shortest path).

Finally, while the measures described above are based on the parts of the product space, the one presented below is based on the network of communities. I apply the fitness measure of Tacchella et al. (2013) to the network of industries.

Between measure: sectorial complexity

The complexity measure is then extended at a higher level of aggregation than the product, that is the community level. The complexity of a country depends on the number of communities it is associated, weighted by their complexity. Community complexity depends negatively on the number of countries exporting from a community, weighted by their complexity. If many countries are able to export products from a given community, the sector is relatively easy to enter and therefore involves a small amount of capabilities. [Why is this measure important?] To this end, I construct a new bipartite network based of the export of product p inside community q by country c. The link between a country and a community is defined as follows (for sake of simplicity the network is made unweighted):

$$N_{c,q} = \begin{cases} 1, & \text{if } \sum_{p \in q} M_{c,p} > 0. \\ 0, & \text{otherwise.} \end{cases} \tag{22}$$

$$\tilde{\boldsymbol{r}}_{c,N} = \boldsymbol{N}_{cq}\boldsymbol{r}_{q,N-1} \tag{23}$$

with

$$\boldsymbol{r}_{c,N} = \frac{\tilde{\boldsymbol{r}}_{c,N}}{\langle \tilde{\boldsymbol{r}}_{c,N} \rangle} \tag{24}$$

$$\tilde{\boldsymbol{r}}_{q,N} = \frac{1}{(\boldsymbol{M}_{cq})^t (\boldsymbol{r}_{c,N-1})^{-1}} \tag{25}$$

with

$$\boldsymbol{r}_{q,N} = \frac{\tilde{\boldsymbol{r}}_{q,N}}{\langle \tilde{\boldsymbol{r}}_{q,N} \rangle} \tag{26}$$

The results for the country fitness and product complexity are the fixed point of each iteration process.

The economic fitness of country c in community q, $\boldsymbol{\Psi}_c$, is given by:

$$\boldsymbol{\Psi}_c = \boldsymbol{r}_{c,N} \tag{27}$$

with

$$\boldsymbol{r}_{c,N} = \boldsymbol{r}_{c,N+1} \tag{28}$$

The complexity of a product p from community q, $\boldsymbol{\Omega}_p$, is given by:

$$\boldsymbol{\Omega}_p = \boldsymbol{r}_{p,N} \tag{29}$$

with

$$\boldsymbol{r}_{p,N} = \boldsymbol{r}_{p,N+1} \tag{30}$$

This exercise enables to explore the extent to which being complex in a given community matter for growth and to detect the key technological clusters.

3.2 Results

4 The effect of sectoral integration on growth

4.1 Data and econometric specification

In this section, I explore the relative importance of different sectors for growth. The dependent variable is the annualized GDP per capita growth and the variables of interest are drawn from the previous section. I use different measures of integration in a sector. First, I include a simple dummy indicating whether a country exports at least one product in a given community, q. However, because the condition of only participating to the production in a sector is englobed for most sectors in many countries of the sample, as shown in Table 1, this condition is likely not to be specific enough to understand the drivers of growth. Therefore, I further introduce a measure of variety in sector q, which counts the number of products a country has a comparative advantage in. Finally, as discussed above, variety is an incomplete measure because it does not account for the heterogeneous complexity among products. To remedy this, I weight variety by the value of the product market in sector q. This measure has also a drawback discussed above, that is the sum does not account for the different patterns of production. For instance, it does not distinguish between producing many low tech products and few high tech products. Finally, I focus on the measure of integration constructed in section 3. To control for other variables affecting growth, I use the level of GDP per capita (in log), the average years of education, the investment in capital, the openness to trade, the population (in log), and the climate (tempered or not). The dataset is further detailed in Table **??**. All the variables are in 5-year average.

The econometric analysis is implemented with panel fixed effects, random effect and the Hausman-Taylor model that combines random and fixed effects. The Hausman test recommends using a fixed effects estimation for all specifications. However, as highlighted in Szirmai and Verspagen (2015) and depicted in Table **??**, the share attributed to the between versus the within variation in the overall variation is widely heterogeneous among the variables. The growth rate varies mostly overtime within countries. It is also the case of investment and openness. However, for most explicative variables, the between variation dominates. Therefore, when estimating the coefficients of the fixed effects model, a large part of the variance is not accounted for. And the differences between countries are likely to influence growth. In order to circumvent this, I also estimate the coefficients using the random effects that accounts for both the within and between variance of variables. In addition, the effect of time constant variables can also be estimated. The assumption associated to the estimation of the random effect model is restrictive and is unlikely to be satisfied for all variables used in the regressions. The residuals are assumed to be uncorrelated with the individual effects. If they are not the random effect estimator is inconsistent. That is, the estimator does not tend to the true value of the coefficient as the sample size increases. Hausman and Taylor (1981) develop a model in order to combine random and fixed effects. In this model, the random effect estimator is made consistent by relying on instrumental variables and two-stage least square regressions. The time-varying and invariant variables uncorrelated with the residuals are used as instruments. The Hausman and Taylor (1981) model require to specify the variables that should be taken as endogenous in the estimation. Baltagi et al. (2003) suggest to use the Hausman test in which the null hypothesis assumes no endogeneity. The test is conducted by regressing each variable in the model on the dependent variable. If the null hypothesis is rejected (p-value ≤ 0.05), the explicative variable is considered endogenous. Furthermore, a problem of multicollinearity arises. The industries of chemical products, metallurgy, plastics, raw material manufactures and machinery suffer from multicollinearity as depicted by their variance inflation factor (VIF). Thus, their coefficients are likely not to be accurate. In the correlation matrix of the variables of interest, these variables are highly correlated among themselves and to a smaller extent with the rest. I therefore exclude all these variables except for machinery that includes most products of the machinery sector. After removing them, the estimation of the coefficients no longer suffers from strong multicollinearity.

