A DIFUSÃO DOS PRODUTOS E SERVIÇOS DE TIC NA ECONOMIA MUNDIAL: NO CAMINHO PARA A IoT

Victor Prochnik*;
”

Resumo: o artigo analisa a difusão conjunta de bens e serviços de eletrônica, telecomunicações e software na economia mundial, entre 2000 e 2014 como insumos em processos de produção na economia mundial. Com dados a preços constantes do World Input-Output Database, foram calculadas matrizes de comércio mundial em valor agregado (VA). Os resultados mostram que aumentou a participação conjunta do VA da eletrônica, software e telecomunicações no VA da economia mundial (de 2,7%, em 2000, para 4,9%, em 2014), isto é. houve uma forte e generalizada difusão dos bens e serviços destes três setores em todos os setores de todos os países. Também existem correlações significativas entre as taxas de crescimento da difusão dos insumos dos setores de ICT por indústria e país consumidores. O VA de eletrônica destinado ao consumo intermediário cresceu mais rápidamente que os dos outros dois setores (respectivamente 9,4%, 6,1% e 5,6% ao ano). Interpreta-se estes dados como o avanço da Internet das Coisas, com a maior participação da eletrônica na constituição dos produtos inteligentes. Estas mudanças têm implicações microeconômicas, sobre a distribuição das vantagens competitivas nas cadeias globais, e macroeconômicas, sobre o desenvolvimento econômico dos países.

Palavras-chave: tecnologias da informação e comunicação; indústria eletrônica
Código JEL: O33 D57 L16
Área Temática: 1.6   Novos temas - Indústria 4.0, Internet das coisas, outros

THE DIFFUSION OF ICT PRODUCTS AND SERVICES IN THE WORLD ECONOMY: IN THE ROAD TO IoT

Abstract: The paper studies the joint diffusion of goods and services of the electronics, telecommunications services, and computer programming sectors (2000/2014) as inputs in production processes in the world economy. Using constant price data from the World Input-Output Database, I have calculated input-output matrices of the world trade in value-added. (VA). The results show the growth in the VA participation of the three industries in the final product of all considered industries and countries, from 2.7%, in 2000, to 4.9%, in 2014. This increase in the intensity of ICT inputs in production processes and products has happened in every industry and country. There are also significant correlations among the diffusion growth rates of the ICT sectors inputs supply by client industry/ country. Another conclusion is that the participation of inputs from the electronics industry in products and production processes over the world economy has grown faster than those from the other two industries. These results are interpreted as an advance in the direction of the Internet of Things, with increased participation of electronic devices in the constitution of intelligent products. These changes have also implications in terms of the distribution of competitive advantages over the global value chains. If economic capabilities are migrating downstream, their producers (firms but also countries) will increase their relative competitive advantage.

Keywords: Information and telecomunnications technologies, electronics industry

* Instituto de Economia da UFRJ. E-mail: victor@ie.ufrj.br

INTRODUCTION

This paper uses deflated input-output data to study the international diffusion of electronics, telecommunication services and computer programming (software) products and services as inputs to production processes of 56 industries in 44 countries, comprising the world economy (total of 2,464 industries). The three supply industries produce deeply interdependent products and services as in general digital electronic devices need software to work and use telecommunication services and vice versa. They are known as ICT sectors (ICT).

This paper shows that the participation of inputs from ICT has significantly increased in every considered client industry and country. Production processes and products have thus becoming more intensive in inputs from ICT.

According to Porter; Heppelmann (2014), the diffusion of ICT products and services has proceed in three waves of automation The first, in the 1960s and 1970s decades of the twentieth century promoted the automation of specific tasks such as payrolls. Parallel to that first wave, a process of standardization of administrative and productive procedures took place. This was a prerequisite for the automation of various management-related activities. Standardization and the diffusion of Japanese industrial techniques, the Just-In-Time method, were relevant determinants of the increase in productivity, as well as of the reduction of workload and of the use of information generated to improve processes. The second wave of automation began in the last century's 1990s and is strongly related to the diffusion of the Internet, which permitted the expansion of connectivity among economic activities. Telecommunication services have been migrating to the Internet protocol or to proprietary digital protocols with broadly similar characteristics

The third wave of automation is the newest Industrial Revolution, characterized by the emergence of the Internet of things (IoT). The relevant capacities of smart products and services comprise the capturing of pieces of information from the surroundings using sensors; processing information that leads to decision making; and implementing these decisions (through actuators among other mechanisms).

Currently, there is a great and increasing number of smart products and services in the market, such as smart watches that capture data from its bearer; elevators that use their passenger flows to enhance their performance; systems that analyze the characteristics of farms, projecting farm defensives, fertilizers, etc.; preventive maintenance services that plan parts replacement based on operational data and on the time of use of wear parts, etc. In the most advanced applications, to the local operation of each product is added the joint and centralized analysis of the information of all products of the same type. An example of this is John Deere, a Corporation that collects data from agriculture implements sold in several countries..

In summary, when comparing previous Industrial Revolutions, Lee et al. (2018, 6) state that

> If the First and Second Industrial Revolutions modernized the physical space, and the Third Industrial Revolution revolutionized modernization in cyberspace, the Fourth Industrial Revolution brought about a fusion of physical space and cyberspace."

The Internet of Things (IoT) is the technological model to promote this fusion. But there are many different definitions of IoT. A simple one is:

> "Broadly speaking, the Internet of Things (IoT) is a system consisting of networks of sensors, actuators, and smart objects whose purpose is to interconnect "all" things, including everyday and industrial objects, in such a way as to make them intelligent, programmable, and more capable of interacting with humans and each other."

As it will be seen later, this definitioon seem to conform to the input-output data used in this paper. But strictly in the sense that these data show that all different industries and countries appear to be in a road to IoT, it does not measure the level of adoption of IoT.

In fact, the available data shows that (1) the purchase of current inputs from the electronics, telecommunication services and software sectors has significantly increased from 2000 to 2014, for every considered industry and country and (2) there are high correlation coefficients among the purchases from these three industries, among sectors and also countries.

But this is a large step when it is taken into consideration that the official statistics in value-added (VA) have been presenting values that are in conflict with the common vision of the rapid diffusion of ICT goods and services and, in the same way, to the main products' physical production data - UNCTAD (2019). The report debates measurement problems of the digital economy and states that:

> Value-added in the ICT sector has not kept pace with overall GDP growth. Despite the increase in access to ICTs over time (chapter I), the share of this sector's value added in world GDP has remained stable over the past decade, averaging around 4.5 per cent. UNCTAD (2019, 51).

This affirmative is in sharp contrast with the rapid observed physical growth of this sector and thus its validity requires more research work. For instance, the traffic on the Global Internet Protocol is a proxy of the international data flow on the Internet. It has increased from 100 gigabits per second in 2002 to 46.600 gigabits per second in 2017 - UNCTAD (2019). Only with reliable data on production, it is possible to gauge the new industrial revolution and show the diffusion patterns of the digital economy's goods and services.

In 2019, the availability of the input-output matrices of the World Input-Output Database (www.wiod.org), hereafter WIOD, in constant prices, has opened a new way to compute the VA growth of the world economic activity between 2000 and 2014 - Timmer et al. (2016). The most recent version of the project (2016) considers the electronics industry, the telecommunication services and the computer programming services separately, allowing the study of the diffusion of its products and services in the world economy. Hereafter, Computer programming industry is named software sector[1].

Although the price indexes used by different countries can be much perfected, WIOD data embodies the best available indexes. The employment of this set of price indexes in data that interconnects the world economy is more dependable than their utilization by specific countries or regions, because of the composition effect generated by its conjoint use. This property is even more relevant in the electronics industry which has productive chains spread through many countries. Other input-output models, as ICIO (https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm) and EORA (https://worldmrio.com/), were not used because they can't be recalculated in constant prices.

The quality of these data allowed the reaching of an unexpected conclusion. The VA of the electronics industry has grown faster than the other two industries' VAs (respectively 9.4%, 6.1% e 5.6% per year). Economic activities based on assembly technology (automobile industry, capital goods, etc.) were particularly benefitted.

