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Sophisticated jobs matter for economic development: an empirical analysis based on input-output matrices and economic complexity

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Abstract

A wide range of economic development theoreticians have discussed the manufacturing sector's properties as an engine for economic growth. More recently, the sophisticated services sector began to share similar characteristics with the industrial sector as a driver for economic growth, particularly as a locus of technological innovation. This paper considers the symbiotic relationship between these two sectors, and assesses their importance in the technological development of countries. More precisely, this study uses economic complexity analysis and input-output matrices to assess the importance of employment creation in advanced sectors for development of countries. Results show that in the long-run, economic development depends on the effort and the ability of countries to generate employment in advanced sectors.

Keywords: Complexity, manufacturing, sophisticated services, employment, economic development.

JEL Code: B2, B5, B23, O1, O14

Introduction

Increased output sophistication in a given country leads to a higher labor division potential within and among companies, following Adam Smith's pin factory example. Sophisticated economies are able to efficiently create productive networks in manufacturing and advanced service sectors, with increasing returns to scale. This set of systemic characteristics implies higher individual worker productivity; a positive relationship between per-capita income and production sophistication or economic complexity (Hausmann *et al,* 2011). Labor productivity measures, calculated as value added divided by the number of workers, show empirically those characteristics of manufacturing and sophisticated services industries. These two sectors employ many workers with higher productivity levels than average. Rich countries stand out as having large shares of their population employed in manufacturing and sophisticated services industries.

For classical economic development, industrialization has always been regarded as the royal path to growth and increased productivity. The essence of structuralist thinking lies in the manufacturing sector being the key to economies' productivity gains. From the argument of the declining trend of terms of trade, through Prebisch's (1950) idea that productivity gains are incorporated into wages in industrialized countries and converted into price decreases in peripheral countries, one cannot conceive economic development within this framework without the idea of industrialization. The entire structuralist literature on deindustrialization,

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and even on the so-called Dutch Disease, stems from this perspective (Bresser-Pereira, 2016). As Kaldor (1966) argued, after Gunnar Myrdal, a country's technological and productivity dynamics are strongly dependent on the capital accumulation process, on its own aggregate output level, and on its level of industrialization.

Broadly speaking, these authors emphasized that productive sectors are different in terms of their potential to generate growth and development. Manufacturing sectors, with high increasing returns, high incidence of technological change and innovations and high synergies and linkages arising from labor division strongly induce Economic Development (Reinert, 2008). These are activities where imperfect competition rules, with all its typical features (learning curves, fast technical progress, high R&D spending, economies of scale and scope, high industrial concentration, entry barriers, product differentiation, etc.). This group of high value-added sectors are usually opposed to low value-added sectors typical of poor and middle income countries and its perfect competition market structure (Low R&D content, low technological innovation, perfect information, absence of learning curves, etc.) (Reinert, 2008).

We follow this literature to address the symbiotic relationship between the manufacturing and sophisticated services sectors, and evaluate their importance for the technological development of countries. More precisely, based on economic complexity databases and employment data from the WIOD world input-output database (Timmer *et al*, 2015a) and GGDC database (Timmer *et al,* 2015b), we use panel analysis to evaluate the importance of employment generation in advanced sectors for the technological development of countries. The paper is divided into five sections. The first section reviews the importance of manufacturing as an economy's productivity powerhouse. The second section emphasises the importance of the so-called modern or sophisticated services sector and its relation to the manufacturing sector. Section three introduces the concept of economic complexity, and analyzes the main characteristics of the manufacturing industry based on this new conceptual view. The fourth section empirically relates the employment structure worldwide with economic complexity indicators. The fifth and final section briefly concludes the study.

1. Manufacturing: the heart of productivity

The structuralist view defines economic development as a radical transformation of economies' productive structure in the sense of sophisticating production and jobs. Based on the assumption that a country's industrial productive structure affects both the pace and direction of economic development, the structuralist literature underscores the importance of industrialization in the growth process (Palma, 2005; Szirmai, 2012; Felipe *et al*, 2014; McMillan *et al,* 2014; Rodrik 2016). For structuralist economists, in the absence of a robust industrialization process a country's employment, productivity, and per-capita income cannot grow in a sustainable manner. For these authors, the development process involves a reallocation of output from low- to high-productivity sectors, where increasing returns to scale prevail. For these economic development authors, increased productivity stems precisely from climbing the technological ladder, migrating from low- to high-quality activities, toward sophistication of the economy and jobs (Bresser-Pereira, 2016). To this end, it is crucial to build a complex and diversified manufacturing system subject to increasing returns to scale, high synergies, and linkages between activities (Reinert, 2008). Specializing in agriculture and extractive industries does not enable such technological evolution.