4.2 Results

4.2.1 The base model: linear effects

I present below the results of the regressions [6]. The regressions give the coefficients of the determinants of growth for four different sets of variables. The estimation is realized using the fixed effects (FE), the random effects (RE) and the Hausman-Taylor (HT) models. The estimations results show that the education, population and openness variables do not have a significant effect on growth. The insignificant effect of education might be due to the nature of the variable that varies very little overtime. Regarding population and openness, the size effect might be capture by GDP per capita. The sign of investment is unexpected as it is negative. Finally, the fact of having a tempered climate plays positively on growth. The coefficients of these variables are stable in all models.
None of the coefficients measuring the effect of the presence of an industry in a country are significant (Table **??**). I attribute this to the lack of information captured by the variable as explained in the previous section. Furthermore, in many cases, a large number of countries are present in an industry. More surprisingly, the variables corresponding to the total value of exports in an industry do not show any significant coefficient either (Table **??**). One explanation can be linked to the fact that the total value may not be representative of the capabilities of a country in a given industry. As depicted in Table 3, the variety of products exported from a given industry does seem to be a more accurate measure. Two industries have a positive and significant effect on growth, namely high-tech machinery and iron metallurgy. Finally, the complexity measure shows the most interesting results as detailed in Table 4. For a country to be complex in the textile industry has a negative effect on growth while the effect of being complex in the electronics industry seems to have a positive effect on growth. This shows that the manufacturing sector is composed of heterogenous industries that have different effect on growth. These differences can be attributed to the fact that, for instance, the textile industry as compared with the electronics one is limited in terms of technological progress, small increasing returns due to limited knowledge content involved in the production process, capital accumulation and higher demand elasticity of income. The textile industry is based on cheap labor that when the country develop creates bottlenecks.

Table 3: The determinants of growth - Diversity of products in sector q

	FE	RE	HT

[6] The results of the Hausman test for choosing the endogenous variables are reported in Table 9.

GDPpc (log)$^{\pm}$	0.982***	0.201***	0.954***
	(0.063)	(0.027)	(0.059)
Education$^{\pm}$	0.038	-0.047***	0.022
	(0.023)	(0.009)	(0.022)
Openness$^{\pm}$	0.014	0.202	0.011
	(0.138)	(0.119)	(0.134)
Investment	-1.053***	-0.054	-1.135***
	(0.280)	(0.223)	(0.270)
Pop (log)$^{\pm}$	-0.059	-0.028	-0.092
	(0.116)	(0.015)	(0.096)
Climate	0.000	0.097*	1.348***
	(.)	(0.049)	(0.224)
Textile (142)$^{\pm}$	-0.002	-0.001	-0.001
	(0.002)	(0.001)	(0.002)
Machinery (132)$^{\pm}$	-0.001	-0.002	-0.002
	(0.002)	(0.001)	(0.002)
Electronics (102)$^{\pm}$	0.004	0.011***	0.005
	(0.003)	(0.002)	(0.003)
Natural resources (53)$^{\pm}$	-0.007	-0.004	-0.009
	(0.006)	(0.003)	(0.006)
Chemicals (29)$^{\pm}$	-0.005	-0.004	-0.006
	(0.007)	(0.006)	(0.007)
High-tech Machinery (18)$^{\pm}$	0.026	0.009	0.026*
	(0.013)	(0.009)	(0.013)
Chemicals - plastics (18)$^{\pm}$	0.024	0.009	0.024
	(0.013)	(0.009)	(0.013)
Metallurgy - Iron (20)$^{\pm}$	0.016*	0.011*	0.016*
	(0.007)	(0.005)	(0.007)
Petroleum$^{\pm}$	-0.006	-0.007	-0.006
	(0.008)	(0.006)	(0.008)
Wood (12)$^{\pm}$	-0.009	-0.008	-0.010
	(0.011)	(0.007)	(0.011)
Period 1965	-0.070	0.065	-0.057
	(0.056)	(0.063)	(0.054)
Period 1970	-0.099	0.196**	-0.066
	(0.069)	(0.062)	(0.063)
Period 1975	-0.032	0.361***	0.017
	(0.084)	(0.063)	(0.076)
Period 1980	0.017	0.509***	0.079
	(0.102)	(0.064)	(0.091)
Period 1985	0.029	0.587***	0.102
	(0.116)	(0.065)	(0.103)
Period 1990	-0.026	0.596***	0.057
	(0.128)	(0.066)	(0.114)
Period 1995	0.009	0.711***	0.104
	(0.143)	(0.067)	(0.127)
Period 2000	0.006	0.833***	0.114
	(0.158)	(0.068)	(0.139)
Constant	-7.747***	-1.726***	-8.299***

	(0.633)	(0.208)	(0.619)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-Squared	0.101	0.395	
Between R-Squared	0.031	0.212	
Within R-Squared	0.596	0.433	
rho	0.916	0.017	0.896