This conclusion is unexpected because the current technical literature emphasizes software activities and artificial intelligence algorithms as not only a basis of competitive advantage to firms but also a potential lever to economic development in the 'digital economy'. In this literature, hardware is seen as an available commodity and the strategic focus of firms and countries should be in developing advanced artificial intelligence (AI) software.

So it was expected that the software sector would growth much faster than the electronic industry.

These observations may be the origin of a discussion debating the present literature, which has emphasized the relevance of artificial intelligence software to enhance the competitiveness of firms and economic development of countries. As the last section seeks to explain, a complementary view would also take into consideration the production and diffusion of integrated packages of hardware, software and telecommunications products and services as a lever of firm's competitiveness. At the

[1] The full name of the software sector is "Computer programming, consultancy and related activities; information service activities"

countries' level, due to the intricate patterns of integration among these three kinds of inputs, the production of electronic devices may be a strong enabler of economic development.

METHODOLOGY

The data base

This paper makes use of the World Input Output Database (WIOD), version 2016 – www.wiod.org - Timmer et al. (2015) e Timmer et al. (2016). The database is composed by 15 annual world input-output output matrices (2000/2014) and 14 annual world input-output in previous year prices (2001/2014), according to the multiregional input-output model (MRIO) - Miller; Blair (2009). The database contains information for 43 countries and estimates the data for a forty-fourth "country', Rest-of-the-World (ROW). WIOD data is disaggregated in 56 industries for each country. Thus, the database has dimensions of 2,464 x 2,464.

The information for the ROW "country" is presented, but it is not debated, despite containing several countries in which the production and consumption of ICT goods have rapidly increased, as Malaysia and Vietnam. Due to the inexistence ou availability of supply and use tables for many of these countries their data on internal relations is less trustworthy.

This paper utilizes the value-added trade-in-value-added matrices (TIVA) from 2000 and 2014. The 2000 TIVA matrix was deflated to 2014 following the method used by Nagengast; Stehrer (2016, 18), Fan et al. (2019, 6) e Xu; Dietzenbacher (2014).

Next, the concept of TIVA matrix is explained.

The trade in value-added matrix (TIVA)

The TIVA matrix is derived from the Leontief's input-output model - Miller; Blair (2009). As it is well known, the main equation of the model is

(1).. $X = (I-A)^{-1}.F$,

Where X is the gross production vector by industry, I is an identity matrix, A is the matrix of technical coefficients and F is the final demand vector. Matrix $(I-A)^{-1}$ is known as the Leontief Inverse Matrix.

The matrix of technical coefficients and thus the Leontief Inverse Matrix only show the flows of current inputs. Purchases of capital goods are considered in the final demand. This fact has relevant implications for the interpretation of the statistics presented in this paper, as seen below.

In the WIOD model, the final demand vector is a matrix with five columns for each country, *Households, Final consumption expenditure by non-profit organizations serving households, Gross fixed capital formation, changes in inventories and valuables and Final consumption expenditure by the government.* It is thus a 2464 X 220 matrix. But, as in Timmer et al. (2015), the columns of this matrix were reclassified by industry, resulting in a 2464 X 2464 square matrix. It is called, hereafter FD matrix (Final Demand).

The Leontief Inverse Matrix is also named total requirement matrix or impact matrix, as it contains the multipliers, the values by which a final demand column vector (any of the five components) is multiplied in order to estimate its impact (the gross production by industry). One of its elements, Lij, is the impact of the final demand for one monetary unit of the product for the industry j in the gross production of industry i.

In particular, line i of the gross production matrix contains the direct and indirect sales of activity i to all other activities j, j=1,2464 that are necessary to fulfill the given FD.

The multiplication of the Leontief Inverse Matrix by the FD matrix generates a square gross production matrix. The generic element (LxFD)ij is the gross production of the industry i required to the production of the final demand for the industry j.

The next step is the estimation of the VA embodied in the elements of this gross production matrix. It is assumed that the participation of the VA in production is the same in regard to all destinations. For instance, the ratio of VA to the value of production (VA/VP) absorbed by the internal market is the same as VA/VP intended to export.

The VA coefficient is VACi=VAi/VPi where VAi and VPi are respectively the VA and the value of the production of activity i, i= 1,2464. These coefficients are then organized in a diagonal matrix. TIVA matrix is found by multiplying this diagonal matrix. by the matrix of gross production.

That is, the TIVA matrix is found through the equation:

(2) TIVA = VAC x L x FD, where

VAC – value-added coefficients diagonal matrix

L - Leontief inverse matrix

FD – squared final demand matrix.

In the TIVA matrix, each cell TIVAij contains an estimate of the total value added incorporated in the direct and indirect sales of current inputs from economic activity i that are necessary to attend the final demand for the activity j. The sum of each line is thus the total value added of economic activity i and the sum of each column is the total final demand for activity j. This last property stems from the fact that each column contains precisely all the value-added incorporated in the current inputs used in production and their sum equals the final demand for the goods of that industry.

The TIVA matrix avoids the common double counting problem in the statistics of international trade as each transaction contributes only to the value it adds. At the same time, it takes into account all the direct and indirect transactions that take place between the two activities. Exports from one country to another comprise all VA generated through direct and indirect transactions, that is, which went through other countries, including the loops, as exports from one country may incorporate VA from previous exports that were imported.

The technical literature has been using trade statistics calculated from equation (2), among which the indicators proposed by Koopman et al. (2014), Johnson; Noguera (2012) and Los; Timmer (2018). But this paper only explores the changes in the participation of the ICT sectors products and services in the total production of industries and countries, measured in VA, between the 2000 and 2014 TIVA matrices. It could have shown that the statistics used are particular cases of the measure proposed by Johnson; Noguera (2012), but a simplified presentation was chosen instead.

Classification of countries and economic activities

The 23 smallest European countries in terms of VA consumption in 2014 were aggregated as if they were only one "country", namely the "23 Smallest European Countries". The tables of the present study display the European total by presenting the sum of these countries' total, added to the bigger European countries' total. Table 1 shows a list of all countries aggregated in the "23 Smallest European Countries" group.

Table 1 Countries aggregated within the "23 Smallest European Countries"

Austria	Slovakia	Ireland	Poland
Belgium	Estonia	Lithuania	Portugal
Bulgaria	Finland	Luxembourg	Romania
Cyprus	Greece	Latvia	Slovenia
Czech Republic	Croatia	Malta	Sweden
Denmark	Hungary	Norway	

Data source: WIOD (WWW.wiod.org)

The 56 industries, in turn, were aggregated in twelve groups – table 2. A flexible format was chosen which permits the aggregation of productive activities according to four criteria that are diverse amongst themselves: technological intensity; commodities/ industries/ services; ICT sectors / non-ICT sectors; and the intensity of automation diffusion. Technological intensity is an aggregation found in the classification proposed by Galindo-Rueda; Verger (2016).

The higher intensity in the adoption of electronics was observed in some sectors that have in common the fact of being assembly industries and being part of the metal-mechanic complex. In view of this, these industries were aggregated in one class named "Assembly industries of the metal-mechanic complex". The class includes the automotive industry, electrical equipment industry, machinery and tools and other transports' equipment. The electronics industry should also be included in this group, nonetheless, as it is part of the ICT, it was studied separately. In the sector classification used, the high technological intensity industries are the following: chemical and pharmaceutical industries; assembly industries from the metal-mechanic complex; Research & Development services;

electronics and software - Lazarova; Tarique (2005).

Table 2 Industrial classification used in this paper

1 Electronics	7 Assembly industries of the metal-mechanic complex
2 Telecommunications	8 Construction and utilities
3 Software	9 Trade, transports and accommodations
4 Commodities	10 R&/D
5 Other industries	11 Financial and technical services
6 Chemicals/ pharmaceutical	12 Government, education and human health

Limitations of the study

The present study has five sets of limitations. The first is related to the use of the Leontief model– Miller; Blair (2009); the second stems from the data analysis in terms of VA, the use of the VA matrix – Ahmad (2019); the third corresponds to the limitations due to using the WIOD database; the fourth set of limitations refers to the restrictions of the indicators used to discuss the results; the fifth, in turn, refers to the data being aggregated at the world level as if there were only one country in the world.