The division of labor – the cause "of this improvement in the productive powers" – is featured in the works of A. Smith as a pillar of productive progress and, therefore, of productivity gains. The famed pin factory example shows in detail how production specialization and the division of tasks lead to productivity gains. For Adam Smith, the division of labor as seen in manufactures was of the utmost importance in explaining increased worker productivity as a result of three reasons: i) improvement and increased skill from concentrating on a single activity, or increase of dexterity, as Smith puts it, ii) time savings in connection of the site and task changes needed in the absence of division of labor; iii) mechanization of the production process, or use of machinery invented by workers, machine makers, and "philosophers". Manufacturing enables greater division of labor because of its intrinsic production characteristics, that is, manufacturing always features a lengthy linkage of production phases. To arrive at an automobile, for example, the engine, tires, chassis, windows, seats, etc. all have to be made. This form of linkage does not occur in agriculture or in commodities extraction; and happens only partially in commodities processing: economic activities differ in terms of the "unfolding" of their production process.

For Smith, economic activities are not neutral from the angle of their potential for generating division of labor; some are more conducive to it, others less. Agriculture and natural resources tend to foster less division of labor. More complex manufactures and products show a greater potential to foster production specialization and division of labor within and among firms, particularly those made on expansive networks, generating increased opportunities for productivity gains. Therefore, "Smithian" productivity gains are not sector-neutral, but depend on the production activity carried out in the economic space at hand. According to Smith, "The nature of agriculture, indeed, does not admit of so many subdivisions of labor, nor of so complete a separation of one business from another, as manufactures" (Smith, 1994, pg. 7, Book 1). Or: "The most opulent nations, indeed, generally excel all their neighbours in agriculture as well as in manufactures; but they are commonly more distinguished by their superiority in the latter than in the former" (Smith, 1994, pg. 8, Book 1).

Agriculture, on the other hand, develops no production linkages, whether within itself or with other sectors. In this sense, manufacturing must be regarded as a system, and not simply as a sector. Agriculture and simple commodities extraction do not amount to systems because there is no linkage in the production phases of their outputs, no links between the final output and the initial product, precisely those links that might be mechanized and show a potential for production specialization. Even the agribusiness sector cannot be characterized as agriculture because it is about the processing of commodities (poultry, orange juice, sugar, etc.); it enables partial productive sophistication or "complexization", so to speak. The same applies to natural resources processing: it is not enough for an activity to be subject to mechanization and division of labor. It must have links to increase the potential for mechanization and the division of labor, something that simple agriculture and mining lack. The agribusiness sector may increase product complexity if its tractors, chemicals, seed mills and harvesters are made domestically and competently, as was the case in the United States and Canada, for example. But this is not guaranteed to be the case. Agriculture may simply import the machinery and chemicals it needs and, in this case, the country will continue to be a large automated farm, employing few to manage lean production processes (driving the tractors, seed mills and harvesters). The path to economic development shows that a country must produce tractors, harvesters, seed mills or fertilizers, or something complex besides soy beans, maize or wheat only.

Possibilities for mechanization and specialization are greater in manufacturing than in other sectors precisely because of the greater potential for division of labor, both inside the manufacturing sector and between it and other sectors, something that the structuralist economics literature has clearly explored and discussed based on the works of Kaldor (1966) and Myrdal (1957) from the 1960s and ‘70s. Smith’s insights were expanded in the works of Allyn Young (1928). Kaldor (1966) starts out from the work of Allyn Young (1928) and the division of labor within and among business firms to emphasize the importance of increasing returns to scale in manufacturing. This feature of manufacturing and of the potential for division of labor became known as “roundaboutness”, as follows: if Robinson Crusoe were alone on an island, it would be more worth his while to spend time making a boat and a fishing rod than to go swimming after fish. That is, if he divides the fishing task and “mechanizes” it, he will be far more productive than if he simply goes chasing after fish. Along these lines, Allyn Young underscores the importance of roundaboutness, which Smith analyzed so keenly. Manufacturing activities are better suited to roundaboutness (division of labor, specialization and mechanization) and, therefore, are the driving force of an economy’s productivity.

2. Sophisticated services

A non-negligible part of the deindustrialization (reduction in manufacturing as share of GDP), seen recently in both developed and developing countries, appears to come from statistical illusions in the sense that these actually reflect changes in statistical classification instead of changes in actual activities. The extent of deindustrialization has been overestimated due to the outsourcing of certain services that were previously provided on-site by the same firms that made up the manufacturing sector. Some examples include: meals and cleaning, research, design, information technology, accounting, telecommunications, engineering, logistics, and legal services (Palma, 2005; Rowthorn & Coutts, 2004). Although the outsourced activities remain the same, they now count as services produced, instead of manufacturing production. As a consequence, services became more important without an actual increase of their share of the economy.