$*p < 0.05, **p < 0.01, ***p < 0.001$

Table 4: The determinants of growth - Complexity in sector q

	FE	RE	HT
GDPpc (log)$^{\pm}$	0.992***	0.236***	0.936***
	(0.061)	(0.027)	(0.054)
Education$^{\pm}$	0.044	-0.044***	0.016
	(0.023)	(0.010)	(0.022)
Openness$^{\pm}$	-0.006	0.098	-0.020
	(0.137)	(0.120)	(0.133)
Investment	-1.038***	-0.147	-1.122***
	(0.279)	(0.229)	(0.267)
Pop (log)$^{\pm}$	-0.063	0.011	-0.105
	(0.107)	(0.016)	(0.072)
Climate	0.000	0.030	1.260***
	(.)	(0.050)	(0.226)
Textile (142)$^{\pm}$	-0.143**	-0.109**	-0.131**
	(0.050)	(0.035)	(0.048)
Machinery (132)	-0.023	-0.044***	-0.033
	(0.024)	(0.013)	(0.022)
Electronics (102)	0.040	0.095***	0.063**
	(0.026)	(0.015)	(0.024)
Natural resources (53)	-0.003	-0.022	-0.026
	(0.034)	(0.017)	(0.031)
Chemicals (29)	0.005	-0.002	0.001
	(0.017)	(0.013)	(0.016)
High-tech Machinery (18)	0.011	-0.001	0.009
	(0.014)	(0.009)	(0.013)
Chemicals - plastics (18)	0.024	0.009	0.020
	(0.015)	(0.010)	(0.014)
Metallurgy - Iron (20)$^{\pm}$	0.022	0.014	0.020
	(0.019)	(0.013)	(0.018)
Petroleum$^{\pm}$	-0.009	-0.034	-0.006
	(0.025)	(0.018)	(0.024)
Wood (12)$^{\pm}$	0.008	-0.009	0.001
	(0.021)	(0.013)	(0.020)
Period 1965	-0.065	0.060	-0.043
	(0.056)	(0.063)	(0.053)
Period 1970	-0.096	0.200**	-0.042
	(0.064)	(0.061)	(0.058)
Period 1975	-0.034	0.366***	0.047
	(0.077)	(0.063)	(0.066)
Period 1980	0.019	0.503***	0.122
	(0.090)	(0.064)	(0.076)
Period 1985	0.028	0.573***	0.147
	(0.103)	(0.065)	(0.085)
Period 1990	-0.036	0.565***	0.096
	(0.115)	(0.067)	(0.093)

Period 1995	-0.014	0.660***	0.139
	(0.129)	(0.068)	(0.104)
Period 2000	-0.015	0.777***	0.160
	(0.143)	(0.071)	(0.114)
Constant	-7.792***	-1.905***	-7.998***
	(0.594)	(0.208)	(0.531)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-Squared	0.093	0.388	
Between R-Squared	0.025	0.194	
Within R-Squared	0.593	0.434	
rho	0.921	0.029	0.904

$*p < 0.05, **p < 0.01, ***p < 0.001$

4.2.2 Does the level of development matter?

Countries' experience in terms of growth dynamics depends largely on their level of income and the initial structure of their production. For instance, the textile and electronics industries have been important drivers of growth through industrialization. However, the scope of potential innovation and productivity varies across industries. Therefore, the transition from an industrialized economy to a mature one that is able to sustain its growth also partially depends on the specialization of the economy and the potential for structural transformation. The econometrics regressions presented below and measuring the effect of each industry on growth conditional on the income level of countries show interesting results. The two sets of variables that were not significant in the base model show non-linear effects as represented in Figure 1 and 2. The positive effect of presence of a country in the textile industry tend to decrease as GDP per capita increases until it becomes negative as the income reaches around $4000. The effect is the opposite when looking at the electronics and machinery industries. The presence in both sector starts having a positive effect on growth as GDP per capita attains $2000. The positive effect continues to increase although at a decreasing rate as income rises. The concavity of the effect is likely due to catching up. That is at low levels of GDP per capita, a country will start imitating countries that are close to the technological frontier which enables them to develop fast with limited costs. This effect is reduced as the country approached the technological frontier. This effect persists when looking at different variables of specialization in the electronics industry, that is the value of exports, diversity and complexity. However, there is a difference between a country being present and being diverse in the textile industry. While the former has a globally negative effect on growth for most levels of income, the latter has a positive effect that increases as GDP per capita rises. However, the increase of the positive effect of being diverse in the textile industry is not as important as the one of being diverse in the electronics industry.

Table 5: The determinants of growth per development stage - Belonging to sector q

	FE	RE	HT
GDPpc (log)$^{\pm}$	1.269***	0.801***	1.226***
	(0.124)	(0.121)	(0.119)
Education$^{\pm}$	0.050*	-0.049***	0.008
	(0.024)	(0.010)	(0.022)
Openness$^{\pm}$	0.069	0.226	0.097
	(0.140)	(0.126)	(0.135)
Investment	-0.937**	0.562**	-0.818**
	(0.287)	(0.218)	(0.272)
Pop (log)$^{\pm}$	0.019	0.025*	-0.003
	(0.109)	(0.012)	(0.070)
Climate	0.000	0.067	1.127***
	(.)	(0.048)	(0.215)
Textile (142)$^{\pm}$	3.698**	6.082***	4.576***
	(1.190)	(1.102)	(1.139)
Machinery (132)	-0.470	-1.527***	-0.687*
	(0.360)	(0.367)	(0.347)
Electronics (102)	-0.758*	-0.793*	-0.789*
	(0.361)	(0.342)	(0.348)
Natural resources (53)	0.173	0.317	0.177
	(0.400)	(0.387)	(0.386)
Chemicals (29)	0.153	0.110	0.176
	(0.305)	(0.309)	(0.294)
High-tech Machinery (18)	-0.007	-0.402	-0.063
	(0.257)	(0.262)	(0.247)
Chemicals - plastics (18)	-0.360	-0.436	-0.492
	(0.335)	(0.318)	(0.319)
Metallurgy - Iron (20)	-0.357	0.562	-0.249
	(0.364)	(0.317)	(0.348)
Petroleum	0.168	0.033	0.125
	(0.337)	(0.331)	(0.325)
Wood (12)	-0.035	0.738**	0.176
	(0.311)	(0.261)	(0.297)
Textile (142) - GDPpc (log)$^{\pm}$	-0.427**	-0.725***	-0.529***
	(0.135)	(0.124)	(0.129)
Machinery (132) - GDPpc (log)	0.063	0.195***	0.090*
	(0.047)	(0.047)	(0.045)
Electronics (102) - GDPpc (log)	0.100*	0.102*	0.103*
	(0.047)	(0.045)	(0.045)
Natural resources (53) - GDPpc (log)	-0.025	-0.047	-0.027
	(0.053)	(0.051)	(0.051)
Chemicals (29) - GDPpc (log)	-0.023	-0.012	-0.025
	(0.038)	(0.038)	(0.037)
High-tech Machinery (18) - GDPpc (log)	0.001	0.047	0.007