Since the countries elaborate input-output matrices on different base years, much of WIOD data has to be adjusted through special statistics models. Also, some countries have incomplete statistics information. As aforementioned, the main problem is related to the ROW. Moreover, other obstacles make the process of deflation of the data more difficult. For instance, at the sectoral level, industrial products are becoming more and more heterogeneous among themselves. In the services sectors, therefore “One reason productivity is difficult to measure in service industries is precisely that there are no identified homogeneous products and that the price changes for almost every customer.”Miroudot (2019, 14)

Nonetheless, scientific articles that use the Leontief model with trade-in VA methodology and the WIOD have been accepted within the academic literature, which indicates assimilation of the three first sets of limitations listed above. This observation also includes articles that focus on the electronics, telecommunications and software sectors and many studies that consider these activities among others, as pointed out by the papers from Strohmaier; Rainer (2016); Chen (2016); and Mattioli; Lamonica (2013). In spite of the widespread acceptance of the data and methodology, there are still issues to be reconciled which go beyond the objectives of the present article - Cette et al. (2019).

The main limitation within the fourth set of limitations –the indicators used in this study– is that they fail to inform of the existing heterogeneity within the sales and purchase flows of ITC goods and services. For example, Edwards; Lawrence (2013) showed that, when exported, technology-intensive goods from the same class vary largely in each country. But the statistical data on intra-sectoral sales and purchase flows, in turn, only indicate the sectoral average. The increasing heterogeneity among enterprises from the same economic segment is a sign that the internal variance of these flows may be rising, at least when it comes to the developed economies - Van Reenen (2018).

The VA trade matrix permits a comparison of value-added flows in every country. However, the data are presented in monetary terms and do not indicate the level of technological sophistication and product efficiency of goods and services consumed in different countries. As to trade flows, Edwards; Lawrence (2013) showed that products exported by the United States are different from those imported by that country, and a differential in terms of unit cost is more significant for less developed economies, which indicates lower levels of technological sophistication. The unit prices of technology-intensive goods that China and OECD countries export to the United States reach up to 50% (China) and 80% (OECD) of the prices of products from the same categories exported by the United States.

International trade, on one hand, may attenuate such differences, if a developing country imports more sophisticated goods or if a more developed country imports less complex goods. On the other hand, a developing country may specialize in the production and exportation of simpler goods, which is the Chinese case.

There have not been found comparative data on the different consumption profiles of electronic goods and services that made possible gauging the evolution of technological sophistication in different countries. However, Edwards; Lawrence (2013) indicate that the aforementioned price proportions in international trade were approximately constant during the observed period (1990/2006). Assuming the hypothesis that the proportions of sophistication levels are constant, the highest consumption growth rates in developing countries displayed in the tables of the present study, suggest significative advances when compared to developed countries.

The fifth set of limitations refers to the level in which the data are informed. In many tables, the aggregation level corresponds to the world economy. The mentioned synthesis of the world economy is affected by various constraints which may decrease its informative power. An example would be the countries that make use of different methods to deflate prices. According to Bart Los, "some countries do quality-adjusted deflation while others don't. Of those who do it, some do it for many products, others for just a few." (Answer to a question I personally asked on November 18th, 2019).

Hence, it is necessary to assess the robustness of the results achieved with the referred to the level of aggregation. An assessment can be performed by expanding the analysis to the level of sector contribution and to larger countries. Since the electronics sector is very concentrated internationally, the cases of the main producers are also thoroughly examined.

In the future more disaggregated analyses focused on studying data variance may complement the present study. In this regard, it is important to note that one of the approaches being adopted in the studies that use input-output matrixes is the integration with complementary microdata researches – Johnson (2018).

THE DIFFUSION OF ICT GOODS AND SERVICES IN THE WORLD ECONOMY BETWEEN 2000 AND 2014

Two general results

The most general result attained was the significantly increased participation of the ICT goods and services VA in the total VA of the world production between 2000 and 2014, as shown in table 3. The annual growth of the ICT production VA (6,8%) more than doubled the growth of total world production VA (2,4%). That is, the sum of the totals for the electronics, telecommunications and software sectors rose 6,8% per year between 2000 and 2014.

The second general result to be mentioned is the higher growth for the electronics industry VA (9,4% per year). As it will be exposed ahead in this paper, a positive correlation was observed between the countries' product VA growth and the intensity of the diffusion of the ICT goods, resulting in relatively higher benefits to the developing countries.

Table 3 Participation percentage of the Electronic Complex VA and of the electronics, telecommunications, and software industries VAs in the total VA of world production – 2000-2014 and VA growth of the ICT and its related sectors

Economic Activity	**2000 %**	**2014 %**	**(2014/ 2000) %**	**Economic Activity**	**2000 %**	**2014 %**	**(2014/ 2000) %**
Electronic Complex	*2,7*	*4,9*	*6,8*	*Telecommunications*	*1,1*	*1,8*	*6,1*
Electronics	*0,6*	*1,6*	*9,4*	*Software*	*1,0*	*1,6*	*5,6*

Data source: WIOD (www.wiod.org)

The participation of the ICT and its industries production VAs in the world economy are compatible with the existing estimates for the 'digital economy'. The 2017 Digital Economy Report, published by the UNCTAD, estimated that, in that year, Digital Economy corresponded to 6,5% of the gross world product - UNCTAD (2017, xiii).

It is worth observing that the TIVA matrix only considers the value-added from current inputs purchases. The analysis of the intensity of inputs from the electronics, software and telecommunications industries does not include the growing automation derived from the increased use of robots and other capital goods.

The above-mentioned results are also valid for virtually all the countries and industries in the World Input-Output Database, as it will be shown in the following sections.

Moreover, the diffusion paths of the three ICT sectors are interdependent, as shown in the next table.

Table Spearman rank order correlation coefficients among the diffusion growth rates (2000/2014)

	Electronics value added growth rate	Software value added growth rate	Telecom munications value added growth rate	Total value added growth rate
Electronics value added growth rate	1,000	0,703	0,636	0,716
Software value added growth rate	0,703	1,000	0,710	0,729
Telecom munications value added growth rate	0,636	0,710	1,000	0,721
Total value added growth rate	0,716	0,729	0,721	1,000

Data source: WIOD (www.wiod.org)

Diffusion of ICT sector's VA across countries

The present section analyzes the diffusion of ICT goods and services as inputs of the different industries. The data are aggregated for all countries as if there was only one country in the world. For formatting purposes, the three tables in this section are presented in transposed order to the one usually used in input-output matrices. The origin activities are placed in the columns and the destination activities in the rows. The same display is used in the subsequent section.

Table 4 shows the distribution of total VA and ICT sector's VA consumption per activity of the world economy. Both variables evolve in a relatively homogeneous trajectory around the annual average growth, namely, around 2.4% and 6.8%. The highest and lowest growth rates are observed in the activities with a relatively lower weight, such as R&D and commodities (total VA column) and

R&D and chemicals (ICT sector's VA column). Therefore, the table indicates that the increased participation of the ICT sector's VA in the World VA is found in all activities.

The participation of the activities "Trade, transports and accommodations" and "Financial and technical services" decreased from 2000 to 2014 (ICT sector's VA columns). Such a drop may be due to a greater automation process of these activities in previous diffusion waves of electronics, software and telecommunications.

A larger proportion of the ICT sector's VA was absorbed by the ICT industries (52,5% to 54,9%). The increase is due, for the most part, to the electronics industry, whose participation grew more when compared to software (negative growth) and to telecommunications services. These data refer to the second main result of the present study, which is better viewed in table 5

In fact, Table 5 details the second general result attained, that the electronics industry participation has grown substantially more than telecommunications and software services.

Table 6 shows the participation of the VA of all three ICT sectors in the total VA destined to final demand. These variables are measures of the adoption of digital technologies.

Observing both tables, it is noticed that the participation of the electronics industry VA in the VA of the other economic activities has increased rapidly in software, telecommunication services and "assembly industries of the metal-mechanic complex". The latter is composed of the automobile, other transports, electrical and mechanical equipment industries. In these economic activities, the proportion of electronics VA in 2014 was higher than 2.0%. It is also worth to observe the rapid growth of the participation of the electronics industry VA in "Construction and utilities" industries. With the exception of software services, these are industries characterized by assembly technology. In these activities, electronic systems come as parts or pieces that can be particularly well adapted to assembly procedures. This is a circumstance that facilitates the diffusion of the *Internet of Things*.

