

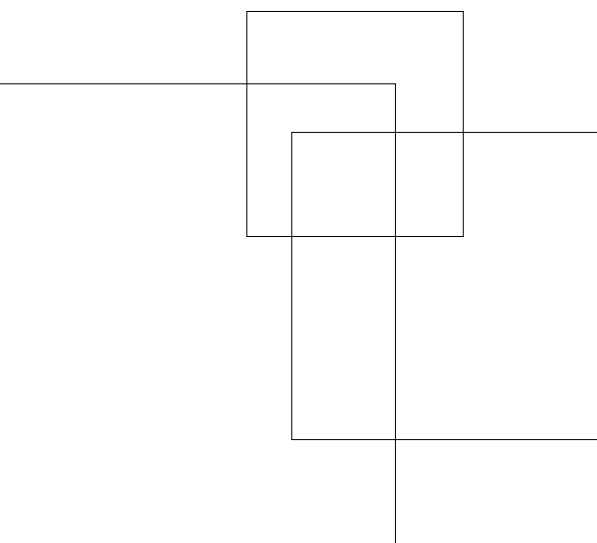


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RESEARCH DEPARTMENT IIII WORKING PAPER NO. 16

# The distribution of value added among firms and countries: The case of the ICT manufacturing sector

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**The distribution of value added  
among firms and countries: The case  
of the ICT manufacturing sector**

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## Abstract

The information and communications technology (ICT) manufacturing sector is one of the key employers worldwide and has undergone dramatic evolutions in the last decades. These evolutions stem from massive reconfigurations in the industry (vertical disintegration, specialization, outsourcing and relocation of production to cheaper countries) which began in the early 1980s leading to a deep transformation in the international division of labour. This paper investigates the evolutions of the supply chain in the sector since 2000 and discusses the impact of these evolutions in terms of distribution of the value added across firms and across countries. During this period, most of the production activities have migrated to East Asia and particularly China, and firms in developed economies have specialized in more strategic activities such as design, development or marketing. Data show large relocations of jobs across countries which have not been accompanied yet by an equivalent change in the distribution of value added. This apparent paradox is largely explained by the vertical specialization of firms and countries as shown by different products case-studies. Hence, economic development depends more on the position in the value than on the simple participation to it. The opportunities and conditions for economic upgrading in the ICT value chain are discussed through the two examples of Taiwanese contract manufacturers and Chinese mobile phone companies. We show that the high modularity of the sector lowers the entry barriers for newcomers but might also turn out to be a disadvantage for less technologically capable firms in the longer term.

Keywords: Economic development, Trade, Technology, Employment, Global value chains, Industrialization

JEL Classification Codes : F63, F66, F16, O14, O15

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## Introduction

The ICT manufacturing sector<sup>1</sup> is one of the key employers worldwide and has undergone significant evolutions in the last decades. We can estimate that more than 12 million employees were involved directly in this sector in 2010. In several Asian countries, they represent a large proportion of manufacturing workers. Since 2000, this population has increased by 65 per cent worldwide but the evolutions have been very much contrasted across countries. Certain countries, such as China or Viet Nam, saw the number of jobs literally exploding in this sector while it shrank significantly in most of the developed countries. However, the ICT manufacturing sector is also of prime importance in terms of trade as it concerns nowadays more than 11 per cent of total world exports, and certain countries, especially in Eastern Asia, are highly dependent on it.<sup>2</sup>

These evolutions can be largely explained by massive reconfigurations in the industry which began in the early 1980s. This industry, which was formerly dominated by vertically integrated corporations, such as IBM, shifted to a more horizontal model integrating specialized suppliers, often called “Wintelism” in the PC industry.<sup>3</sup> Most of new leading firms concentrated exclusively on some strategic and high level skills and allocated their production activities to rapidly growing external contractors first in the United States and Europe and later in emerging countries leading to a deep transformation of the international division of labour. These evolutions have even accelerated in the 2000s after the bursting of the dot-com bubble which highlighted important overcapacity and engendered large job cuts worldwide (Lüthje et al. 2013). These developments have been made possible thanks to the high modularity of the ICT products (Sturgeon et al. 2010) relying on the standardization of components, system features and production processes<sup>4</sup>.

This sector is also often singled out as a sector where the compliance to international labour standards is considered as largely deficient in the production stage (Ngai et al. 2012, Vérité 2014) but also in the raw material extraction stage (Nathan et al. 2011). Excessive working hours, compulsory over-time and high proportion of temporary jobs are common features in the sector (Raj-Reichert 2016). As pointed out by the ILO in 2014 (ILO 2014), these trends are largely due to the characteristics of the products implying short life cycle and based on just-in-time or lean production model adopted by most of the

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<sup>1</sup> In this article, we will focus our analysis on the manufacturing of information and communications technology (ICT) products which is part of the broader electronics manufacturing industry. According to OECD (2011), “ICT products must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display”. They include communication equipment (phones, network equipment,...), computing and peripheral equipment (computers, office machinery, servers etc.), consumer electronic equipment and components which correspond to codes 3000, 3210, 3220 and 3230 in classification ISIC rev3 and codes 2610, 2620, 2630 and 2640 in ISIC rev4.

<sup>2</sup> For Sturgeon et al. (2010), the electronics sector is also an important sector because it has positive spillovers on productivity, employment and innovation in other activities. For this reason, it can be considered as a “propulsive sector” (Hirschman 1958) for a national economy.

<sup>3</sup> Wintelism is a portmanteau word combining the names of the two companies at the epicenter of this new industrial organization: the operating software provided by Microsoft, Windows, and the core chips supplier Intel.

<sup>4</sup> As mentioned by Sturgeon et al. (2010), standardization is not limited to goods but also concerns processes : “The key business processes in the electronics industry that have been formalized, codified, standardized, and computerized are product design (for example, computer-aided design), production planning and inventory and logistic control (for example, enterprise resource planning), as well as various aspects of the production process itself (for example, assembly, test and inspection, materials handling).”



firms in the sector.<sup>5</sup> According to Locke (2013), the bad practices in the workplaces stem mainly from the series of decisions made all along the value chain in response to a very dynamic and volatile market which can cause uncertainty for firms. One of the strategic responses to this uncertainty is often the postponement of final assembly until accurate demand signals are available and consequently the need of a very flexible labour supply.

The aim of this article is to describe the evolution of the supply chain in this manufacturing sector and discuss its impact in terms of distribution of value added and economic upgrading. Both macro and inter-firm evolutions will be analyzed through a literature review and data analysis. In the first part, we will describe, through trade and jobs statistics, the rapid geographical concentration of the ICT manufacturing towards East Asia and especially China in the last decades. In a second part, we will introduce an analysis in terms of value added to 1) show remaining differences between developed and emerging economies and 2) explain these differences by the vertical specialization of firms and countries in the value chain. In a third part, relying on two national examples, the Taiwanese contract manufacturers and Chinese mobile phone companies, we will discuss the conditions for economic upgrading in such a highly modularized sector. Finally, in a fourth part, we will quickly examine a set of factors which may impact the sector in the coming years.