	(0.032)	(0.032)	(0.031)
Chemicals - plastics (18) - GDPpc (log)	0.048	0.060	0.065
	(0.042)	(0.039)	(0.040)
Metallurgy - Iron (20) - GDPpc (log)	0.052	-0.069	0.038
	(0.045)	(0.040)	(0.043)
Petroleum - GDPpc (log)	-0.021	-0.012	-0.017
	(0.045)	(0.044)	(0.043)
Wood (12) - GDPpc (log)	0.001	-0.102**	-0.027
	(0.039)	(0.032)	(0.037)
Period 1965	-0.073	0.081	-0.034
	(0.056)	(0.063)	(0.053)
Period 1970	-0.126	0.210***	-0.039
	(0.065)	(0.062)	(0.058)
Period 1975	-0.076	0.376***	0.051
	(0.077)	(0.062)	(0.065)
Period 1980	-0.036	0.534***	0.126
	(0.090)	(0.063)	(0.074)
Period 1985	-0.048	0.610***	0.141
	(0.102)	(0.064)	(0.082)
Period 1990	-0.120	0.621***	0.094
	(0.114)	(0.065)	(0.091)
Period 1995	-0.098	0.734***	0.148
	(0.128)	(0.066)	(0.101)
Period 2000	-0.113	0.859***	0.172
	(0.142)	(0.067)	(0.111)
Constant	-10.637***	-6.962***	-10.962***
	(1.146)	(1.085)	(1.093)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-squared	0.096	0.403	
Between R-squared	0.024	0.141	
Within R-squared	0.599	0.451	
rho	0.917	0.026	0.898

$*p < 0.05, **p < 0.01, ***p < 0.001$

Figure 1: The effect of the presence in different sectors conditional on the income level

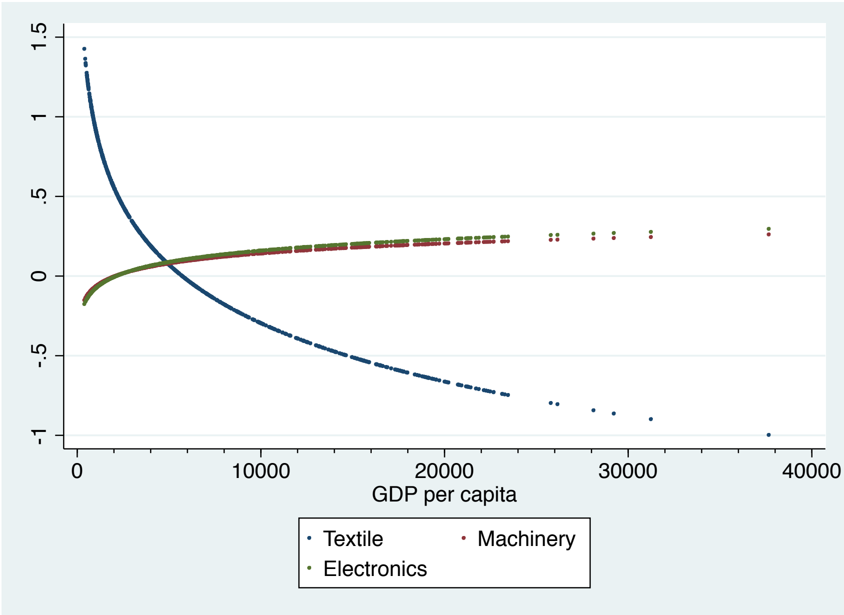


Table 6: The determinants of growth per development stage - Value of exports in sector q

	FE	RE	HT
GDPpc (log)$^{\pm}$	1.016***	0.247**	0.991***
	(0.093)	(0.078)	(0.091)
Education$^{\pm}$	0.038	-0.053***	0.025
	(0.024)	(0.010)	(0.022)
Openness$^{\pm}$	0.019	0.267*	0.023
	(0.140)	(0.123)	(0.136)
Investment	-1.014***	0.417	-1.053***
	(0.284)	(0.217)	(0.274)
Pop (log)$^{\pm}$	0.067	0.010	0.005
	(0.122)	(0.017)	(0.099)
Climate	0.000	0.091	1.371***
	(.)	(0.047)	(0.219)
Textile (142)$^{\pm}$	0.126	0.129*	0.128
	(0.069)	(0.059)	(0.067)

Machinery (132)$^{\pm}$	-0.065	-0.148***	-0.067
	(0.040)	(0.040)	(0.039)
Electronics (102)$^{\pm}$	-0.092*	-0.113***	-0.095*
	(0.038)	(0.034)	(0.037)
Natural resources (53)$^{\pm}$	0.036	0.054	0.035
	(0.041)	(0.035)	(0.040)
Chemicals (29)$^{\pm}$	0.033	0.041	0.037
	(0.036)	(0.035)	(0.035)
High-tech Machinery (18)$^{\pm}$	-0.004	-0.019	-0.002
	(0.029)	(0.030)	(0.028)
Chemicals - plastics (18)$^{\pm}$	-0.039	0.018	-0.039
	(0.042)	(0.040)	(0.040)
Metallurgy - Iron (20)$^{\pm}$	-0.016	0.054	-0.012
	(0.039)	(0.033)	(0.038)
Petroleum$^{\pm}$	-0.002	-0.045	-0.002
	(0.030)	(0.027)	(0.030)
Wood (12)$^{\pm}$	0.005	0.065**	0.011
	(0.035)	(0.025)	(0.034)
Textile (142) - GDPpc (log)$^{\pm}$	-0.015	-0.016*	-0.015
	(0.008)	(0.007)	(0.008)
Machinery (132) - GDPpc (log)$^{\pm}$	0.008	0.019***	0.009
	(0.005)	(0.005)	(0.005)
Electronics (102) - GDPpc (log)$^{\pm}$	0.012*	0.015***	0.012**
	(0.005)	(0.004)	(0.005)
Natural resources (53) - GDPpc (log)$^{\pm}$	-0.005	-0.007	-0.005
	(0.005)	(0.005)	(0.005)
Chemicals (29) - GDPpc (log)$^{\pm}$	-0.005	-0.005	-0.005
	(0.004)	(0.004)	(0.004)
High-tech Machinery (18) - GDPpc (log)$^{\pm}$	0.001	0.002	0.000
	(0.003)	(0.003)	(0.003)
Chemicals - plastics (18) - GDPpc (log)$^{\pm}$	0.005	-0.002	0.005
	(0.005)	(0.005)	(0.005)
Metallurgy - Iron (20) - GDPpc (log)$^{\pm}$	0.003	-0.006	0.003
	(0.005)	(0.004)	(0.005)
Petroleum$^{\pm}$	0.000	0.005	0.000
	(0.004)	(0.003)	(0.004)
Wood (12) - GDPpc (log)$^{\pm}$	-0.001	-0.009**	-0.002
	(0.004)	(0.003)	(0.004)
Period 1965	-0.085	0.066	-0.068
	(0.056)	(0.064)	(0.054)
Period 1970	-0.140*	0.199**	-0.100
	(0.066)	(0.062)	(0.061)
Period 1975	-0.100	0.364***	-0.040
	(0.081)	(0.064)	(0.074)
Period 1980	-0.065	0.523***	0.011
	(0.097)	(0.066)	(0.087)
Period 1985	-0.097	0.571***	-0.009
	(0.110)	(0.068)	(0.098)
Period 1990	-0.176	0.581***	-0.073