These data seem to indicate that the ICT's goods and services are not, for the most part, sold in integrated packages. The economic activities purchase hardware, telecommunications and software separately. A favorable example is the acquisition of software from a supplier to be used in hardware acquired from another supplier. A contrary example is the outsourcing in corporate telecommunications networks. The substantial self-consumption observed for all three ICT activities supports the results achieved. The increased participation of software and telecommunications sales in the overall sales of the electronics sector suggests a contrary trend, which is the technological integration within this sector's supply.

This discussion has implications for the analysis of vertical competition in specific industries, and for studies in economic development. If a country increases its participation in the electronics industry and if this industry incorporates growing portions of the core competences of downstream sectors, this country tends to gain competitive advantage in relation to other countries. The following section will demonstrate that there is an increasing economic concentration process of the ICT activities per country.

Table 4 Distribution of the consumption of total World VA and of the ICT World VA per industry group in the world in 2000 and 2014, and their respective annual growth rates

Buyer Industry	Total VA 2000 %	Total VA 2014 %	Total VA growth 2000/ 2014 %	ICT sector's VA 2000 %	ICT sector's VA 2014 %	ICT sector's VA growth 2000/ 2014 %
ICT sectors (ICT)	**3.3**	**4.5**	**4.7**	**52.5**	**54.9**	**7.2**
Electronics	**1.4**	**1.6**	**3.5**	**14.8**	**16.7**	**7.8**
Telecommunications	**1.0**	**1.5**	**5.5**	**19.2**	**20.1**	**7.2**
Software	**0.9**	**1.3**	**5.6**	**18.5**	**18.1**	**6.7**
Commodities	**4.0**	**3.1**	**0.6**	**0.5**	**0.5**	**6.9**
Other industries	**11.1**	**10.2**	**1.8**	**4.8**	**3.7**	**4.9**
Chemicals/ pharmaceutical	**1.3**	**1.3**	**2.5**	**0.7**	**0.5**	**4.8**
Assembly industries of the	**5.8**	**7.1**	**3.9**	**4.6**	**6.0**	**8.8**

metal-mechanic complex						
Construction and utilities	**14.0**	**14.5**	**2.7**	**7.1**	**7.4**	**7.2**
Trade, transports and accommodations	**16.9**	**16.8**	**2.3**	**8.5**	**7.0**	**5.3**
R&D	**0.3**	**0.5**	**7.2**	**0.2**	**0.4**	**12.3**
Financial and technical services	**19.2**	**18.6**	**2.2**	**9.6**	**8.1**	**5.5**
Government, education and human health	**24.2**	**23.2**	**2.1**	**11.5**	**11.5**	**6.8**
Total	**100.0**	**100**	**2.4**	**100.0**	**100.0**	**6.8**

Data source: WIOD (www.wiod.org)

Table 5 Distribution of VA consumption of the ICT sectors per industry in 2000 and 2014 and their respective annual growth rates

Buyer Industry	Electronics VA 2000 %	Electronics VA 2014 %	Electronics VA growth 2000/ 2014 %	Telecommunications VA 2000 %	Telecommunications VA 2014 %	Telecommunications VA growth 2000/ 2014 %	Soft-ware VA 2000 %	Soft-ware VA 2014 %	Soft-ware VA growth2000/ 2014 %
Electronics Complex	**62.8**	**54.9**	**8.3**	**49.2**	**55.2**	**7.0**	**49.8**	**54.5**	**6.3**
Electronics	**60.3**	**50.8**	**8.1**	**1.1**	**0.7**	**2.8**	**1.6**	**0.9**	**1.3**
Telecommunications	**1.6**	**2.3**	**12.1**	**46.9**	**52.7**	**7.0**	**1.3**	**1.4**	**6.1**
Software	**0.9**	**1.7**	**14.4**	**1.1**	**1.7**	**9.6**	**46.9**	**52.2**	**6.4**
Commodities	**0.0**	**0.5**	**na**	**0.8**	**0.6**	**3.6**	**0.6**	**0.5**	**4.5**
Other industries	**4.5**	**3.7**	**7.9**	**4.8**	**3.3**	**3.5**	**5.1**	**4.2**	**4.2**
Chemicals/ pharmaceutical	**0.5**	**0.5**	**8.5**	**0.7**	**0.5**	**2.5**	**0.7**	**0.7**	**4.8**
Assembly industries of the metal-mechanic complex	**8.5**	**12.2**	**12.2**	**3.2**	**2.7**	**4.7**	**3.7**	**3.6**	**5.4**
Construction and utilities	**6.2**	**8.7**	**12.0**	**7.8**	**8.6**	**6.8**	**6.7**	**4.8**	**3.0**
Trade, transports and accommodations	**4.8**	**4.6**	**9.0**	**9.7**	**7.9**	**4.6**	**9.4**	**8.2**	**4.6**
R&D	**0.2**	**0.5**	**18.2**	**0.2**	**0.3**	**8.3**	**0.2**	**0.5**	**11.5**
Financial and technical services	**4.9**	**5.4**	**10.1**	**11.0**	**8.3**	**4.0**	**11.1**	**10.4**	**5.2**
Government, education and human health	**7.5**	**9.1**	**10.9**	**12.7**	**12.8**	**6.2**	**12.6**	**12.5**	**5.5**
Total	**100**	**100**	**9.4**	**100**	**100**	**6.1**	**100**	**100**	**5.6**

Data source: WIOD (www.wiod.org)

Table 6 Percentage of participation of VA consumption of the ICT and its sectors in the total VA consumption per industry group in 2000 and 2014.

Buyer Industry	CE VA 2000 / total VA	CE VA 2014 / total VA 2014	Elec tronics VA 2000 / total VA	Elec tronics VA 2014 / total VA	tele- com muni cations VA 2000 / total VA 2000	tele- com muni cations VA 2014 / total	soft- ware VA 2000 / total VA	soft- ware VA 2014 / total VA

	2000 %	%	2000 %	2014 %	%	VA 2014 %	2000 %	2014 %
ICT sectors (ICT)	**43.6**	**60.1**	**11.9**	**19.1**	**16.0**	**21.7**	**15.7**	**19.4**
Electronics	**28.3**	**49.6**	**26.3**	**48.0**	**0.9**	**0.8**	**1.2**	**0.9**
Telecom munications	**53.1**	**66.2**	**1.0**	**2.4**	**50.7**	**62.3**	**1.3**	**1.5**
Software	**57.7**	**66.5**	**0.7**	**2.0**	**1.4**	**2.3**	**55.7**	**62.2**
Commodities	**0.4**	**0.8**	**0.0**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**
Other industries	**1.2**	**1.8**	**0.3**	**0.6**	**0.5**	**0.6**	**0.5**	**0.7**
Chemicals/ pharmaceutical	**1.5**	**2.0**	**0.3**	**0.6**	**0.6**	**0.6**	**0.6**	**0.8**
Assembly industries of the metal-mechanic complex	**2.2**	**4.1**	**0.9**	**2.7**	**0.6**	**0.7**	**0.7**	**0.8**
Construction and utilities	**1.4**	**2.5**	**0.3**	**0.9**	**0.6**	**1.0**	**0.5**	**0.5**
Trade, transports and accommodations	**1.4**	**2.0**	**0.2**	**0.4**	**0.6**	**0.8**	**0.6**	**0.8**
R&D	**2.0**	**3.7**	**0.3**	**1.4**	**0.7**	**0.9**	**0.9**	**1.5**
Financial and technical services	**1.4**	**2.1**	**0.2**	**0.5**	**0.6**	**0.8**	**0.6**	**0.9**
Government, education and human health	**1.3**	**2.4**	**0.2**	**0.6**	**0.6**	**1.0**	**0.5**	**0.9**
Total	**2.7**	**4.9**	**0.6**	**1.6**	**1.1**	**1.8**	**1.0**	**1.6**

Data source: WIOD (www.wiod.org)

Diffusion of ICT sector’s VA across countries

The data is aggregated by country of the ICT sector’s VA absorption. It supports, in every case, the two core conclusions, firstly, that the VA consumption of the ICT sectors increased more than the total VA absorbed, leading to growth in automation intensity; Secondly, the participation of the VA of the electronics sector increased faster than that of the two remaining ICT activities.