Several experts agree that the outsourcing effect has been a significant source of the deindustrialization process in high- and middle-income countries, particularly since 1980. McCarthy & Anagnostou (2004) and Vittucci (2008), among others, have discussed this potential overestimation of the decline of production in industrialized countries. Another group of theorists (see Rocha 2015) point out that this statistical effect has also affected Latin-American countries. As Guerrieri & Meliciani (2005) suggest, a country’s ability to develop its services depends on its manufacturing sector’s specific structural and technological composition. Some knowledge-intensive services are spin-offs from industrial production, as the manufacturing sector has been the main source of innovation for the remainder of the economy. In addition, the manufacturing sector generates a demand for the growth of high-productivity services, such as finance, engineering, design, accounting, consulting and telecommunications (business services). Therefore, the growth of the sophisticated services sector is closely linked with the manufacturing industry and, as a result, a weakened manufacturing base would end up leading to a decline in the quality of these services (Chang 2014). In this sense one could divide an economy’s service sector into sophisticated (manufacturing related) and non-sophisticated services.

Focusing on 2000s onwards, sophisticated services have been growing relatively fast globally and are becoming more similar to manufactures. Both benefit from technological

advancement, and their costs depend on economies of scale, agglomeration, networks, and division of labor. Many countries are taking advantage of the globalization of services. As exemplified by Anand *et al* (2012), the growing importance of business services are reflected in success stories such as India's software and business-process activities, Singapore's knowledge-processing offices in legal and business consulting, Sri Lanka's accountancy services, Abu Dhabi's HR processing services firms, as well as the growing internationalization of innovation, R&D, design and marketing. The sophistication of exports of both manufactures and services has increased over time, and became an important variable to interpret successful trajectories of economic growth.

To empirically analyze the importance of these "sophisticated" service sectors and their connection to economic complexity and technological development we use below the 10 sectors of the GGDC database (Timmer et al 2015b). We use the GGDC database criteria to label transport, storage, communications, financial intermediation, insurance, real estate and business activities as "sophisticated services" in the sense that these industries are complementary to or, sometimes, simply "outsourced" from the manufacturing sector itself. We contrast these business related services to personal services, community and social services, government services and retail trade, hotels and restaurants. The logic behind this classification follows the previous discussion on the special characteristics of the manufacturing sector and related services with possible economies of scale and scope, synergies and more room for innovation and R&D; characteristics that more traditional service sectors lack. It's not easy to empirically separate manufacturing related services from other types of services. For example: to what extent can we say that transport services or telecommunications are related to personal use, to retail activities or to manufacturing logistics? The kind of empirical analysis we do here is, thus, somewhat ad hoc due to the unavailability of data at the disaggregation level needed. As a robustness check below we also use WIOD (Timmer et al 2015a) data for the panel analysis with complexity indexes. From the WIOD database we use only financial and business services employment as an indication of "sophistication" of services, again in a relatively ad hoc way (see Rubalcaba and Kox (2007) for a detailed discussion of business services).

3. Manufacturing complexity

Hausmann *et al* (2011) use computing, networks and complexity techniques to create a method capable of measuring the productive sophistication, or "economic complexity", of countries with extraordinary simplicity. Based on an analysis of a given country's exports, they can indirectly measure the technological sophistication of its production fabric. The methodology developed to build economic complexity indices culminated in an *Atlas* (http://atlas.media.mit.edu) that gathers extensive material on countless products and countries since 1963. How does one measure an economy's "economic complexity"? Hausmann *et al* (2011) devised a method that combines simplicity and comparability across countries. The two basic concepts for measuring whether a country is economically complex, or sophisticated, are the ubiquity and diversity of the products it exports. If a certain economy is capable of producing non-ubiquitous goods, this is indication of a sophisticated production fabric. Of course, this brings up a relative scarcity issue, particularly for natural products such as diamonds and uranium. Non-ubiquitous goods can be divided into those with high technology content, which are difficult to manufacture (such as airplanes), and those that are highly scarce in nature (niobium, for example), and which are therefore naturally non-ubiquitous.

The authors use an ingenious technique to control the issue of scarce natural resources as concerns the measurement of complexity: they compare the ubiquity of a product made in a certain country with the diversity of products that the same country can export. To illustrate: Botswana and Sierra Leone export something that is rare and therefore non-ubiquitous: uncut diamonds. On the other hand, their exports are extremely limited and undiversified. These, then, are cases of non-ubiquity without complexity. At the opposite end lie, for example, products such as medical image processing equipment, which only Japan, Germany, and the United States can make; they are certainly non-ubiquitous products. But, in this case, the Japanese, American, and German exports are extremely diversified, indicating that these countries are highly capable of making many different things. That is, non-ubiquity coupled with diversity means "economic complexity". On the other hand, a country with a very diversified exports list that is made up of ubiquitous goods (fish, fabric, meat, ores, etc.) lacks economic complexity; it does what everyone else can also do (see Hausmann *et al* (2011) for the formal definition of economic complexity ECI).