	(0.125)	(0.070)	(0.111)
Period 1995	-0.162	0.686***	-0.045
	(0.140)	(0.071)	(0.124)
Period 2000	-0.177	0.808***	-0.045
	(0.155)	(0.072)	(0.136)
Constant	-8.428***	-2.265***	-8.976***
	(0.789)	(0.627)	(0.793)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-squared	0.100	0.401	
Between R-squared	0.031	0.176	
Within R-squared	0.601	0.446	
rho	0.916	0.017	0.897

$*p < 0.05, **p < 0.01, ***p < 0.001$

Figure 2: The effect of the value of exports in different sectors conditional on the income level

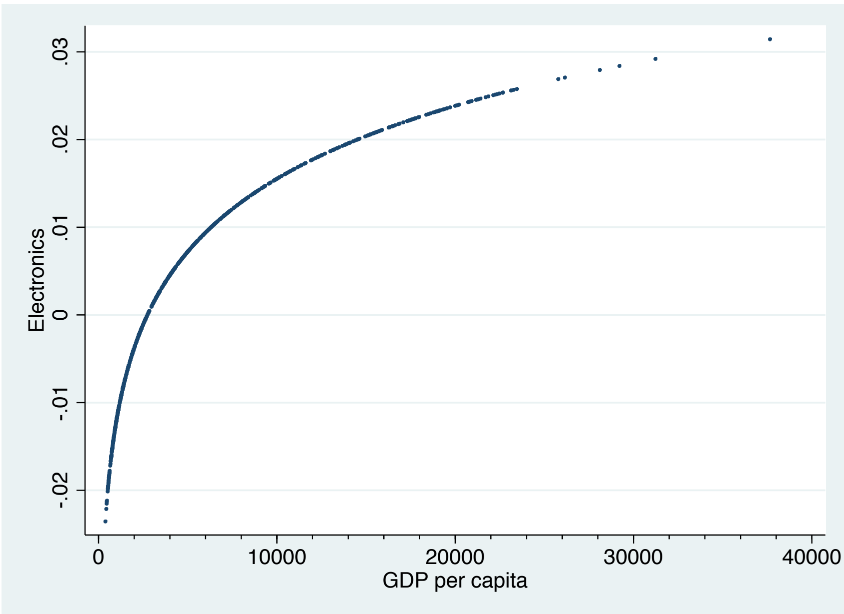


Table 7: The determinants of growth per development stage - Diversity in a sector q

	FE	RE	HT
GDPpc (log)$^{\pm}$	0.913***	0.109**	0.880***
	(0.072)	(0.036)	(0.068)
Education$^{\pm}$	0.033	-0.038***	0.018
	(0.023)	(0.009)	(0.022)
Openness$^{\pm}$	0.078	0.192	0.076
	(0.139)	(0.119)	(0.135)
Investment	-1.143***	-0.001	-1.209***
	(0.280)	(0.219)	(0.270)
Pop (log)$^{\pm}$	-0.043	-0.010	-0.071
	(0.125)	(0.016)	(0.101)
Climate	0.000	0.149**	1.297***
	(.)	(0.049)	(0.223)
Textile (142)$^{\pm}$	-0.026*	-0.009	-0.025*
	(0.012)	(0.008)	(0.012)
Machinery (132)$^{\pm}$	-0.013	-0.054*	-0.015
	(0.027)	(0.025)	(0.026)
Electronics (102)$^{\pm}$	-0.049*	-0.038**	-0.053**
	(0.020)	(0.015)	(0.020)
Natural resources (53)$^{\pm}$	0.061	0.010	0.056
	(0.045)	(0.029)	(0.043)
Chemicals (29)$^{\pm}$	-0.025	0.090	-0.016
	(0.068)	(0.065)	(0.067)
High-tech Machinery (18)$^{\pm}$	0.002	-0.040	0.002
	(0.117)	(0.116)	(0.114)
Chemicals - plastics (18)$^{\pm}$	-0.049	-0.200	-0.051
	(0.119)	(0.121)	(0.116)
Metallurgy - Iron (20)$^{\pm}$	0.060	-0.003	0.056
	(0.061)	(0.048)	(0.060)
Petroleum$^{\pm}$	0.113	-0.052	0.111
	(0.080)	(0.064)	(0.077)
Wood (12)$^{\pm}$	-0.057	-0.039	-0.049
	(0.088)	(0.061)	(0.085)
Textile (142) - GDPpc (log)$^{\pm}$	0.003*	0.001	0.003*
	(0.001)	(0.001)	(0.001)
Machinery (132) - GDPpc (log)$^{\pm}$	0.001	0.005*	0.001
	(0.003)	(0.003)	(0.003)
Electronics (102) - GDPpc (log)$^{\pm}$	0.006*	0.006***	0.006**
	(0.002)	(0.002)	(0.002)
Natural resources (53) - GDPpc (log)$^{\pm}$	-0.008	-0.002	-0.007
	(0.005)	(0.003)	(0.005)
Chemicals (29) - GDPpc (log)$^{\pm}$	0.002	-0.010	0.001
	(0.007)	(0.007)	(0.007)
High-tech Machinery (18) - GDPpc (log)$^{\pm}$	0.002	0.004	0.002