There was a growing concentration of the consumption of ICT goods in the United States and China. This was exclusively due to the increased participation of China in the electronic goods consumption. In 2014, almost half of the value-added from the electronics industry inputs was purchased by US and China’s firms.

In addition, there is also a great deal of heterogeneity among the countries as to the evolution of the ICT sector’s VA consumption. The United States are the biggest consumers of the ICT sectors’s VA, even though their participation decreased in the observed period. China and Japan swapped places, as the first jumped to be the second biggest ICT sector’s VA consumer. Regarding software – the least concentrated EC activity– Japan remained the second biggest purchaser.

The ICT sector’s VA consumption rapidly increased in China, Indonesia and Taiwan. The country that benefited the most was China, which accumulated over 50% of all the gains of developing countries. For a second group of countries, the United States, Germany, India, Russia and South Korea, the ICT sector’s VA consumption also rose more than the total VA consumption. A relative underperformance characterized the two Latin American countries, namely, Brazil and Mexico, and the following developed countries: Japan, England, France and Italy. These two groups of countries are amongst the countries whose productivity has had less gains than the global average, which has raised specific discussions on the topic. Recent studies point to a lower adoption of the ICT sector’s VA’s goods and services as one of the causes of the observed slow-moving productivity growth.

Finally, a positive correlation (0,71, Spearman index) was noted between the ICT sector’s VA consumption growth rate and the total VA growth rate. In other words, the countries that have increased their ICT sector’s VA consumption were also the ones to present higher growth, as was the case in China, India and Indonesia.

This result casts in doubt the proposition that the impact of digital technology adoption on developing countries’ growth would be smaller. This suggestion, named the complementarity hypothesis - Stanley et al. (2018) – asserts that developing countries have restrictions to the efficient adoption of ICT goods due to limitations in the quality of its manpower, entrepreneurialship organization (decentralization of decision making, autonomy of group work, etc.) corporate environment, economic infrastructure, etc

Table 7 Distribution of total VA consumption and of the ICT sector's VA per country in 2000 and 2014, and their respective annual growth rates

Buyer Country	Total VA 2000 %	Total VA 2014 %	Total VA growth 2000/ 2014 %	ICT sector's VA 2000 %	ICT sector's VA 2014 %	ICT sector's VA growth 2000/ 2014 %
United States	**27.3**	**23.7**	**1.4**	**28.9**	**26.0**	**6.0**
China	**5.9**	**13.0**	**8.4**	**3.9**	**13.5**	**16.7**
Japan	**8.4**	**6.0**	**0.0**	**10.2**	**6.8**	**3.8**
Germany	**5.9**	**4.3**	**0.1**	**5.4**	**4.0**	**4.6**
England	**4.3**	**3.7**	**1.5**	**5.7**	**3.9**	**3.9**
France	**4.3**	**3.5**	**1.0**	**4.2**	**3.1**	**4.5**
Brazil	**2.8**	**3.1**	**3.0**	**3.7**	**2.6**	**4.1**
India	**1.6**	**2.8**	**6.8**	**0.7**	**1.9**	**14.8**
Italy	**3.9**	**2.6**	**-0.6**	**3.7**	**2.0**	**2.2**
Russia	**1.8**	**2.1**	**3.6**	**1.4**	**1.4**	**6.7**
Canada	**2.2**	**2.2**	**2.4**	**2.9**	**2.4**	**5.4**
Australia	**1.6**	**1.8**	**3.5**	**2.0**	**1.7**	**5.7**
South Korea	**1.6**	**1.6**	**2.5**	**1.7**	**1.5**	**5.9**
Spain	**2.2**	**1.7**	**0.6**	**1.8**	**1.3**	**4.6**
Mexico	**1.8**	**1.6**	**1.5**	**0.8**	**1.0**	**8.8**
Indonesia	**0.9**	**1.2**	**3.8**	**0.4**	**1.0**	**14.0**
Netherlands	**1.0**	**0.9**	**1.7**	**1.6**	**1.1**	**3.8**
Turkey	**0.9**	**1.0**	**2.6**	**0.9**	**0.7**	**4.8**
Switzerland	**0.9**	**0.8**	**1.4**	**1.6**	**1.0**	**3.6**
Taiwan	**0.7**	**0.6**	**0.9**	**0.8**	**0.8**	**6.1**
23 Smallest European Countries	**7.2**	**5.4**	**0.8**	**6.9**	**4.8**	**4.7**
Rest of the world	**12.8**	**16.2**	**4.0**	**11.0**	**17.6**	**10.3**
TOTAL	**100.0**	**100**	**2.4**	**100.0**	**100**	**6.8**

Data source: WIOD (www.wiod.org)

Table 8 Distribution of VA consumption of the ICT sectors per country in 2000 and 2014, and their respective annual growth rates

Buyer Country	Electronics VA 2000 %9	Electronics VA 2014 %	ElectronicsVA Growth 2000/ 2014 %	Tele Communications VA 2000 %	Tele Communications VA 2014 %	Tele Communications VA Growth 2000/ 2014 %	Software VA 2000 %	Software VA 2014 %	VA soft-ware Growth 2000/ 2014 %
United States	**30.3**	**25.5**	**8.1**	**33.1**	**24.3**	**3.8**	**23.9**	**28.2**	**6.9**
China	**4.2**	**18.8**	**21.7**	**6.0**	**15.5**	**13.6**	**1.6**	**6.0**	**16.3**
Japan	**6.1**	**6.5**	**9.9**	**8.8**	**6.9**	**4.3**	**14.1**	**7.2**	**0.6**
Germany	**6.6**	**3.4**	**4.3**	**4.1**	**2.8**	**3.4**	**6.0**	**6.0**	**5.6**
England	**4.5**	**2.8**	**5.8**	**5.0**	**3.3**	**3.0**	**7.0**	**5.5**	**3.8**
France	**3.4**	**1.6**	**3.7**	**2.2**	**2.5**	**6.9**	**6.6**	**5.2**	**3.8**

Brazil	**3.3**	**2.2**	**6.3**	**4.2**	**2.5**	**2.5**	**3.4**	**2.9**	**4.4**
India	**0.8**	**1.4**	**13.9**	**0.4**	**1.6**	**17.3**	**0.9**	**2.7**	**13.9**
Italy	**4.2**	**1.4**	**1.4**	**2.3**	**1.8**	**4.0**	**4.9**	**2.8**	**1.5**
Russia	**2.9**	**1.6**	**4.7**	**1.7**	**2.2**	**8.1**	**0.1**	**0.2**	**10.0**
Canada	**1.4**	**2.5**	**13.9**	**3.7**	**2.4**	**2.8**	**2.9**	**2.3**	**3.9**
Australia	**1.5**	**1.4**	**8.8**	**2.1**	**1.6**	**4.0**	**2.3**	**2.3**	**5.6**
South Korea	**2.4**	**3.0**	**11.1**	**0.7**	**0.6**	**5.2**	**2.2**	**0.9**	**-1.0**
Spain	**2.0**	**0.9**	**3.5**	**1.6**	**1.7**	**6.4**	**1.9**	**1.4**	**3.3**
Mexico	**1.4**	**0.9**	**6.4**	**1.0**	**1.8**	**10.6**	**0.2**	**0.2**	**6.3**
Indonesia	**0.2**	**0.9**	**20.3**	**0.6**	**1.6**	**13.5**	**0.2**	**0.3**	**7.1**
Netherlands	**1.1**	**1.2**	**9.8**	**1.5**	**0.8**	**1.1**	**1.9**	**1.3**	**2.5**
Turkey	**0.9**	**0.8**	**9.0**	**1.4**	**1.0**	**3.4**	**0.4**	**0.2**	**2.2**
Switzerland	**2.2**	**1.3**	**5.4**	**0.8**	**0.6**	**4.8**	**2.1**	**1.2**	**1.4**
Taiwan	**1.2**	**1.3**	**10.2**	**0.8**	**0.6**	**3.4**	**0.7**	**0.4**	**2.6**
23 Smallest European Countries	**8.1**	**4.6**	**5.5**	**5.9**	**4.3**	**4.3**	**7.1**	**5.7**	**4.5**
Rest of the world	**11.3**	**15.7**	**11.9**	**12.1**	**19.7**	**9.8**	**9.7**	**17.2**	**9.8**
TOTAL	**100.0**	**100**	**9.4**	**100.0**	**100**	**6.1**	**100.0**	**100**	**5.6**