## 1. A rapid concentration of jobs and trade towards Asia

### In the last decade, China became by far the largest exporting economy in the ICT sector

Since 2000, the exports of ICT goods have almost doubled in current value to reach 2,000 billion USD. This evolution has mainly been driven by an explosion in the exports of communication equipment, including mobile phones, and components (Figure 1). The markets of computers (and other peripheral equipment) and other consumer electronic equipment have stagnated in value respectively since 2006 and 2008. During the same period, the location of the ICT manufacturing sector has continued its shift from advanced industrial countries towards emerging countries, especially Eastern Asian countries. The observation previously made by Lee and Gereffi in 2013 (Lee et al. 2013) on the specific issue of the concentration in the mobile phone production sub-sector is also valid for the whole sector. It can be seen in the evolution of the share of Asian countries with the exception of Japan in ICT goods exports which grew from 36 per cent to 67 per cent between 2000 and 2014 (Table 1). This concentration is especially high for the export of electronic components (75.9 per cent) and communication equipment (68.8 per cent).

With 42.7 per cent of all exports, China takes by far the lion's share in the ICT market and is in position of leadership for all the type of goods and especially for final products (Figure 2). For example, China exported 63 per cent of all mobile phones, 73 per cent of all computers and 37 per cent of transmission devices (including television) in 2015.<sup>6</sup> The evolution of this country has been impressive since 2000 while North America, Western European countries and Japan have seen their share in exports dramatically reduced during the same period. Central European countries (Poland, Hungary, Slovakia and Czech Republic) and Mexico have managed to maintain or increase their market share during the decade. The market for electronic components is the least concentrated as three countries other than China are able to reach a market share of 9 per cent and more (Singapore, Taiwan and Korea). In the

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<sup>5</sup> ILO (2014) gives the example of the iPhone for which the time to market shortened from six months in 2007 to less than two weeks in 2012.

<sup>6</sup> Source : Comtrade database, HS codes 84713, 852520 and 852580, accessible at [www.comtrade.un.org](http://www.comtrade.un.org).

mobile phones sub-sector, the evolution has been even more pronounced with the decline since 2000 of former leading countries such as Canada, Germany, Finland and Sweden which heavily depended on flagship companies and the current domination of China and to a lesser extent Korea. These four countries have seen their market share respectively reduced by 5 to 6 ppts each in communication equipment because their leading enterprises have since decided either to relocate their production abroad (e.g. Nokia) or to exit the market (e.g. Siemens) (Lee et al. 2013).

Figure 1. Evolutions of ICT exports by products (in billions of USD) since 2000

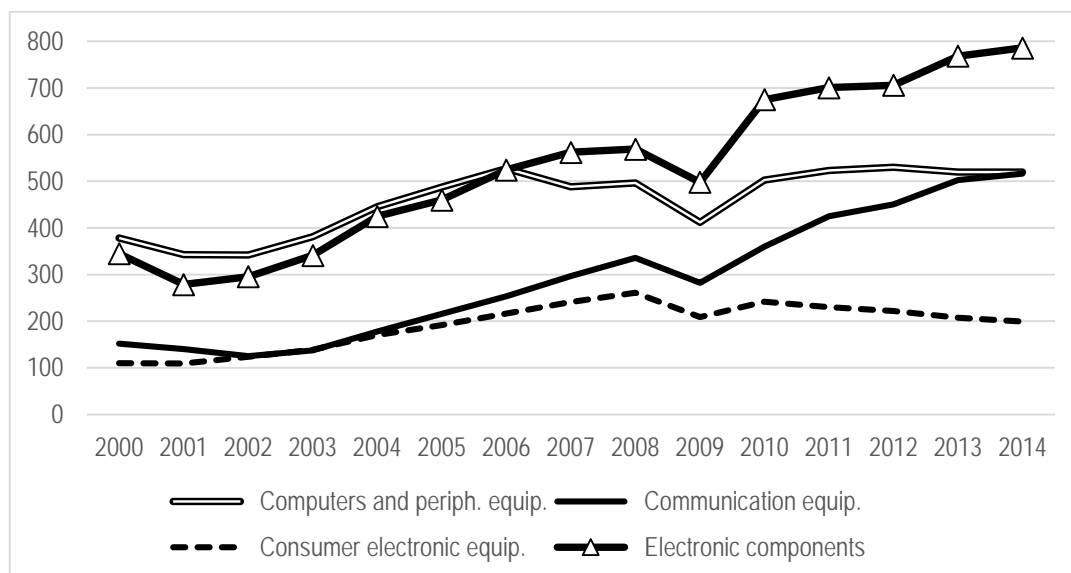
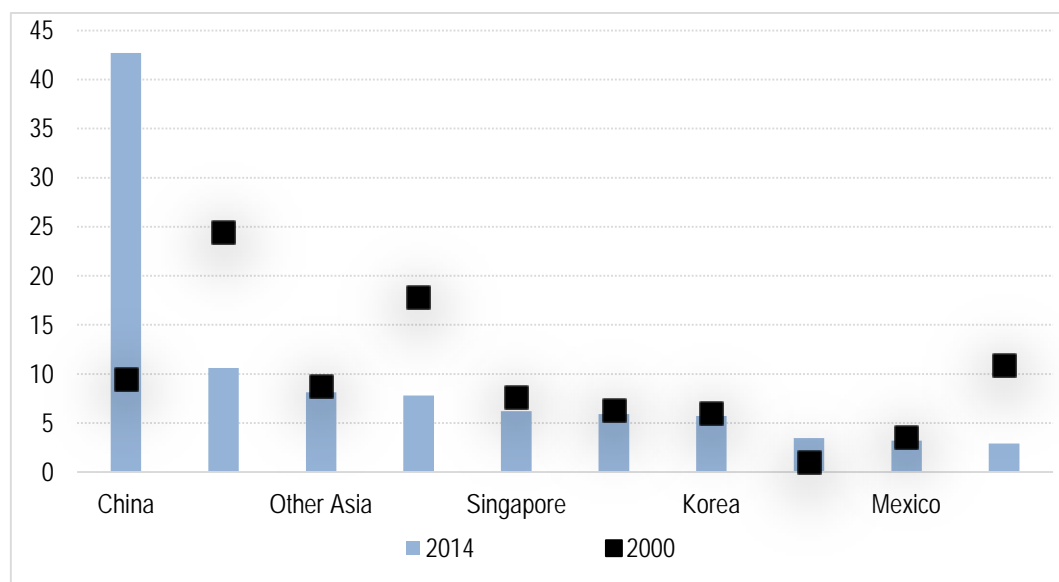


Figure 2. Share in total ICT exports in 2000 and 2014 (per cent)



Source: Author's own calculation based on UNCTAD

Notes: China corresponds to China PRC and Hong-Kong, Western Europe corresponds to France, Germany, Italy, Finland, Netherlands, Belgium, Ireland, Sweden and United Kingdom, Central Europe corresponds to Hungary, Poland, Czech Republic and Slovak Republic, and Other Asian countries corresponds to Malaysia, Thailand, Philippines, Viet-Nam, Indonesia (2003-2010) and Singapore.