The *Atlas of Economic Complexity* adds an interesting contribution to the structuralist discussion of the importance of industrialization for economic development; from the angle of the empirical analysis that the *Atlas*' algorithm performs, manufactured goods are clearly characterized as more complex goods and commodities as less complex. Out of the 34 main communities of products calculated based on a compression algorithm from the *Atlas* (Rosvall and Bergstrom, 2007) one may see that machinery, chemicals, airplanes, ships, and electronics stand out as more complex and interconnected goods (that is, knowledge hubs). On the other hand, precious stones, oil, minerals, fish and seafood, fruit, flowers, and tropical agriculture show very low complexity and connectivity. Cereals, textiles, construction equipment and processed foods lie at an intermediate position between more and less complex goods.

By calculating the probability of goods being jointly exported by several countries, the *Atlas* creates an interesting measure of the production know-how contained in the goods, and of the local capabilities needed to produce them: the "product space" (Hidalgo *et al* 2007). The greater the probability of two products being jointly exported, the greater the indication that they contain similar characteristics and, therefore, require similar production capabilities: they are "sibling" or "cousin" products. The joint exportation indicator ends up serving as a measure of the production know-how linkage between products, that is, it indicates the production links among various goods thanks to the shared requirements needed to make them. Highly connected and complex goods are therefore loaded with potential technological know-how. This makes them knowledge hubs; whereas low connectivity and less complex goods require simple production capabilities, and with low knowledge multiplication potential: manufactures again stand out here when compared to commodities. For example: countries that make advanced combustion engines probably have engineers and knowledge that enable producing a range of similar and sophisticated things. Countries that only produce bananas or other fruit have limited know-how, and will probably be unable to make more complex goods. It is important to emphasize at this point that any difficulty observing this is a result of the inability to directly measure and capture such local productive skills. International trade shows products, not the skills that countries use to produce them.

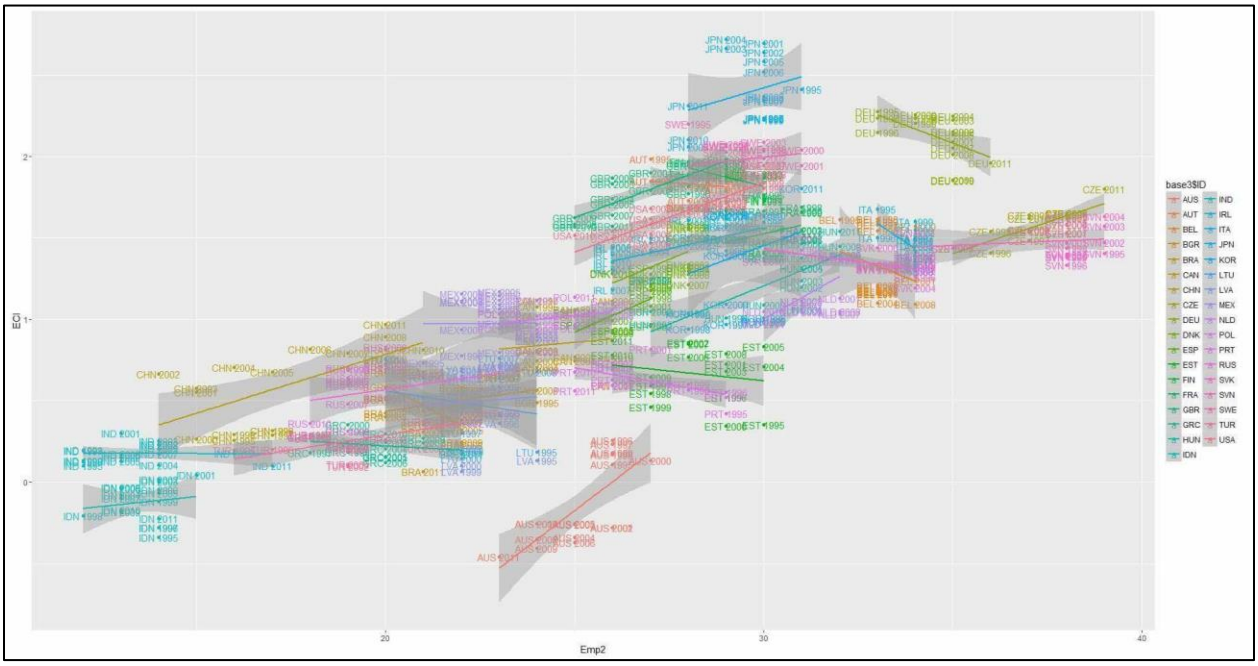
As for criticism of and potential problems with this complexity analysis methodology, its main flaw may lie in the use of export data alone as a *proxy* for the productive structure. This is indeed a weakness, as many countries produce but do not export goods for *n* reasons. The entire analysis is based on what can be "seen" from world trade data; an ample,

disaggregated, standardized base that dates back to the 1960s. The main advantage of such trade bases lies precisely in data standardization, capillarity, and longevity; its disadvantage lies in failing to capture domestic idiosyncrasies. On the other hand, national accounts databases that might include such data fail to capture the same kind of information at the granularity needed for the kind of analysis done here; these datasets usually have fewer productive disaggregation layers. By combining complexity data analyses with employment structures using input-output matrices below we try to contribute further with this literature. Another problem with the methodology is that it fails to identify *maquila* countries: those that simply import and then export complex products, Mexico's case being the best known. In this regard, Schteingart (2014) does an interesting job qualifying "genuine" complexity of countries by taking into account the number of patents filed, and R&D spending as percentage of GDP.