Data source: WIOD (www.wiod.org)

Table 9 Percentage of participation of the ICT sector's VA consumption in the total VA per countries in 2000 and 2014

Buyer Country	CE VA 2000 / total VA 2000 %	CE VA 2014 / total VA 2014 %	Elec tronics VA 2000 / total VA 2000 %	Elec tronics VA 2014 / total VA 2014 %	tele-com muni cations VA 2000 / total VA 2000 %	tele-com muni cations VA 2014 / total VA 2014 %	soft-ware VA 2000 / total VA 2000 %	soft-ware VA 2014 / total VA 2014 %
United States	**2.9**	**5.4**	**0.7**	**1.7**	**1.3**	**1.8**	**0.9**	**1.9**
China	**1.8**	**5.1**	**0.4**	**2.2**	**1.1**	**2.1**	**0.3**	**0.7**
Japan	**3.3**	**5.5**	**0.4**	**1.7**	**1.1**	**2**	**1.7**	**1.9**
Germany	**2.5**	**4.6**	**0.7**	**1.2**	**0.7**	**1.1**	**1.0**	**2.2**
England	**3.6**	**5**	**0.6**	**1.2**	**1.3**	**1.5**	**1.7**	**2.3**
France	**2.6**	**4.3**	**0.5**	**0.7**	**0.6**	**1.2**	**1.6**	**2.3**
Brazil	**3.5**	**4.1**	**0.7**	**1.1**	**1.6**	**1.5**	**1.2**	**1.5**
India	**1.2**	**3.3**	**0.3**	**0.8**	**0.3**	**1**	**0.6**	**1.5**
Italy	**2.6**	**3.8**	**0.7**	**0.9**	**0.6**	**1.2**	**1.3**	**1.7**
Russia	**2.1**	**3.2**	**1.0**	**1.2**	**1.0**	**1.8**	**0.1**	**0.2**
Canada	**3.5**	**5.3**	**0.4**	**1.8**	**1.8**	**1.9**	**1.3**	**1.6**
Australia	**3.5**	**4.6**	**0.6**	**1.2**	**1.4**	**1.5**	**1.5**	**2**
South Korea	**2.8**	**4.4**	**0.9**	**2.9**	**0.4**	**0.6**	**1.4**	**0.9**
Spain	**2.2**	**3.8**	**0.6**	**0.8**	**0.8**	**1.7**	**0.9**	**1.3**
Mexico	**1.2**	**3.1**	**0.5**	**0.9**	**0.6**	**2**	**0.1**	**0.2**
Indonesia	**1.1**	**4.1**	**0.2**	**1.3**	**0.7**	**2.5**	**0.2**	**0.4**
Netherlands	**4.2**	**5.6**	**0.7**	**2**	**1.6**	**1.5**	**1.9**	**2.2**
Turkey	**2.6**	**3.5**	**0.6**	**1.3**	**1.6**	**1.8**	**0.4**	**0.4**
Switzerland	**4.6**	**6.2**	**1.5**	**2.5**	**0.9**	**1.4**	**2.3**	**2.3**
Taiwan	**3.1**	**6.2**	**1.0**	**3.4**	**1.2**	**1.7**	**0.9**	**1.2**
23 Smallest European Countries	**2.6**	**4.4**	**0.7**	**1.3**	**0.9**	**1.4**	**1.0**	**1.7**
Rest of the world	**2.3**	**5.3**	**0.5**	**1.5**	**1.0**	**2.1**	**0.8**	**1.7**
TOTAL	**2.7**	**4.9**	**0.6**	**1.6**	**1.1**	**1.8**	**1**	**1.6**

Data source: WIOD (www.wiod.org)

AN INTERPRETATION OF THE HIGHEST VA GROWTH OBSERVED FOR THE ELECTRONICS INDUSTRY

As earlier mentioned, the second core result of the present study is the more rapid growth in the consumption of the electronics industry VA. At 2014, the world consumption of the electronics industry VA as a fraction of total world VA reached levels similar to those of the software and telecommunications sectors in 2014, while in 2000 it was less than half of the participation observed for these two sectors – table 3.

The above mentioned result was not expected for three different reasons related to (1) the statistics available; (2) the emphasis in the servitization of the industry versus a "productification" of the services; and (3) the focus on the diffusion of software and of artificial intelligence techniques. These three reasons are commented below.

The VA statistics available until now indicated a more significant growth of the computer services sector. For instance, a recent UNCTAD report stated: "Computer services, which is the only subsector that is growing across all region" - UNCTAD (2019, XVII). Additionally, according to

OECD,

> Growth in the ICT sector is increasingly driven by software production and services, with the latter accounting for more than 80% of total ICT value added. Slower growth in the ICT sector seems due to the sluggish performance of the semiconductor industry, which was previously a key branch of the industry. OECD (2017b, 115)

As to the second reason, the literature on ICT adoption values the servitization of industrial goods without noting with the same frequency the counterpart that the production of services is becoming more and more mechanized and automatized. In this regard, an author who is critical of that perspective, Fritzsche (2019, 2) claims: "we find that smart services are systematically described or defined with respect to an object or a product equipped with smart properties.". In other words, according to Fritzsche, smart services are a product class of their own, instead of a result of the servitization process of the industry. Parallel to Fritzche's perspective is the more recent conception that the servitization process of products is in force as well as a "productification" of services. Cutting-edge research includes papers such as Miroudot (2019), in which the growing undifferentiation of products and services is discussed.

For instance, a "productification" trend of services in all three sectors of the ICT is noted in a greater extent than the servitization proclivity of products in the industry. This is due to the observation that the amount of electronics purchased by the telecommunications and software sectors has grown more than the consumption of telecommunications and software services during the same time span.

Ultimately, the interest of many scholars is on the economics of artificial intelligence, as many relevant innovations are anticipated for this research area - Brynjolfsson et al. (2018, 1). The present study aims to add the contribution that in the ongoing automation process the recent hardware revolution plays a complementary role. This can be seen in the continuous advances in processors, sensors, actuators, 3D printers, etc.. The inclination towards dedicated processors is also a good indication of this ongoing process in society - Thompson; Spanuth (2018).

Moving forward after analyzing the reason why the aforementioned results had not been foreseen, an interpretation of the leadership of the electronics sector in the ICT activity growth is now presented.

It is proposed that the change in the level observed in the intermediary consumption of electronics industry VA when compared to the remaining two ICT sectors suggests a shift in the automation framework of goods, services and industrial processes in the global economy.

An increase in the number and heterogeneity of tasks that are undertaken, greater coordination among activities and the centralization of their control are characteristics of the evolution of ICT products like automobile brakes, suction pumps, cell phones, etc. These new functions require specialized electronic devices.

For instance, automobile braking systems have incorporated new traction control technologies that include reducing the activation time, increasing stability, signal blockers, energy regeneration, among others. These technologies require electronic control systems, which, in turn, are responsible for integrated operation and for syncing other functions of the vehicle.

Another example is the cellular phone. Now, besides the capacity of making and receiving calls, the cell phone is also a radio, a TV, a voice recorder, a computer, answering machines, an audio system a cameras, etc.

The same is valid for robots, 3D printers, etc. These changes have required an incorporation of increasingly complex inputs from the ICT industries.

Another relevant example is the one of the John Deere Corporation, which manufactures tractors and agricultural machinery. This company's machines embody products and services from the ICT sectors and are currently collecting many pieces of information at the farms in which they are employed. The firm centralizes these data and uses them either for their own consumption or to increase revenue, since they may be sold to farmers.

In summary, the coupling of electronics to products and services and its parts –new or modified– integrated to software and to telecommunications systems are building blocks in the way toward the *Internet of Things*.