The structure of bilateral trade shows the growing inter-linkages of economies and the increasing share taken by Eastern-Asia and especially China in ICT hardware trade (Figure 3 and annex). China is mainly

an exporter of final goods such as mobile phones, computers, etc. (left panel). If Europe and the United States still attracts 36.6 per cent of all Chinese exports, outflows are now for the major part directed towards other Eastern Asian countries and developing countries. This demonstrates the shift in global demand towards emerging economies where more people have been able to access to more sophisticated products, including electronics in the last years.<sup>7</sup> But China also exports electronic components, most of them towards other Eastern-Asian countries showing its role in different segments of the value chain. Nevertheless, China is also very dependent on imports of components from Eastern Asian countries (right panel). According to Gereffi (2009), China and its East-Asian neighbors have developed in the last decades a regional network for high-tech products mainly based on complementarity rather than confrontation.

Japan, Taiwan and to a lesser extent Korea also show a high dependency on other Eastern Asian economies especially for exports of components (Figure A1 in annex). Concerning final goods exports of Japan and Korea, these are now in major part directed to developing countries (including China) rather than US or EU. Regarding imports, these countries also rely heavily on other Eastern Asian economies. On the specific mobile phones sub-sector, Lee et al. (2015) showed that Korea and Taiwan emerged both as key players in the global market, yet on different segments on the value chain: Korea is mainly a branded manufacturer while Taiwan is a more specialized supplier. The analysis of the US bilateral trade gives another perspective. Exports destination are more varied (Figure 3b). The US export mainly final goods to Europe, Mexico and developing economies and electronic components towards Eastern Asia (including China). By mirror effect to the Chinese trade situation, the US globally import more final goods and especially from Eastern Asia (three-fourth of the total). Finally, Mexico and Central European countries show very similar patterns of trade. Exports are massively directed to a single partner (respectively the United States and European Union) and consist almost exclusively of final goods (Figure A2 in annex). Imports come in major part from Eastern & South-eastern Asia and consisted mainly of final goods to be consumed locally.

### **Jobs have globally followed a similar path towards Asia**

In terms of jobs, the concentration has also been impressive. In 2010, 12.3 millions of employees were involved directly in this sector worldwide (Table 1). Since 2000, this population has increased by 65 per cent but the evolutions have been much contrasted at the country level: the number of jobs developed rapidly in countries like China or Viet Nam while it shrank significantly in former leading countries such as Japan (-42.4 per cent) or the United States (-52 per cent). Almost two thirds of all jobs in the ICT manufacturing are now located in China while they were only a third in 2003. The second country in terms of jobs, Taiwan, is far behind with only 5.8 per cent of all jobs. The evolution of the workforce in Asian developing countries has been varied with a majority experiencing an increase and a few encountering difficulties (Singapore, Indonesia and Malaysia). On the contrary, most European countries, with the exception of Slovakia, have seen massive drops of their workforce in the same period. In certain countries, the job collapse during the last decade is concentrated in one particular sub-sector because a national champion has to face a stronger competition or because of relocation in production: for example, communication equipment in Finland (two thirds of all the job losses in the

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<sup>7</sup> For example, the ratio of mobile-phone subscriptions rose from 22,9 per 100 inhabitants in developing countries in 2005 to 91,1 in 2014 (ITC). In China, the same ratio went from 6,6 per cent in 2000 to 92,3 per cent in 2014. The share of households with a computer in developing countries has also increased significantly in recent years (from 14,6 per cent in 2005 to 31 per cent in 2014).

Figure 3a. Bilateral trade of China by main partners (per cent of the total)

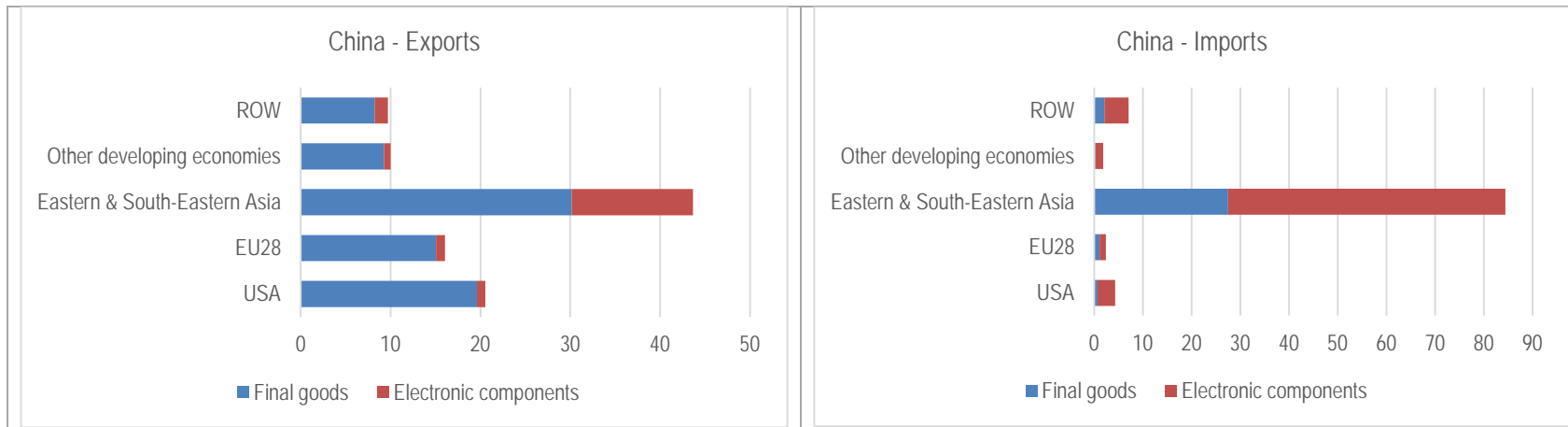
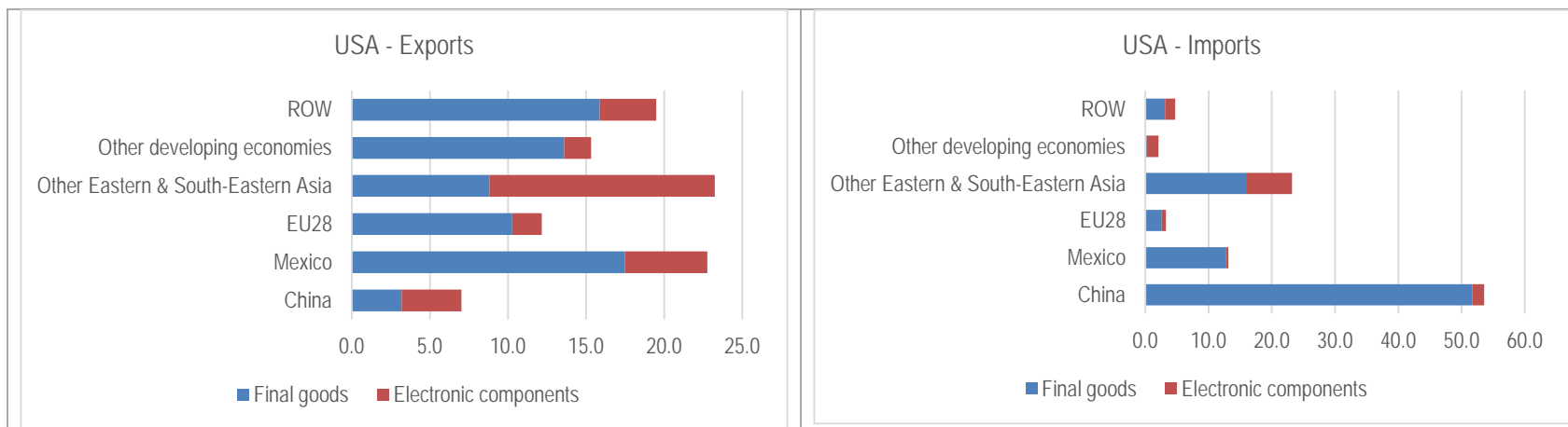