4. Panel data analysis

Figure 1 below shows the evolution of the productive structure of several countries in 1995-2011 (WIOD data available, see below). The Y axis shows economic complexity as measured from *Atlas of Economic Complexity* data, and the X axis shows the percentage of sophisticated jobs relative to total jobs in the economy. Each country has a regression using its own time series (1995-2011), the shaded area is a 95% confidence interval of the regression. The figure shows the data from a cross-country and time-series perspective at the same time. By sophisticated jobs we mean those in manufacturing and sophisticated services. According to the literature on the subject, we regard as sophisticated services those services to business that either migrated from or complement manufacturing, in addition to financial services as discussed above. Generally speaking, the data show that technologically dynamic emerging countries show remarkable improvement in their production structure as measured by economic complexity indexes (ECI) in the last 20 years: South Korea, China, India, Indonesia, Mexico (Hausmann et al 2011). Problematic emerging countries show no productive structure improvements; the spotlight, here, falls on Brazil that shows one of the worst dynamics of ECI among emerging countries in recent years. Rich countries stand out, with large shares of the population employed in sophisticated jobs and high economic complexity (ECI). The USA, France, UK, and Austria have low industrial employment and high sophisticated services employment in relative terms, and great product complexity. Australia shows low complexity, a low level of industrial employment, but a high number of sophisticated services jobs. Although they have previously employed many workers in the manufacturing sector, both Australia and the United States have now been able to migrate to an employment profile that privileges sophisticated services. Australia had almost 25% of its GDP coming from the manufacturing sector in the 1960s.

Figure 1 – Complexity and Sophisticated jobs, by countries (1995-2011)



The United States, which once had 20 million workers in manufacturing, has also migrated to a financial and business services profile, although the share of people employed in non-sophisticated services has been rising rapidly there. Rich countries employ many in their manufacturing and sophisticated services sectors, and show a complex productive structure. Poor countries have been unable to establish a complex productive structure, and are incapable of constituting sophisticated services industries and employing their workers in them. China and India have a very low share of their population in sophisticated service industries and enormous total population. They have been able to move ahead in terms of workers employed in manufacturing, and are moving swiftly to build a complex productive system. At the opposite end lie countries like Germany, South Korea and Japan, with huge sophisticated services industries, many workers employed in the manufacturing industry, and a highly complex productive structure.

We used panel data analysis of economic complexity and job types introduced above to evaluate the importance of the generation of jobs in advanced industries for development of countries. We take the Economic Complexity Index (ECI) as a proxy for technological development, since, as discussed before, the index indirectly measures a country's productive technological sophistication. In spite of certain shortcomings, such as the exclusive use of export data as a proxy for countries' productive structures, the index captures effectively the diversity and ubiquity level of productive systems around the world, and therefore enables a very clear appreciation of countries' technological development level. Furthermore, as seen in several studies, such as Felipe *et al* (2012) and Hausmann *et al* (2011), there is a tight relationship between countries' economic complexity levels and per-capita incomes.

To assess the degree to which employment generation in manufacturing and sophisticated services industries impact economic development, we use a database for 35 countries between 1995 and 2011 (WIOD, Timmer et al 2015a) and a 10-sector database form Groningen (GGDC, Timmer et al 2015b) for 32 countries from 1970 to 2010. The economic complexity indices are available from the *Atlas of Economic Complexity* (Hausmann *et al*, 2011) database, the Appendix shows the sector classification used. Furthermore, to control the regressions, we used national accounts data available from the UN Statistic Database

(UNStat) and the World Development Indicators, World Bank, and education data available from Barro & Lee (2013).

The econometric method used was System GMM (Blundell & Bond, 1998). This estimator was developed based on Arellano & Bond's (1991) GMM estimator, which considers two sources of persistence over time: autocorrelation, due to the inclusion of lagged variables, and individual effects, controlling for heterogeneity between individuals. In these estimators, the orthogonality between the time-lagged variables and the disturbances generates additional instruments. Baltagi (2013) advocates that the difference between the Arellano-Bond GMM estimator and the Blundell & Bond's System GMM (the one applied here) is that the latter enables causality analysis without the need for additional exogenous instrumental variables, as it uses lagged variables as instruments for level equations and level variables as instruments for lagged variables. Thereby, once the initial condition assumption is satisfied, there is no need for using exogenous regressors as instruments when the estimation method is the System GMM, because it uses lagged differences as instruments for equation in levels in addition to lagged levels as instruments for equations in first differences. The Hansen test is applied to verify whether the initial conditions are satisfied. This test analyses the orthogonality of the variables, and hence it is necessary to avoid overidentification or underidentification problems.