Industry 4.0 techniques in the competition for competitive advantage in the global production chains

In the ‘digital economy’, the property and use of information generated in the activities of production and consumption generate competitive advantages to the firms. Although the current industrial revolution is characterized by the fusion of cyber-physical systems, there are papers on firms’ strategy and economic development that emphasize the undertaking of software activities and the successful implementation of artificial intelligence algorithms as the source of this competitive advantage. Two cases are seeing below.

Helper et al. (2019) study strategies of value creation and value capture in the vertical relations between industrial firms and their consultants in data analytics and automation. They show how consulting firms may capture value from their clients who do not follow more elaborated strategies in the use of the data and the knowledge generated in the factory floor. Their research finds that firms that empower their workforce to utilize this data and knowledge “… will be better able to prevent value from migrating to ‘digital entrants’ that offer automation consulting and data analytics. … Conversely, to the extent that digital entrants develop a more abstract version of these tools that they spread across industries, they will capture more value.” . - Helper et al. (2019, 2)

Mayer (2018) has a similar concern, in his paper on economic development perspectives for the poorest countries. But, as Helper et al. (2019), he restricts the analysis to the software services, artificial intelligence algorithms and big data with applications to marketing and other firms’ functions. He emphasizes that the growing data digitalization “... can provide new opportunities for industrialization in developing countries if these countries can leverage data on market demand for design and production decisions.” - Mayer (2018). In particular, still according to Mayer (2018, 4)

> “Digitalization gives intangibles a more prominent role in income generation, including along value chains. Intangibles refer to R&D, design, blueprints, software, market research and branding, databases etc..”

In synthesis,

> “using the new digital technologies with a view to harnessing market intelligence on the functionalities and features of goods and services that appeal to customers for design and production decisions may allow developing countries to engage in the higher value-added activities in the value chain and benefit from the income-generating potential of digitalization.” Mayer (2018, 15).

But behind these consulting firms on data analytics, etc. there are large firms who provide bundles of software, hardware and telecommunication services which also have an important role in the value capture in the vertical relations on global value chains. For instance, in the automation segment, there are large vendors as Siemens, Emerson and ABB. In telecommunication equipments, Huawei, Cisco, Fujitsu etc. In hardware, Apple, Samsung, Hon Hai, etc. In order to undertake these tasks, its current inputs are increasingly intensive in goods from the ICT sectors

Their products and services are becoming more complex. Another trend is the development of specialized computing systems, at the expense of an exclusive focus on general purpose computers - Thompson; Spanuth (2018). These characteristics increase their potential to product differentiation, competition on standards and/ or intellectual property rights.

These firms integrate the software and artificial intelligence capabilities and hardware to capture the digital information from their clients and to explore its potential to increase value. Two well known examples are John Deere and Tesla. Robots vendors follow the same pattern. In general, suppliers of products and parts intensive in electronic can develop this kind of competitive advantage, in part based on a more intense consumption of inputs directly or indirectly originated in the ICT sectors.

The bargaining ability of suppliers of proprietary electronic equipment is large because they are the ones who design the digital systems that will capture and use the data, besides frequently having access to data from several stages of the productive chains. The paradigmatic case is Huawei,

Software and hardware electronic systems inside these products bring other competitive advantages besides the potential access to the clients information. They substitute tasks previously undertaken by parts and products which were produced by downstream firms. Technical capabilities become incorporated in these systems and the production process of upstream producers lose in technical complexity and also in competitive advantages.

This trend is visible in the automobilie industry that sees the entrance attempt of firms from the ICT sectors, like Google and Apple, based in their capabilities of production in software and hardware. It is also observed that several products cease to exist because they are substituted by electronic products.

The larger growth of the electronics VA is thus not only a consequence of the increased efficiency of the technology, but is also the result of strategies from suppliers of goods and services, among them many firms from the ICT sectors, to augment the encapsulation of hardware, software and telecommunication services, not only to compete with their rivals but also to take the opportunities to advance in the downstream way.

CONCLUSIONS

The paper assesses the diffusion of products and services from the ICT industries, electronics, telecommunications and programming and information services (software, to simplify) in the world economy, between 2000 and 2014. Methodologically, the economy of the input-output and data at constant prices from the World Input-Output Database are used, from which world trade matrices in value-added (VA) were calculated. Thus, all data express transactions in VA.

While the world economy grew 2.4% a year, sales of the ICT sectors other productive activities increased 6.8% a year and those of the electronics sector 9.4% a year. These data were disaggregated by industry and country and the results are systematically supported.

Several specific observations have also been made. For example, there is a correlation between the increase in the intensity of the adoption of ICT products and services and the rate of economic growth. That is, the diffusion of these goods grew more in the fastest growing countries, such as China, India and Indonesia. It was also seen that the growth pattern of the adoption of ICT goods and services is related to the pattern of productivity evolution. In countries with productivity slowdown, such as Italy and England, among others, adoption was slower.

The increase in the VA's participation in the ICT sector's productive activities in the world economy was already expected. But electronics growth leadership is a new result. This is understood as a growing integration of ICT products and services in products and services in other sectors. It is a necessary condition to the advent of the Internet of Things. This interpretation reinforces the fact that the VA's share of electronics in the costs of other activities grew more in the sectors of assembly, automobile, electrical material, machinery and other transportation products, where electronic components more naturally integrate production processes and products.

Based on examples, it was also suggested that the growing integration of electronics in the products and services has not insignificant consequences on competitive processes in supplier / customer relations, as shown by the cases of Huawei, John Deere, etc. Their new competitive advantages may allow them to absorb value generated downstream.

Lastly, it can be speculated, for future research work, in development economics, that if a country increases its participation in the electronics industry and if this industry incorporates growing portions of the core competences of downstream sectors, this country tends to gain more competitive advantage in relation to other countries.

BIBLIOGRAPHY

AHMAD, N. Improving the accounting frameworks for analyses of global value chains. **GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2019**, p. 155, 2019.

CETTE, G.; LOPEZ, J.; PRESIDENTE, G.; SPIEZIA, V. Measuring 'indirect'investments in ICT in

OECD countries. **Economics of Innovation and New Technology**, v. 28, n. 4, p. 348–364, 2019. Taylor & Francis.
CHEN, Y. Intra-industry fragmentation: Bilateral value added in electronics exports. **Economics Letters**, v. 138, p. 22–25, 2016. Elsevier B.V.
EDWARDS, L.; LAWRENCE, R. Z. Do Developed and Developing Countries Compete Head to Head? **RISING TIDE: IS GROWTH IN EMERGING ECONOMIES GOOD FOR THE UNITED STATES?** p.91–131, 2013. Washington DC: Peterson Institute for International Economics, PIEE Press.
FAN, J.-L.; ZHANG, X.; WANG, J.-D.; WANG, Q. Measuring the Impacts of International Trade on Carbon Emissions Intensity: A Global Value Chain Perspective. **Emerging Markets Finance and Trade**, p. 1–17, 2019. Taylor & Francis.
GALINDO-RUEDA, F.; VERGER, F. OECD taxonomy of economic activities based on R&D intensity. , 2016. OECD.
HELPER, S.; MARTINS, R.; SEAMANS, R. Who Profits from Industry 4.0? Theory and Evidence from the Automotive Industry. **Theory and Evidence from the Automotive Industry (January 31, 2019)**, 2019.
JOHNSON, R. C. Measuring global value chains. **Annual Review of Economics**, , n. 0, 2018. Annual Reviews 4139 El Camino Way, PO Box 10139, Palo Alto, California 94303~….
JOHNSON, R. C.; NOGUERA, G. Accounting for intermediates: Production sharing and trade in value added. **Journal of international Economics**, v. 86, n. 2, p. 224–236, 2012. Elsevier.
KOOPMAN, R.; WANG, Z.; WEI, S.-J. Tracing value-added and double counting in gross exports. **American Economic Review**, v. 104, n. 2, p. 459–494, 2014.
LAZAROVA, M.; TARIQUE, I. Knowledge transfer upon repatriation. **Journal of World Business**, v. 40, n. 4, p. 361–373, 2005.
LEE, M.; YUN, J.; PYKA, A.; et al. How to respond to the Fourth Industrial Revolution, or the Second Information Technology Revolution? Dynamic new combinations between technology, market, and society through open innovation. **Journal of Open Innovation: Technology, Market, and Complexity**, v. 4, n. 3, p. 21, 2018. Multidisciplinary Digital Publishing Institute.
LOS, B.; TIMMER, M. P. **Measuring Bilateral Exports of Value Added: A Unified Framework**. 2018.
MATTIOLI, E.; LAMONICA, G. R. The ICT role in the world economy: an input-output analysis. **Journal of World Economic Research**, v. 2, n. 2, p. 20–25, 2013.
MAYER, J. **Digitalization and industrialization: friends or foes?** 2018.
MILLER, R. E.; BLAIR, P. D. **Input-output analysis: foundations and extensions**. Cambridge university press, 2009.
MIROUDOT, S. Services and Manufacturing in Global Value Chains: Is the Distinction Obsolete? , 2019. ADBI Working Paper 927.
NAGENGAST, A. J.; STEHRER, R. The great collapse in value added trade. **Review of International Economics**, v. 24, n. 2, p. 392–421, 2016. Wiley Online Library.
OECD. **Digital Economy Outlook 2017**. 2017.
PORTER, M. E.; HEPPELMANN, J. E. How smart, connected products are transforming competition. **Harvard business review**, v. 92, n. 11, p. 64–88, 2014.
VAN REENEN, J. Increasing differences between firms: market power and the macro-economy. , 2018. Centre for Economic Performance, London School of Economics and Political~….
STANLEY, T. D.; DOUCOULIAGOS, H.; STEEL, P. Does ICT Generate Economic Growth? A Meta-Regression Analysis. **Journal of economic surveys**, v. 32, n. 3, p. 705–726, 2018. Wiley Online Library.
STROHMAIER, R.; RAINER, A. Studying general purpose technologies in a multi-sector framework: The case of ICT in Denmark. **Structural Change and Economic Dynamics**, v. 36, p. 34–49, 2016. Elsevier.
THOMPSON, N.; SPANUTH, S. The Decline of Computers As a General Purpose Technology: Why Deep Learning and the End of Moore's Law are Fragmenting Computing. **Available at SSRN 3287769**, 2018.