Figure 3b. Bilateral trade of the USA by main partners (per cent of the total)



Source: Author's own calculation based on UNCTAD

Notes: Eastern & South-Eastern Asia refers to China PRC, Hong Kong, Macao, Taiwan, North-Korea, South Korea, Mongolia, Brunei Darussalam, Cambodia, Indonesia, Lao PRC, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Viet-Nam.

sector) and Sweden (80 per cent of all job losses) or computer and other peripheral equipment in Ireland (half of all job losses). The losses have been more widespread along the different products in France and Germany, the latter being even able to gain jobs in the components sub-sector (+10 per cent).

Table 1. Employees in the ICT manufacturing sector (main countries)

	Number of employees in 2010 (thousands)	Share in total manufacturing (%)	Evolution (%)	Period
China PRC	7,814	9.3	168.6	2003-2010
Taiwan	723	25.9	38.1	2001-2011
Japan	570	7.8	-42.4	2000-2010
USA	484	4.6	-52.0	2000-2010
Korea	394	14.9	20.3	2000-2011
Malaysia	314	17.6	-22.0	2000-2010
Thailand	257	6.4	20.2	2000-2011
Mexico	232	7.6	11.4	2003-2010
Philippines	181	20.8	8.7	2001-2010
India	177	1.5	34.7	2000-2010
Indonesia	150	3.3	-4.1	2000-2010
Germany	135	2.0	-38.2	2000-2010
Viet Nam	133	3.0	614.6	2000-2010
Brazil	127	1.6	29.9	2000-2010
Singapore	85	20.6	-16.7	2000-2010
United Kingdom	79	2.9	-60.4	2000-2008
France	78	2.6	-61.1	2000-2010
Italy	68	2.0	-34.3	2000-2010
Canada	46	3.1	-43.7	2000-2010
Hungary	45	7.1	-11.8	2000-2010
Poland	31	1.4	-12.0	2000-2010
Finland	28	7.8	-29.2	2000-2010
Czech Republic	26	2.5	-16.6	2000-2010
Slovakia	17	4.5	38.3	2000-2010
Netherlands	11	1.6	-18.8	2000-2010
Belgium	9	1.7	-55.7	2000-2010
Ireland	7	4.0	-81.6	2000-2010
Sweden	6	1.0	-87.7	2000-2010
<b>World (estimate)</b>	<b>12,345</b>		<b>65,0</b>	<b>2000-2010</b>

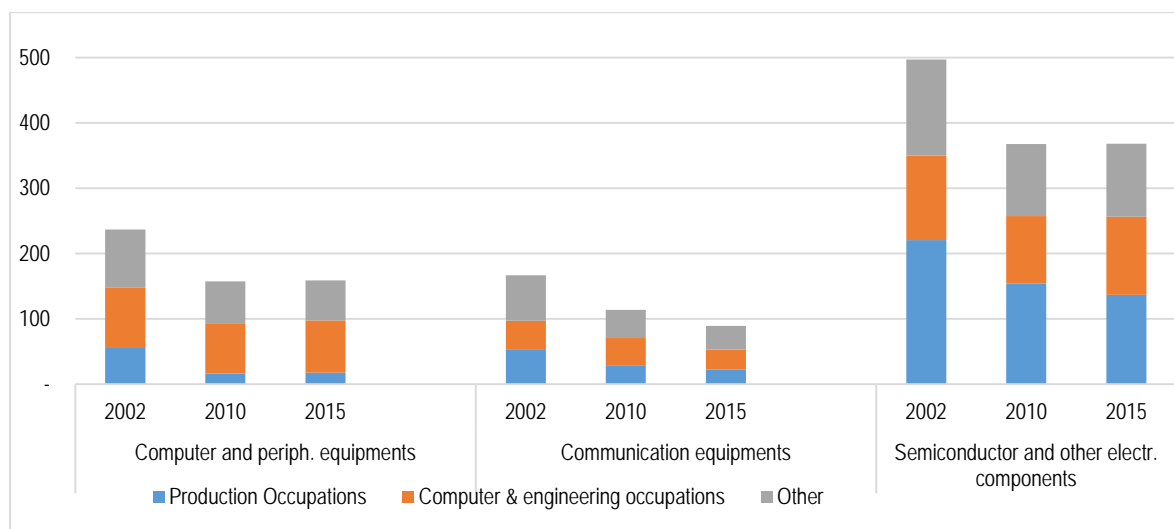
Source: Author's own calculation based on UNIDO

Notes: For Taiwan, Korea and Thailand, employees' data refer to 2011. ICT hardware sectors corresponds to codes 3000, 3210, 3220 and 3230 in classification ISIC rev3 and codes 2610, 2620, 2630 and 2640 in ISIC rev4. In order to ensure time-consistency and coherence over modifications in classification, a rather restrictive range of products have been taken into account in this estimate (see Table A1 in annex for definitions). Certain products such as optical and photographic equipment, instruments for measuring and navigating or magnetic and optical media have been excluded. The total number of ICT manufacturing employees worldwide is calculated on the basis of 57 countries representing around 70 per cent of the world population.

This shift towards China and other emerging economies is confirmed by firm-level data as observed by Lee et al. (2013). For example, in the case of Nokia, the share of jobs located in Finland dropped from 40 per cent in 2000 to 15 per cent in 2010 which is below the shares of workers located in China and India (where the firm opened a production facility in 2006). The case of Samsung is less dramatic as a majority of workers are still located in Korea but the share of China and Southeast Asian countries increased sharply since 2005. However, we should also take into account the effect of the increasing fragmentation and outsourcing into the ICT value chain, especially in the assembling activities. This has led the Taiwanese company Hon Hai Precision Group (also known as Foxconn) who acts as a contractor for major leading firms such as Apple to increase its employment from 47 000 persons to 1.1 million in ten years (99 per cent are located in Mainland China [see Foxconn, 2014]) and becoming the largest private employer in China.

It is also possible to see some signs of re-composition across occupations in the ICT sector. For example, in a context of global decline of jobs in the United States, the production occupations have been by far the most affected regardless of the type of ICT products (Figure 4). This type of occupation now represents 11 per cent of total jobs in computer industry, 25 per cent in communication equipment and 37 per cent in components industry. In the same period, engineering and computer sciences occupations increased their share in total jobs. In the last years, a little rebound has been observed in the number of these occupations in computer and components industries (but not in communication equipment).<sup>8</sup>

Figure 4. Employment level by occupations in three ICT industries in the United States (thousands)



Source: Author's own calculation based on Occupational Employment Statistics (OES), US Bureau of Labor Statistics.