	(0.013)	(0.012)	(0.012)
Chemicals - plastics (18) - GDPpc (log)$^{\pm}$	0.008	0.021	0.008
	(0.013)	(0.013)	(0.012)
Metallurgy - Iron (20) - GDPpc (log)$^{\pm}$	-0.006	0.002	-0.005
	(0.007)	(0.005)	(0.007)
Petroleum - GDPpc (log)$^{\pm}$	-0.013	0.006	-0.013
	(0.009)	(0.007)	(0.009)
Wood (12) - GDPpc (log)$^{\pm}$	0.006	0.004	0.005
	(0.010)	(0.007)	(0.010)
Period 1965	-0.058	0.070	-0.046
	(0.056)	(0.062)	(0.054)
Period 1970	-0.081	0.198**	-0.051
	(0.070)	(0.061)	(0.063)
Period 1975	-0.009	0.349***	0.037
	(0.086)	(0.061)	(0.076)
Period 1980	0.027	0.467***	0.085
	(0.105)	(0.064)	(0.092)
Period 1985	0.030	0.524***	0.098
	(0.120)	(0.065)	(0.105)
Period 1990	-0.028	0.517***	0.050
	(0.134)	(0.067)	(0.117)
Period 1995	0.005	0.624***	0.094
	(0.151)	(0.067)	(0.130)
Period 2000	0.001	0.737***	0.102
	(0.167)	(0.069)	(0.144)
Constant	-7.195***	-1.112***	-7.698***
	(0.676)	(0.274)	(0.665)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-squared	0.109	0.430	
Between R-squared	0.031	0.207	
Within R-squared	0.610	0.469	
rho	0.913	0.015	0.895

$*p < 0.05, **p < 0.01, ***p < 0.001$

Figure 3: The effect of the diversity different sectors conditional on the income level

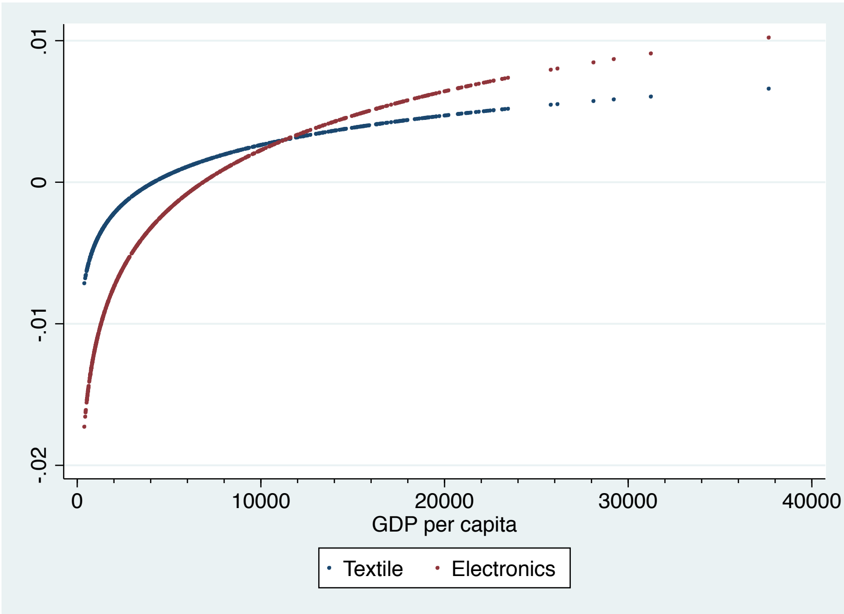


Table 8: The determinants of growth per development stage - Complexity in sector q

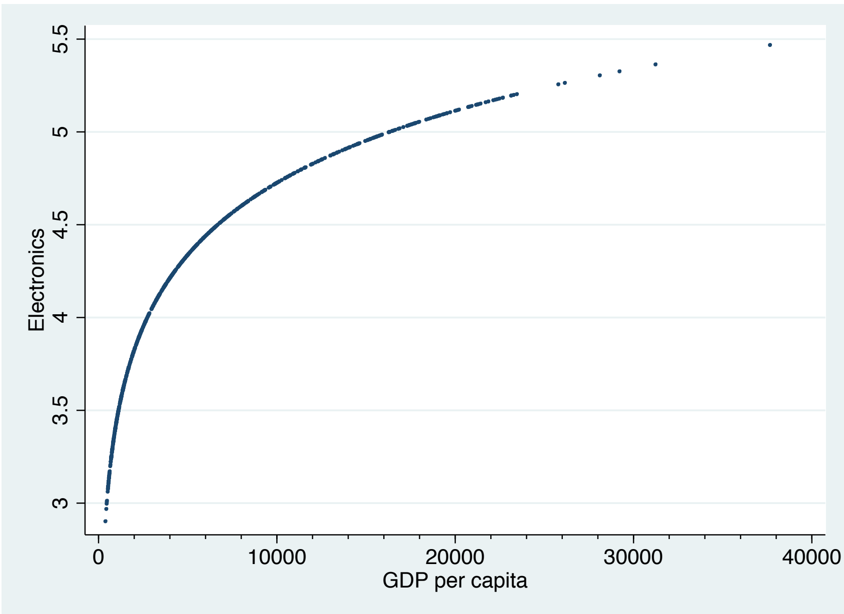
	FE	RE	HT
GDPpc (log)$^{\pm}$	0.897***	0.179***	0.839***
	(0.072)	(0.037)	(0.065)
Education$^{\pm}$	0.043	-0.035***	0.007
	(0.023)	(0.010)	(0.021)
Openness$^{\pm}$	0.010	0.089	0.003
	(0.138)	(0.118)	(0.133)
Investment	-1.120***	-0.120	-1.188***
	(0.281)	(0.224)	(0.268)
Pop (log)$^{\pm}$	-0.063	0.020	-0.036
	(0.115)	(0.017)	(0.070)
Climate	0.000	0.077	1.113***
	(.)	(0.051)	(0.222)
Textile (142)$^{\pm}$	-0.662	0.102	-0.524
	(0.367)	(0.248)	(0.352)