TIMMER, M. P.; DIETZENBACHER, E.; LOS, B.; STEHRER, R.; VRIES, G. J. An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. **Review of International Economics**, v. 23, n. 3, p. 575–605, 2015. Wiley Online Library.
TIMMER, M. P.; LOS, B.; STEHRER, R.; DE VRIES, G. J.; OTHERS. **An anatomy of the global trade slowdown based on the WIOD 2016 release**. Groningen, NL, 2016.
UNCTAD. **Digital Economy Report**. Geneva: United Nations Geneva, 2019.
XU, Y.; DIETZENBACHER, E. A structural decomposition analysis of the emissions embodied in trade. **Ecological Economics**, v. 101, p. 10–20, 2014. Elsevier.
AHMAD, N. Improving the accounting frameworks for analyses of global value chains. **GLOBAL VALUE CHAIN DEVELOPMENT REPORT 2019**, p. 155, 2019.
CETTE, G.; LOPEZ, J.; PRESIDENTE, G.; SPIEZIA, V. Measuring 'indirect'investments in ICT in OECD countries. **Economics of Innovation and New Technology**, v. 28, n. 4, p. 348–364, 2019. Taylor & Francis.
CHEN, Y. Intra-industry fragmentation: Bilateral value added in electronics exports. **Economics Letters**, v. 138, p. 22–25, 2016. Elsevier B.V.
EDWARDS, L.; LAWRENCE, R. Z. Do Developed and Developing Countries Compete Head to Head? **RISING TIDE: IS GROWTH IN EMERGING ECONOMIES GOOD FOR THE UNITED STATES?** p.91–131, 2013. Washington DC: Peterson Institute for International Economics, PIEE Press.
FAN, J.-L.; ZHANG, X.; WANG, J.-D.; WANG, Q. Measuring the Impacts of International Trade on Carbon Emissions Intensity: A Global Value Chain Perspective. **Emerging Markets Finance and Trade**, p. 1–17, 2019. Taylor & Francis.
GALINDO-RUEDA, F.; VERGER, F. OECD taxonomy of economic activities based on R&D intensity. , 2016. OECD.
HELPER, S.; MARTINS, R.; SEAMANS, R. Who Profits from Industry 4.0? Theory and Evidence from the Automotive Industry. **Theory and Evidence from the Automotive Industry (January 31, 2019)**, 2019.
JOHNSON, R. C. Measuring global value chains. **Annual Review of Economics**, , n. 0, 2018. Annual Reviews 4139 El Camino Way, PO Box 10139, Palo Alto, California 94303~….
JOHNSON, R. C.; NOGUERA, G. Accounting for intermediates: Production sharing and trade in value added. **Journal of international Economics**, v. 86, n. 2, p. 224–236, 2012. Elsevier.
KOOPMAN, R.; WANG, Z.; WEI, S.-J. Tracing value-added and double counting in gross exports. **American Economic Review**, v. 104, n. 2, p. 459–494, 2014.
LAZAROVA, M.; TARIQUE, I. Knowledge transfer upon repatriation. **Journal of World Business**, v. 40, n. 4, p. 361–373, 2005.
LEE, M.; YUN, J.; PYKA, A.; et al. How to respond to the Fourth Industrial Revolution, or the Second Information Technology Revolution? Dynamic new combinations between technology, market, and society through open innovation. **Journal of Open Innovation: Technology, Market, and Complexity**, v. 4, n. 3, p. 21, 2018. Multidisciplinary Digital Publishing Institute.
LOS, B.; TIMMER, M. P. **Measuring Bilateral Exports of Value Added: A Unified Framework**. 2018.
MATTIOLI, E.; LAMONICA, G. R. The ICT role in the world economy: an input-output analysis. **Journal of World Economic Research**, v. 2, n. 2, p. 20–25, 2013.
MAYER, J. **Digitalization and industrialization: friends or foes?** 2018.
MILLER, R. E.; BLAIR, P. D. **Input-output analysis: foundations and extensions**. Cambridge university press, 2009.
MIROUDOT, S. Services and Manufacturing in Global Value Chains: Is the Distinction Obsolete? , 2019. ADBI Working Paper 927.
NAGENGAST, A. J.; STEHRER, R. The great collapse in value added trade. **Review of International Economics**, v. 24, n. 2, p. 392–421, 2016. Wiley Online Library.
OECD. **Digital Economy Outlook 2017**. 2017.
PORTER, M. E.; HEPPELMANN, J. E. How smart, connected products are transforming competition. **Harvard business review**, v. 92, n. 11, p. 64–88, 2014.

VAN REENEN, J. Increasing differences between firms: market power and the macro-economy. , 2018. Centre for Economic Performance, London School of Economics and Political~….

STANLEY, T. D.; DOUCOULIAGOS, H.; STEEL, P. Does ICT Generate Economic Growth? A Meta-Regression Analysis. **Journal of economic surveys**, v. 32, n. 3, p. 705–726, 2018. Wiley Online Library.

STROHMAIER, R.; RAINER, A. Studying general purpose technologies in a multi-sector framework: The case of ICT in Denmark. **Structural Change and Economic Dynamics**, v. 36, p. 34–49, 2016. Elsevier.

THOMPSON, N.; SPANUTH, S. The Decline of Computers As a General Purpose Technology: Why Deep Learning and the End of Moore’s Law are Fragmenting Computing. **Available at SSRN 3287769**, 2018.

TIMMER, M. P.; DIETZENBACHER, E.; LOS, B.; STEHRER, R.; VRIES, G. J. An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. **Review of International Economics**, v. 23, n. 3, p. 575–605, 2015. Wiley Online Library.

TIMMER, M. P.; LOS, B.; STEHRER, R.; DE VRIES, G. J.; OTHERS. **An anatomy of the global trade slowdown based on the WIOD 2016 release**. Groningen, NL, 2016.

UNCTAD. **Digital Economy Report**. Geneva: United Nations Geneva, 2019.

XU, Y.; DIETZENBACHER, E. A structural decomposition analysis of the emissions embodied in trade. **Ecological Economics**, v. 101, p. 10–20, 2014. Elsevier.