Note: Computer & engineering occupations correspond to "computer and mathematical occupations" and "architecture and engineering occupations".

<sup>8</sup> The analysis of World Input-Output Database also gives an indication of a growing share of better educated workers worldwide. This analysis should be taken with caution as it is based on a wider scope than the previous analysis in this article (all electrical and optical equipment and not only ICT hardware goods). Nevertheless, it shows that in all the countries, emerging or developed, the share of high-skilled workers, according to the ISCED classification, in the total labour compensation is growing and the one of low-skilled workers is decreasing. The share of medium-skilled workers is globally reducing with exceptions in Taiwan and United Kingdom. In the United States, the share of high-skilled workers in labour compensation went from 49 per cent in 2000 to 61.3 per cent in 2009. These workers also take the major share in Korea (50.8 per cent). In China, high-skilled workers still represent nowadays only 12.1 per cent of the earnings in the industry even if their share have grown by 5.4 pts between 2000 and 2009.

Finally, the study carried out by Linden et al. (2011) gives the opportunity to summarize all the issues related to jobs reallocation across countries and re-composition across occupations or education levels in the case of a particular ICT device, the Apple's iPod. It confirms the fact that even if innovative products are manufactured offshore in low-cost countries, they contribute to the creation of valuable jobs, in particular in design, product development or marketing, in the country of origin, the United States. These authors estimated that the value chain of this product concerned 41,000 jobs worldwide in 2006. Around two thirds of them were located outside the United States and consisted primarily of low-wage manufacturing positions in China (44 per cent) or Philippines (17.4 per cent).<sup>9</sup> Concerning the jobs remaining in the United States, those were fairly distributed between high wages engineers and managers and lower wage retail and non-professional workers. This result tends to confirm the growing polarization of jobs and the decline of medium-skill jobs in advanced economies as highlighted by the ILO in 2015 (ILO 2015). However, in the iPod case, this global allocation of jobs led to an allocation of earnings of more than two-thirds in favor of US workers and one-third for foreign workers<sup>10</sup>. As we will see in the next part, the allocation of occupations across countries has indeed a great importance in the way the value added is distributed all along the supply chain.

## 2. The role of vertical specialization in the distribution of value added

### The divergent paths in the distribution of value added and jobs across countries

In the first part, we saw that the production and trade data have shown a rapid concentration of manufacturing towards Asia and especially China. It largely explains the trade deficit in this sector between, for example, the United States and China: according to Xing et al. (2010), the introduction of the iPhone contributed US\$1.9 billion to the US trade deficit with China in 2009 (approximately 0.8 per cent of the total US deficit with China). However, this analysis can be misleading as each final goods, but also components, can “contain” physical parts from various countries in the world but also non-physical properties such as product conceptualization, design or marketing capacities, which can be difficult to track down. This is why it is necessary to analyze the ICT hardware sector not only in terms of trade data but also in terms of distribution of the value added.

According to the OECD TiVA database, the value added is increasingly uncorrelated from the flows of physical goods (intermediate or final). Indeed, the evolution of value added has been rather different than the evolution of trade and jobs. The total value added has increased by 56.5 per cent in current value during the decade, a relatively slower pace than in other industries (+98.6 per cent). The United States and Western Europe still attract 22.7 per cent and 14 per cent of all the value added in the sector while China where the number of jobs have almost tripled during the decades, “only” increased its share from 5.5 per cent in 2000 to 15.4 per cent in 2011 (Figure 5). Japan lost its first rank in the late 1990s and now ranges behind China at 14.4 per cent. Korea, Taiwan and other Asian economies have grown at a much slower pace than China. Finally, the situation of Central Europe, India, Brazil and Mexico has not changed considerably during the decade. These countries remain low contributors to the global value added in the industry.

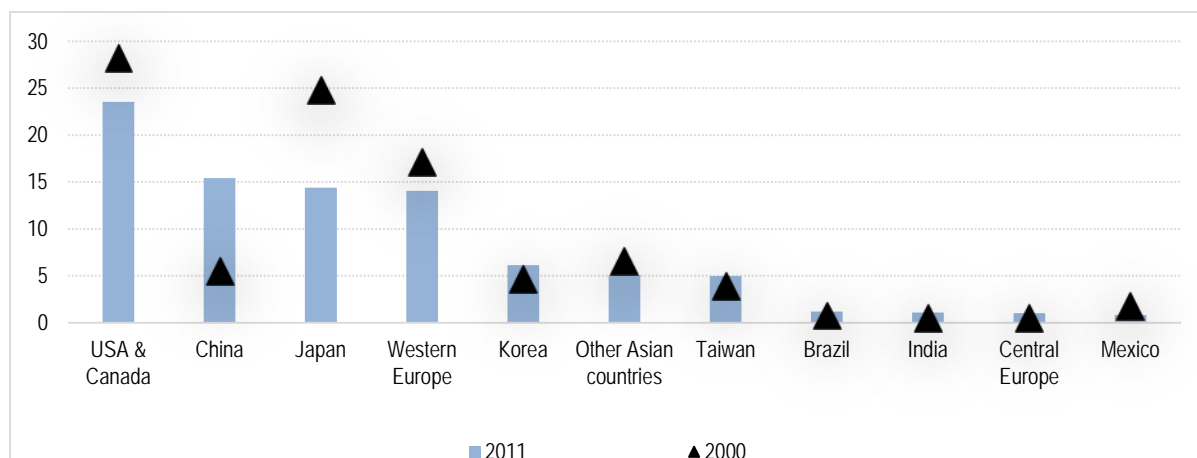
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<sup>9</sup> Other jobs were located in Japan, Korea, Thailand, Taiwan and Singapore. None of these countries represent more than 6.7 per cent of all foreign jobs.

<sup>10</sup> This study has been later refined by Alberro (2012) who took into account inter-industry relations and consequently jobs indirectly created through this new product. This author estimates that 22,200 additional jobs have been indirectly created in the United States.