Two panels are estimated to analyze the impact of employment in manufacturing and sophisticated services on economic complexity. The first estimation uses the World Input-Output Database (WIOD), which has more sectors but data range only from 1995 to 2010. The second estimation uses GGDC database, which ranges from 1970 to 2010 but sectors are more aggregated. The first estimation evaluates the impact of employment in advanced sectors (jointly manufacturing and sophisticated sectors) on economic complexity. It begins with the following equation to be estimated:

$$ECI_{i,t} = \delta_1 \, ECI_{i,t-1} + \beta_1 \, EMP_{i,t} + \gamma \, Z_{i,t} + a_i + \mu_{i,t} \quad (1),$$

where ECI is the economic complexity index, EMP is the ratio of manufacturing and sophisticated services jobs to the total of workers employed, and Z is the control variables set. The long-run effect of advanced-industry employment on economic complexity is therefore given by:

$$\beta = \beta_1 \, / \, (1 - \delta_1) \qquad (2).$$

We emphasize that, because the analysis focuses on long-run impacts, instead of having t represent continuous years, the analysis was restricted to the years of 1995, 2000, 2005, and 2010. As a result, in the equation for period t, the period $t-1$ does not stand for the previous year, but the previous analytical period, that is, five years prior.

For control purposes we selected variables that are frequently used in studies attempting to evaluate the determinant of countries' income and productivity, such as schooling, government spending, population, and degree of economic openness. Government spending is frequently used to measure their weight, which may have a positive or negative effect on growth. Our analysis uses government spending as share of GDP, gov, lagged to prevent its impact on aggregate demand from affecting the results. The degree of openness is reflected in exports as share of GDP, exp. Inclusion of this variable is particularly relevant for this study to reduce the bias created by the use of exports complexity, rather than productive structure,

as a measure of economic complexity. Finally, schooling uses data on the average years of schooling for the population more than 15 years old, sch, and the population's average number of higher-education years, sch_terc, to control for the impact of population's with higher education. Table 1 shows the estimations' results:

Table 1 – Impact of sophisticated jobs on economic complexity – Panel 1 (WIOD)

	(1) ECI_t	(2) ECI_t	(3) ECI_t	(4) ECI_t
ECI_{t-1}	0.773***	0.735***	0.717***	0.633***
	(0.136)	(0.105)	(0.123)	(0.142)
EMP_t	0.0153	0.0216**	0.0228**	0.0289**
	(0.0107)	(0.00940)	(0.0116)	(0.0135)
gov_{t-1}		-0.00131	-0.00148	-0.00252
		(0.00515)	(0.00546)	(0.00600)
pop_t		$1.76\cdot10^{-7}$***	$1.92\cdot10^{-7}$***	$2.33\cdot10^{-7}$***
		(6.23e-08)	(6.32e-08)	(7.14e-08)
sch_t			0.00296	-0.00138
			(0.0231)	(0.0291)
sch_terc_t			0.00159	0.0465
			(0.0954)	(0.105)
exp_t				0.00121
				(0.00188)
$Constant$	0.773***	0.735***	0.717***	0.633***
	(0.136)	(0.105)	(0.123)	(0.142)
Long-term impact (β)	0.0674***	0.0815***	0.0806***	0.0787***
	(0.0107)	(0.00940)	(0.0116)	(0.0135)
Observations	105	105	105	105
Number of code	35	35	35	35
Hansen test	1.660	1.740	1.742	2.316
Hansen p-value	0.436	0.419	0.419	0.314

Standard errors in parentheses; ***: p<0.01, **: p<0.05, *: p<0.1.
Estimation based on data for 35 countries (WIOD) ranging from 1995 to 2010.

Analysis of the results in Table 1 allows concluding that the long-run impact of advanced sector employment generation on economic complexity is relevant. In the first estimation, with no controls, although the short-run impact (measured directly by the estimated parameter) is not significant, the long-run impact of employment in advanced sectors on the ECI is 0.0674, meaning that a 10 p.p. increase in the share of people employed in the manufacturing or sophisticated services sectors increases the complexity index by 0.674. In spite of the different estimations for short-run impact, the long-run impact of generating employment in advanced sectors is very similar in all other estimations. Regardless of the controls, the impact is always of approximately 0.08 for estimations 2, 3 and 4, indicating that a 10 p.p. increase in employment in industries like manufacturing and sophisticated services would increase the economic complexity (ECI) of countries by 0.8. For an idea of what this means, such a 0.8-point increase would cause Brazil to rise from 33rd to 24th among the countries analyzed in this study, or for China to leap from 20th to 7th, overtaking the United States, France, and Finland in terms of ECI. This therefore shows that technological development as measured by the economic complexity of countries depends directly on the effort and ability to generate jobs in advanced sectors, as argued before.