Machinery (132)	-0.139	-0.430*	-0.176
	(0.216)	(0.208)	(0.202)
Electronics (102)	-0.404*	-0.468***	-0.432**
	(0.177)	(0.128)	(0.167)
Natural resources (53)	0.289	0.108	0.390
	(0.242)	(0.161)	(0.228)
Chemicals (29)	-0.140	0.123	-0.095
	(0.152)	(0.142)	(0.146)
High-tech Machinery (18)	-0.068	-0.046	-0.043
	(0.123)	(0.109)	(0.117)
Chemicals - plastics (18)	0.045	-0.127	0.031
	(0.128)	(0.128)	(0.123)
Metallurgy - Iron (20)$^{\pm}$	0.250	-0.012	0.208
	(0.176)	(0.139)	(0.170)
Petroleum$^{\pm}$	0.185	-0.124	0.083
	(0.217)	(0.189)	(0.208)
Wood (12)$^{\pm}$	0.002	-0.053	0.003
	(0.165)	(0.118)	(0.158)
Textile (142) - GDPpc (log)$^{\pm}$	0.071	-0.017	0.056
	(0.045)	(0.029)	(0.043)
Machinery (132) - GDPpc (log)	0.013	0.039	0.015
	(0.024)	(0.022)	(0.022)
Electronics (102) - GDPpc (log)	0.050*	0.065***	0.056**
	(0.020)	(0.015)	(0.019)
Natural resources (53) - GDPpc (log)	-0.034	-0.015	-0.048
	(0.028)	(0.018)	(0.026)
Chemicals (29) - GDPpc (log)	0.015	-0.014	0.010
	(0.017)	(0.016)	(0.016)
High-tech Machinery (18) - GDPpc (log)	0.009	0.004	0.006
	(0.014)	(0.012)	(0.013)
Chemicals - plastics (18) - GDPpc (log)	-0.003	0.013	-0.001
	(0.014)	(0.014)	(0.013)
Metallurgy - Iron (20) - GDPpc (log)$^{\pm}$	-0.027	0.004	-0.022
	(0.021)	(0.015)	(0.020)
Petroleum - GDPpc (log)$^{\pm}$	-0.022	0.013	-0.010
	(0.025)	(0.021)	(0.024)
Wood (12) - GDPpc (log)$^{\pm}$	0.000	0.006	-0.001
	(0.020)	(0.014)	(0.019)
Period 1965	-0.058	0.056	-0.037
	(0.056)	(0.062)	(0.053)
Period 1970	-0.093	0.175**	-0.040
	(0.068)	(0.061)	(0.059)
Period 1975	-0.033	0.330***	0.046
	(0.083)	(0.062)	(0.068)
Period 1980	0.019	0.446***	0.119
	(0.098)	(0.064)	(0.078)
Period 1985	0.016	0.496***	0.127
	(0.112)	(0.065)	(0.088)
Period 1990	-0.052	0.493***	0.073

	(0.125)	(0.067)	(0.096)
Period 1995	-0.021	0.582***	0.125
	(0.140)	(0.069)	(0.107)
Period 2000	-0.025	0.693***	0.148
	(0.157)	(0.071)	(0.119)
Constant	-7.018***	-1.564***	-7.228***
	(0.670)	(0.290)	(0.593)
Nb. Obs.	796	796	796
Nb. Countries	103	103	103
Overall R-squared	0.101	0.422	
Between R-squared	0.026	0.202	
Within R-squared	0.605	0.465	
rho	0.917	0.024	0.901

$*p < 0.05, **p < 0.01, ***p < 0.001$

Figure 4: The effect of the complexity different sectors conditional on the income level



5 Conclusion

As a conclusion, the manufacturing sector contains a wide range of heterogenous industries. Specialization in different manufacturing industries sometimes display opposite effect. Overall, it seems that the electronics industry is a key growth determinant. The machinery industry does not appear to have a substantial effect on growth as it was the case during the industrial revolution. The effect of specializing in the textile industry can be beneficial for growth but is also likely to create perverse effect.

6 Testing for variables endogeneity using the Hausman test

Table 9: Hausman test: choice of the endogenous variables in the Hausman-Taylor model

	χ^2	p-value
GDPpc (log)	795.51164	5.10e-175
Education	207.09385	5.915e-47
Investment	3.0839819	.07906673
Openness	3.9893423	.04578893
Catch-up	76.801308	1.891e-18
Population (log)	91.174014	1.316e-21
Diversity	131.67809	1.760e-30
Complexity	1.6727503	.19589056
Textile (dummy)	3.889932	.04857639
Machinery (dummy)	2.6950634	.10065948
Electronics (dummy)	.91811984	.33796913
Natural resources (dummy)	.0006627	.97946235
Chemicals (dummy)	.34279398	.55822091
High-tech Machinery (dummy)	.91740493	.33815728
Chemicals - plastics (dummy)	.44386534	.5052627
Metallurgy - Iron (dummy)	2.9996471	.08328266
Petroleum (dummy)	.99951223	.31742856
Wood (dummy)	.04383321	.83416423
Other machinery (dummy)	4.9264979	.02644786
Textile (value)	115.09018	7.520e-27
Machinery (value)	61.555307	4.305e-15
Electronics (value)	81.194377	2.046e-19
Natural resources (value)	34.496724	4.270e-09
Chemicals (value)	33.23346	8.173e-09
High-tech Machinery (value)	17.239807	.00003295
Chemicals - plastics (value)	42.50015	7.068e-11
Metallurgy - Iron (value)	41.604185	1.118e-10
Petroleum (value)	28.440135	9.664e-08
Wood (value)	10.124002	.00146351
Other machinery (value)	42.98952	5.503e-11
Textile (diversity)	45.597078	1.453e-11
Machinery (diversity)	80.553733	2.829e-19