Figure 5. Evolution of the value added in the computer, electronic and optical equipment sector since 2000

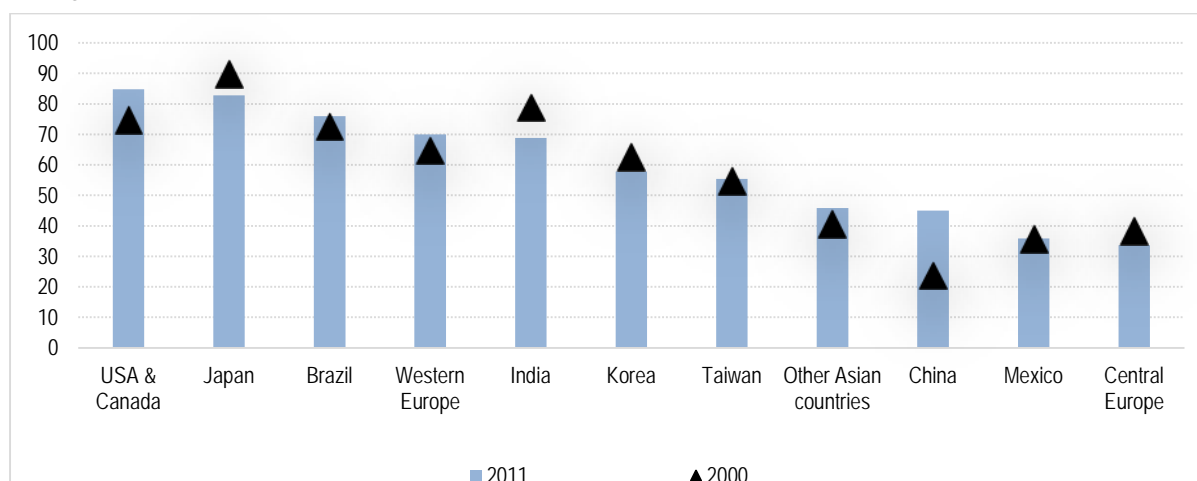


Source: Author's own calculation based on OECD TiVA database

Notes: Western Europe corresponds to France, Germany, Italy, Finland, Netherlands, Belgium, Ireland, Sweden and United Kingdom, Central Europe corresponds to Hungary, Poland, Czech Republic and Slovak Republic, and Other Asian countries corresponds to Malaysia, Thailand, Philippines, Viet-Nam, Indonesia and Singapore

The development of global value chains in manufacturing sectors can be observed in the global decrease in the share of domestic value added in total exports. This has been particularly the case in the ICT manufacturing sector in which only 57.9 per cent of exports were produced locally in 2011 (against 62.8 per cent in 2000) (Figure 6). This is of course due to the highly fragmented production process in the sector. Nevertheless, the share of domestic value added in exports is still fairly high, over 70 per cent, in economies such as the United States, Japan, Brazil or Western Europe while it lags behind 50 per cent in countries such as China (even if a rapid rise is being observed), other Asian economies, Mexico and Central Europe. Korea and Taiwan are in an intermediate situation. There is still apparently no relation between the nature of products exported, either intermediary or final, and the share of domestic value added in exports (figure A3 in annex).

Figure 6. Share of domestic value added in exports of Computer, electronic and optical equipment (per cent)



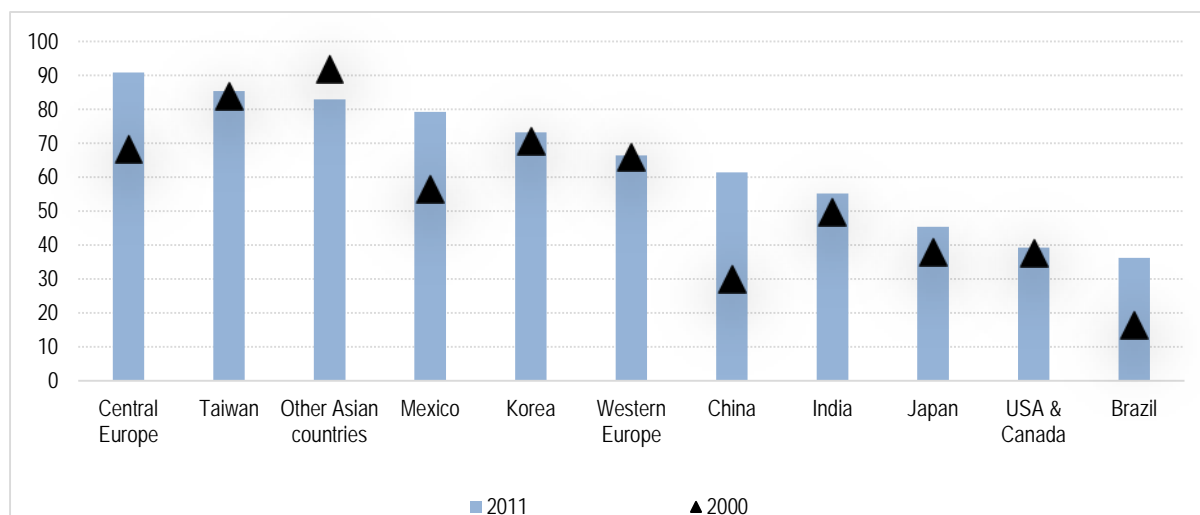
Source: Author's own calculation based on OECD TiVA database

The exposure of national ICT industry to foreign demand varies significantly from one country to another as indicated by the share of domestic value added embodied in foreign final demand (Figure 7). Central Europe, Taiwan, Mexico and other Asian economies are heavily dependent on foreign demand.



In contrast, North America, Brazil, India and Japan can rely on a large domestic market. Nevertheless, in the case of Japan, the low level of value added directed to foreign demand can also be interpreted as a difficulty to translate its success on the local market abroad while the country remains quite successful at the global level in the components segment (Lee et al. 2015). Despite a large and growing domestic market, Chinese ICT industry also relies more than before on foreign demand.

Figure 7. The share of domestic value added embodied in foreign final demand of Computer, Electronic and optical equipment (per cent)



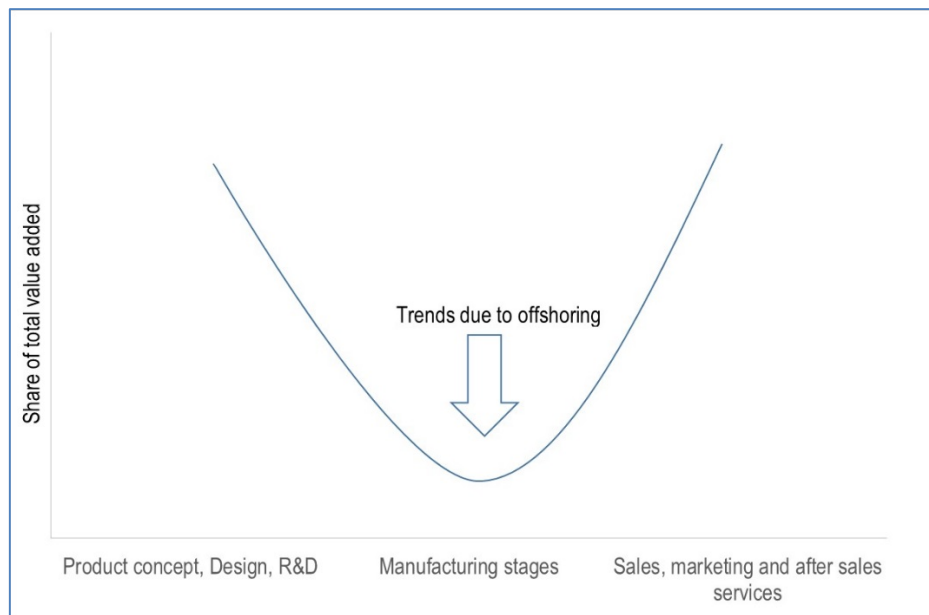
Source: Author's own calculation based on OECD TiVA database

### Mapping the ICT industry: smiling curve and models of enterprises

As we have seen in the last section, developed economies such as United States and to a lesser extent Japan or Western Europe have managed to maintain a high share in global value added in the ICT industry while their workforce shrank considerably. At the same time, employment in developing or emerging economies such as China have grown very rapidly without a shift in the distribution of value added of the same magnitude. To understand this apparent paradox, it is necessary to enter into the architecture of the ICT value chain. Its evolution over time can be summed up by a double movement (Lüthje et al. 2013): vertical disintegration and specialization of production by brand-name firms and vertical reintegration between contract manufacturers.