With the aim of complementing this analysis and as a robustness check, a second panel is also estimated. The source of employment data in this second estimation is the GGDC database. Although both databases have a similar number of countries, the difference is that data range from 1970 to 2010 in this database, whilst in WIOD they start in 1995. The

drawback of this second database, however, is that it disaggregates the economy only into 10 sectors, and hence the notion of sophisticated services applied here is more embracing (see Appendix).

The second estimation also considers the difference between the impact of sophisticated services and manufacturing jobs on economic complexity. Therefore, rather than estimation equation (1), which evaluates the impact of advanced sectors, in the second estimation, services are consider separately from manufacturing, as follow:

$$ECI_{i,t} = \delta_1\, ECI_{i,t-1} + \beta_1\, EMPS_{i,t} + \beta_2\, EMPM_{i,t} + \gamma\, Z_{i,t} + a_i + \mu_{i,t} \quad (3),$$

where ECI is the economic complexity index, $EMPS$ is the ratio of sophisticated services jobs to the total of workers employed, $EMPM$ is the ratio of manufacturing jobs to the total of workers employed, and Z is the control variables set. In this case, the long-run effect of sophisticated services employment and manufacturing employment on economic complexity are therefore given respectively by:

$$\beta_S = \beta_1 \,/\, (1 - \delta_1) \quad (4), \text{ and}$$

$$\beta_M = \beta_2 \,/\, (1 - \delta_1) \quad (5).$$

It is important to note that, similarly to the first estimation, because the analysis focuses on long-run impacts, instead of having t represent continuous years, the analysis was restricted to the years of 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010. Thereby, in the equation for period t, the period $t-1$ does not stand for the previous year, but the previous analytical period, that is, five years prior.

The control variables are the same as in estimation 1 (government spending, exports of goods and services, schooling and higher-education). Table 2 presents the results for the second group of estimation. Estimation (1) and (4) consider only the impact of manufacturing jobs on economic complexity, estimations (2) and (5) consider only the impact of sophisticated services jobs, whilst estimations (3) and (6) consider both manufacturing and sophisticated services jobs. The first three do not consider any control, whilst all controls are included on the last three estimations.

Table 2 – Impact of sophisticated jobs on economic complexity – Panel 2 (GGDC)

	(1) ECI_t	(2) ECI_t	(3) ECI_t	(4) ECI_t	(5) ECI_t	(6) ECI_t
ECI_{t-1}	0.851***	0.810***	0.191	0.620***	0.880***	0.600***
	(0.214)	(0.214)	(0.325)	(0.239)	(0.218)	(0.216)
$EMPS_t$		0.0274	0.0842**		0.0178	0.0377*
		(0.0196)	(0.0376)		(0.0192)	(0.0197)
$EMPM_t$	0.0103		0.0461*	0.0187		0.0173
	(0.025)		(0.0276)	(0.0192)		(0.0159)
gov_{t-1}				0.00537	-0.0119	0.00168
				(0.0144)	(0.0130)	(0.0119)
pop_t				$3.04 \cdot 10^{-7}$	$1.96 \cdot 10^{-7}$	$4.33 \cdot 10^{-7}$
				$(1.91 \cdot 10^{-7})$	$(1.85 \cdot 10^{-7})$	$(2.28 \cdot 10^{-7})$
sch_t				0.0714	0.0224	0.0298
				(0.0493)	(0.0437)	(0.0379)
sch_terc_t				0.306	0.0405	0.135
				(0.300)	(0.227)	(0.229)

	(1)	(2)	(3)	(4)	(5)	(6)
exp_t				-0.00123	-0.00094	-0.00224
				(0.00148)	(0.00312)	(0.00229)
$Constant$	-0.122	-0.348	-1.418**	-1.016	-0.0335	-1.004
	(0.256)	(0.266)	(0.659)	(0.725)	(0.362)	(0.65)
Long-term impact (β_S)		0.144***	0.104***		0.148***	0.0942***
		(0.0196)	(0.0376)		(0.0192)	(0.0197)
Long-term impact (β_M)	0.0691***		0.0570**	0.0492***		0.0432***
	(0.025)		(0.0276)	(0.0192)		(0.0159)
Observations	263	263	263	252	252	252
Number of code	33	33	33	32	32	32
Hansen test	10.21	9.502	13.27	11.11	8.135	10.16
Hansen p-value	0.177	0.219	0.0658	0.134	0.321	0.179

Standard errors in parentheses; ***: p<0.01, **: p<0.05, *: p<0.1.
Estimation based on data for 32 countries (GGDC) ranging from 1970 to 2010.