Electronics (diversity)	67.883746	1.734e-16
Natural resources (diversity)	19.364457	.0000108
Chemicals (diversity)	50.994566	9.262e-13
High-tech Machinery (diversity)	47.618684	5.177e-12
Chemicals - plastics (diversity)	35.520166	2.524e-09
Metallurgy - Iron (diversity)	17.451638	.00002947
Petroleum (diversity)	47.315719	6.043e-12
Wood (diversity)	5.5338518	.018652
Other machinery (diversity)	39.743744	2.896e-10
Textile (complexity)	8.741626	.00311027
Machinery (complexity)	2.5797858	.10823631
Electronics (complexity)	2.7034862	.10012909
Natural resources (complexity)	3.4940007	.06159157
Chemicals (complexity)	.72626286	.39409723
High-tech Machinery (complexity)	.00377551	.95100466
Chemicals - plastics (complexity)	3.0786494	.07932638
Metallurgy - Iron (complexity)	13.133016	.00029014
Petroleum (complexity)	4.8057225	.02836537
Wood (complexity)	5.2544476	.02189075
Other machinery (complexity)	1.5640919	.21106709

References

Arthur, W. B. (1990). Positive feedbacks in the economy. *Scientific American 262*(2), 92–99.

Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves.* Simon and Schuster.

Balassa, B. (1965). Trade liberalisation and revealed comparative advantage1. *The Manchester School 33*(2), 99–123.

Baltagi, B. H., G. Bresson, and A. Pirotte (2003). Fixed effects, random effects or hausman–taylor?: A pretest estimator. *Economics letters 79*(3), 361–369.

Barro, R. and J.-W. Lee (2010). Barro-lee educational attainment dataset. Technical report.

Cornwall, J. (1977). *Modern capitalism: its growth and transformation.* Martin Robertson London.

Fagerberg, J. (2000). Technological progress, structural change and productivity growth: a comparative study. *Structural change and economic dynamics 11*(4), 393–411.

Fagerberg, J. and B. Verspagen (1999). 'modern capitalism' in the 1970s and 1980s. (1999002).

Fagerberg, J. and B. Verspagen (2002). Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation. *Research Policy 31*(8), 1291–1304.

Feenstra, R. C., R. E. Lipsey, H. Deng, A. C. Ma, and H. Mo (2005). World trade flows: 1962-2000. Technical report, National Bureau of Economic Research.

Frenken, K., F. Van Oort, and T. Verburg (2007). Related variety, unrelated variety and regional economic growth. *Regional studies 41*(5), 685–697.

Gallup, J. L., J. D. Sachs, and A. D. Mellinger (1999). Geography and economic development. *International regional science review 22*(2), 179–232.

Grossman, G. M. and E. Helpman (1991). Quality ladders in the theory of growth. *The Review of Economic Studies 58*(1), 43–61.

Hausman, J. A. and W. E. Taylor (1981). Panel data and unobservable individual effects. *Econometrica: Journal of the Econometric Society*, 1377–1398.

Hausmann, R., C. A. Hidalgo, B. Sebastián, C. Michele, C. Sarah, J. Juan, S. Alexander, and M. A. Yildirim (2011). The atlas of economic complexity.

Hausmann, R. and B. Klinger (2006). Structural transformation and patterns of comparative advantage in the product space. *Center for International Development Working Paper* (128).

Hausmann, R., L. Pritchett, and D. Rodrik (2005). Growth accelerations. *Journal of Economic Growth 10*(4), 303–329.

Hidalgo, C. A. and R. Hausmann (2009). The building blocks of economic complexity. *PNAS 106*(26), 10570–10575.

Hidalgo, C. A., B. Klinger, A.-L. Barabási, and R. Hausmann (2007). The product space conditions the development of nations. *Science 317*(5837), 482–487.

Malerba, F. (2007). Innovation and the evolution of industries. In *Innovation, Industrial Dynamics and Structural Transformation*, pp. 7–27. Springer.

Pasinetti, L. L. (1981). *Structural Change and Economic Growth*. Cambridge University Press.

Prebisch, R. (1950). The economic development of latin america and its principal problems.

Romer, P. (1990). Endogenous technological change. *journal of Political Economy 98*(5), 71–102.

Rosvall, M., D. Axelsson, and C. T. Bergstrom (2010). The map equation. *The European Physical Journal Special Topics 178*(1), 13–23.

Rosvall, M. and C. T. Bergstrom (2008). Maps of information flow reveal community structure in complex networks. *PNAS 105*(4), 1118–1123.

Saviotti, P. P. and K. Frenken (2008). Export variety and the economic performance of countries. *Journal of Evolutionary Economics 18*(2), 201–218.

Singer, H. (1950). The distribution of gains between borrowing and investing nations. *American Economic Review 40*(2), 473–85.

Szirmai, A. (2012). Industrialisation as an engine of growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics 23*(4), 406–420.

Szirmai, A. and B. Verspagen (2015). Manufacturing and economic growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics 34*, 46–59.

Tacchella, A., M. Cristelli, G. Caldarelli, A. Gabrielli, and L. Pietronero (2013). Economic complexity: Conceptual grounding of a new metrics for global competitiveness. *Journal of Economic Dynamics and Control 37*(8), 1683 – 1691.

Weitzman, M. L. (1998). Recombinant growth. *Quarterly Journal of Economics*, 331–360.