The concept of the “smiling curve” (Figure 8) is often used to represent the distribution of activities and value added in the electronics sector (Baldwin 2011 and Shin et al. 2012). The concept has been originally developed by Acer founder Stan Shih who argued that the higher value is created at both upstream (product concept, design and R&D) and downstream (sales, marketing) of the value chain. One of the major issues regarding the capture of the value added is entry barriers and competitive advantages, also known as “capabilities”, such as intellectual property and branding which requires large investment of R&D or marketing. Manufacturing and especially assembly capture less value added as the competitive advantages are easier to build and subject to more competition. According to Baldwin, the offshoring of assembling activities to emerging countries with lower cost has tended to “deepen” the smiling curve.

Figure 8. The “smiling curve” in the ICT hardware sector



Source: Adapted from Baldwin (2011)

The ICT sector is generally presented as composed of four models of enterprises (or four business models): Original brand-name manufacturing (OBM), Original equipment manufacturing (OEM), Electronics manufacturing services (EMS) and Original design manufacturing (ODM) (Table 2). Each of these models appeared at a different stage in the history of the electronics industry and resulted from the increasing value chain modularity enabling a clear technical division of labour between design and manufacturing at multiple points in the value chain (Sturgeon et al. 2010).

**OBMs** usually sell products of their own brand in the final market either to individual consumers, business or public administration. In most cases, OBMs design and develop their products themselves, purchase the components and distribute to resellers (or communication operators in the case of mobile phones). **OEMs** also known as Platform leaders, provide components or sub-systems which can be used in the OBM's final product. This model emerged in the 1970s at the beginning of the *Wintelism* era. These enterprises are generally focused on product innovation and have been successful in implanting their technology in other companies' products and consequently gaining a significant share of the value added (see next section).

OBMs and OEMs usually contract out with the two other models of firms (both usually referred as contract manufacturers) which operate in rather different features:

- **EMS** enterprises were mainly created by US contract manufacturers in the 1990s through mergers and acquisitions of facilities from brand-name companies (OBMs). They are specialized in manufacturing high volume products. EMS developed a new model of integrated manufacturing services “comprising all essential elements of the production, procurement, and logistics chains required to manufacture electronics products” (Lüthje et al. 2013).
- Finally, the **ODM** model is a more recent type of contractors which emerged in Taiwan, originally in the PC industry but has since expanded in other products manufacturing such as mobile phones. ODMs distinguish from the EMS by their capacities of design on behalf of the brand-name customers and consequently by the development of substantial intellectual property rights.

Table 2. Models of enterprises in the ICT hardware sector

	Types	Specialization	Examples (country/ sales in US \$ million/no. of workers)
Brand-name enterprises	Original Brand-name manufacturing (OBM)	Product development, manufacturing, component purchasing, manufacturing and logistics of a brand-named final products	Apple (USA/233 270 / 110 000), Hewlett-Packard (USA/51 830/ 240 000), Samsung Electronics (Korea/ 177 290 / 235 999)
	Original Equipment Manufacturing (OEM) or Platform leaders	Product development, manufacturing, purchasing of materials and components of brand-named parts	Intel (USA/ 56 280/107 300), Microsoft (USA/86 600/118 000), Mediatek (Taiwan/6 720/74 497)
Contract manufacturers	Electronics manufacturing services (EMS)	Manufacturing, production-related engineering, purchasing of components and after-sales services	Flextronics (Singapore, ex-USA/24 600/150 000), Hon Hai Precision - Foxconn (Taiwan/141 150 / 1 097 000)
	Original design manufacturing (ODM)	Same as EMS + design and technical system development	Quanta computer (Taiwan/31 720/39 427), Compal (Taiwan/26 680 /5 771)

Source: based on Lüthje et al. (2013) and Sturgeon et al. (2010), data on sales and number of workers from Forbes 500 (2/06/2016) except for Foxconn taken from Foxconn's CSER Annual report (2013)

Nevertheless, this presentation remains highly theoretical and boundaries between these different models can also be sometimes blurred and overlaps are frequent. Due to thin margins in their traditional activities, contract manufacturers started to offer more services to their clients such as designing, testing, repairing or prototyping. More recently, we have observed some attempts to find new outlets through a renewed vertical integration. For example, the Taiwanese enterprise Foxconn is usually classified as an EMS as its main activity consists in the assembly of final products for well-known leading firms such as Apple. But this enterprise has also acquired recently capacities in development through the acquisition of brand-name enterprises.<sup>11</sup> Other interesting examples are several ODMs from Taiwan such as Acer, HTC or Asustek which tried with variable success to migrate to the OBM model by entering the markets of laptops or mobile phones with their own branded products (see part 3).

Besides, outsourcing can be variable depending on the products and on the business models of the leading firm. According to Lee et al. (2013) and based on data from the Korean national IT industry promotion agency (NIPA), in 2010, only 30 per cent of all mobile phones were produced through outsourcing, whereas more than 90 per cent of game consoles and laptops were. For Wilde et al. (2006), there were different reasons explaining at that time the difference between mobile phones and other electronics devices in terms of outsourcing globally. Main reasons were the lower level of standardization in comparison with PCs (many more design platforms are available for mobile phones) and a higher level of complexity driven by constant technological innovation. But, the differences can also stem from deliberated choices by companies. For example, Samsung and Apple are regularly

<sup>11</sup> FIH, a subsidiary of Foxconn, bought part of Microsoft Mobile's (ex Nokia) featurephone division. In March 2016, Foxconn also bought Sharp Corporation which among other things produces displays for smartphones.

presented as “dueling business models” (Brien, 2013). Indeed, after becoming a global leader in both semi-conductors and consumer electronics, the Korean company started competing with Apple on high-end smartphones, tablets and PC markets with a completely different model: Apple is known to outsource 100 per cent of the inputs of its products from external suppliers while Samsung is almost totally vertically integrated.<sup>12</sup>

### Products case-studies: the smiling curve in practice

In order to understand the role of different business models, various researchers tried to measure the distribution of value added between the different segments of the ICT industry (Table 3). While these studies are based on different methodologies and assumptions, similar or complementary conclusions can be drawn on.