Many interesting results arise from the comparison of the first and second group of estimations (Tables 1 and 2). Firstly, the second panel (Table 2) corroborates the importance of advanced sectors jobs to promote economic complexity. In all estimations, the long-term impact is positive and significantly different from zero at the 5% confidence level. Moreover, except from estimation (3), which has a Hansen p-value of 0.0658, all other estimations have acceptable values, which indicates that the instruments are appropriate and hence there is no problem of misidentification of the causality.

Another result that emerges from the analysis of these estimations is that sophisticated services jobs are more important for economic complexity than manufacturing jobs. The long-term impact of manufacturing jobs on economic complexity is 0.0492 in estimation (4) and 0.432 in estimation (6), whilst the long-term impact of sophisticated services is 0.148 and 0.0942 in estimations (5) and (6), respectively. It means that an increase of 10 percentage points (p.p.) on manufacturing jobs will increase the ECI by around 0.5, whilst the ECI could rise 1.48 due to an increase of 10 p.p. on sophisticated services jobs.

Finally, another important issue that emerges from the analysis of the results is that the long-term coefficient is always greater when the impact of sophisticated services and manufacturing jobs on economic complexity are estimated separately. In equations (3) and (6), with both variables included in the regression, the value of β_S and β_M are smaller than in the other four estimations. This finding is probably due to the high correlation of manufacturing and sophisticated jobs. As discussed before, countries' ability to develop services depends on its manufacturing sector. Guerrieri & Meliciani (2005), for example, advocate that sophisticated services are spin-offs from industrial production, as the manufacturing sector has been the main source of innovation for the other activities. Thereby, when both variables are included in the regression only the direct impact of manufacturing jobs and sophisticated services are being considered. The indirect impacts that arises from the impact of manufacturing on sophisticated services (and *vice-versa*) are excluded from the coefficients.

5. Conclusion

A simple way to understand what economic development means is to think in terms of productive sophistication. Rich and developed countries are those that can produce complex goods and sophisticated services and sell them on the world market. Poor ones are those that can only produce and sell simple and rudimentary things. This is why economic development

can also be understood as a society's ability to know and control production techniques, particularly in the more relevant world markets. This paper illustrates these ideas based on an analysis of employment profiles worldwide, covering both the manufacturing and sophisticated services sectors. More precisely, we use economic complexity analysis and input-output matrices to evaluate the importance of generating employment in advanced sectors to countries' economic development. Our findings show that, in the long run, economic development depends directly on the effort and ability to generate jobs in advanced sectors. The increase in both manufacturing and sophisticated services jobs impact positively on countries' economic complexity.

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Appendix

WIOD (Timmer et al 2015a) sector classification

Agro	agriculture, hunting, forestry and fishing
Extr ind	mining and quarrying
Manuf ind	food , beverages and tobacco
Manuf ind	textiles and textile
Manuf ind	leather, leather and footwear
Manuf ind	wood and of wood and cork
Manuf ind	pulp, paper, paper , printing and publishing
Manuf ind	coke, refined petroleum and nuclear fuel
Manuf ind	chemicals and chemical
Manuf ind	rubber and plastics
Manuf ind	other non-metallic mineral
Manuf ind	basic metals and fabricated metal
Manuf ind	machinery, nec
Manuf ind	electrical and optical equipment
Manuf ind	transport equipment
Manuf ind	manufacturing nec; recycling
Utilities	electricity, gas and water supply
Constr ind	Construction

Non-soph serv	sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
Non-soph serv	wholesale trade and commission trade, except of motor vehicles and motorcycles
Non-soph serv	retail trade, except of motor vehicles and motorcycles; repair of household goods
Non-soph serv	hotels and restaurants
Non-soph serv	other inland transport
Non-soph serv	other water transport
Non-soph serv	other air transport
Non-soph serv	other supporting and auxiliary transport activities; activities of travel agencies
Non-soph serv	post and telecommunications
Soph serv	financial intermediation
Non-soph serv	real estate activities
Soph serv	renting of m&eq and other business activities
Non-soph serv	public admin and defence; compulsory social security
Non-soph serv	Education
Non-soph serv	health and social work
Non-soph serv	other community, social and personal services
Non-soph serv	private households with employed persons

GGDC (Timmer et al 2015b) sector classification

Agro	Agriculture, hunting, forestry and fishing
Extr Ind	Mining and quarrying
Manuf Ind	Manufacturing
Utilities	Electricity, gas and water supply
Constr Ind	Construction
Non-Soph Serv	Wholesale and retail trade, hotels and restaurants
Soph Serv	Transport, storage, and communication
Soph Serv	Finance, insurance, real estate and business services
Non-Soph Serv	Government services
Non-Soph Serv	Community, social and personal services