First, in all cases, the leading firms (OBMs) attract a large part of the value added. At least 30 per cent of value added or gross profits, and up to 58 per cent in the case of an iPhone, goes to these companies. This is due to the fact that these firms keep internalized most of their product design, software development, marketing and other high-wage functions. There is nevertheless a substantial difference between leading firms in terms of value capture with regards to the type of products. For example, Dedrick et al. (2008) showed that Apple receives 36 per cent of the value in the case of the iPod while HP only attracts 28 per cent of the value in the case of a notebook. The difference is largely explained by the fact that Apple has managed to keep the control of the core software, proprietary standards and complementary infrastructure of their products while PC firms are highly dependent on two platform leaders, Microsoft and Intel who attract together around 20 per cent of the value added. Apple has indeed been able to innovate at the system level introducing a dominant design with the iPod, later applied to the iPhone, and kept control over key elements such as the user interface and ecosystem (iPod or iPhones/iTunes). In comparison, PC companies do not control the key interfaces of their products which have been standardized and depend on Microsoft and Intel which rely on user lock-in, IP protection and R&D resources to maintain their own market power. In terms of geographical distribution, the United States usually capture the major part of the value added because the headquarters of leading firms or key component providers are located in this country. It is also the case for Finland for Nokia’s high-end phone, N95, but less the case for low-end phones for which the margin is less important (Ali-Yrkkö et al. 2011 and 2015).

Regarding other components, some suppliers are capable of capturing a substantial share of the value added such as certain microchips companies in the case of the iPod (US firms Broadcom and Portalplayer). Nevertheless, others have to face severe competition which limits their margin. This is the case for example of display providers where historical Japanese leaders are more and more challenged by Korean and Taiwanese firms. In the case of hard drive, Apple has been also able to maintain market power over its suppliers by shifting from hard drives to “flash” memory chips (Dedrick et al. 2008 and Kraemer et al. 2011).

More important for this article, the levels of value added gained and employment do not seem to be correlated as shown by the very low share of value added attributed to the activity of final assembly. In the case of a high-end phone, such as Nokia N95, the shift in assembly location from Finland to China had little impact on the value captured by HQ country (around 2 ppts, from 41 per cent to 39 per cent) (Ali-Yrkkö et al. 2011). Kraemer et al. (2011) have found a quite similar result for the iPhone (and the

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<sup>12</sup> Another Korean leading mobile phone producer, LG, is known to be also highly vertically integrated (Lee et al. 2013).

iPad). For feature phones, such as Nokia 3310, the share captured by assembly is nevertheless bigger (up to 9 per cent).

Table 3. Distribution of the value added in the supply chain (findings from main studies)

Authors	Products	Main conclusions
Dedrick et al. (2008)	iPod (video & music device) and HP nc6230 (notebook PCs)	Video iPod : Apple captures 36% of the value, US suppliers 3%, Japanese suppliers 12%, Korean suppliers 0,4%, total cost of goods sold (including labour) 44%  HP notebook : HP captures 28%, US suppliers (mainly Microsoft and Intel) 19%, Japanese suppliers (7%), Korean (1%), Taiwan (2%), total cost of goods sold (including labour) 38%
Ali-Yrkkö et al. (2011)	Nokia N95 (high-end phone)	Depending on the assumptions between 34% and 47,2% of the VA goes to Finland (HQ country), 1,9% to 9,3% to EU, 6,6% to 9,1% to US, 4,7% to 8,3% to Asia (not assembly). The country of final assembly (either Finland or China) receives 2,1%.
Kraemer, Linden and Dedrick (2011)	iPad (tablet) and iPhone (smartphone)	Apple keeps 30% of sales price on an iPad and 58% on an iPhone (not taking into account communication carriers).  Korean companies (LG, Samsung) who provide key components such as display and memory chips gain 5 to 7% of gross profits and U.S., Japanese and Taiwanese suppliers capture between 1 and 2% each. Only 2% of gross profits can be attributed to Chinese workers in assembling plants.
Dedrick et al. (2011)	Motorola V3 RAZR, Treo 650 CDMA and RIM Curve 8300 (high-end phones)	<u>Without communication carriers</u> : Suppliers' gross profits range from 15% (RIM) to 33% (Palm) of leading firms gross profits. Suppliers share being distributed between the US (36 to 41%), Japan (2 to 28%), Europe (0 to 12%), other asian countries (6 to 8%) and unidentified suppliers (30 to 37%)  <u>With communication carriers</u> : In the case of the Motorola V3 RAZR, three quarters of total gross profits goes to the communication carrier (Cingular AR&T) and Motorola captures one fifth.
Ali-Yrkkö et al. (2015)	Same as Ali-Yrkkö et al. (2011) and three low-end phones : Nokia 3310 (2000), Nokia 1100 (2003) and Nokia 1200 (2007) (identical technologies, features and functionality)	Nokia N95 : see Ali-Yrkkö et al. (2011) Low-end phones : while the price is falling, the HQ country (Finland) captures a decreasing share of the value added (39% in 2000 to 8% in 2007). During the same period, Asia's share grew from 14 to 36% illustrating the gradual shift of tasks towards developing countries. In terms of functions, assembly captures 2% (N95) to 9% (low-end phones) of total value added and distribution around 15% of total value.

In a later article, Shin et al. (2012) have made the analysis of the smiling curve slightly more complex by introducing three different models of enterprises: lead firms, component suppliers and contract manufacturers. Unsurprisingly, with regard to the previous findings, the lead firms and component suppliers earn higher gross income and net margins than contract manufacturers. However, one should distinguish between “active” component suppliers (such as suppliers of integrated circuits, displays and hard drives) and “passive” component suppliers which are less specialized (such as capacitors, resistors

or printed circuit boards). The active component suppliers who invest more on R&D are able to receive higher gains than passive component suppliers.

Finally, in the particular case of smartphones, another important feature to take into account is the distribution channel. These devices can be sold directly to the customers via distribution partners but are more and more often sold through an arrangement between phone makers and communication carriers (Verizon, Orange, T-Mobile etc.). In these cases, phones are partly subsidized by carriers who usually profit from subscribers fees. In many cases, carriers can benefit from a period of exclusivity from the manufacturer. Dedrick et al. (2011) demonstrate that the carriers capture the greatest share of gross profits from each phone (more than twice the per-phone profit estimates reported by phone makers in the case of Motorola and Palm). However, the net profits of carriers are less important than those of phone makers as they must invest heavily to maintain their communication infrastructure. According to these authors, subsidies are a key driver for innovation on the smartphone markets as it allows a more rapid renewal and innovative firms to cover more rapidly fixed development costs. As we will see in the case of the Chinese mobile phone producers, communication carriers can have a direct impact on the structuring of the phone market.

The results of these studies are quite striking. They demonstrate that in the ICT hardware industry a large premium is attributed to the most knowledge based activities, such as design, development or marketing, over the most labour intensive activities such as assembly. They also show the premium captured by some companies in different segments of the value chain who are able to influence its architecture through intellectual property, lock-in mechanisms and/or the definition of a new dominant design (ex : Apple, Microsoft, Intel). As Baldwin said, there is a need for “more thinking on the role of manufacturing in the development strategies” (Baldwin 2011). These researches show that enterprises’ revenues, and consequently nation’s revenues, depend more on the position in the value chain than on the simple participation in it.

### **3. Economic upgrading in a modular industry: lessons from the Chinese mobile phone industry and Taiwanese contract manufacturers**

As we saw previously, the situation in the value chain is one of the key factors explaining the level of value added for a firm and consequently for countries. However, there is no reason to consider business models or the position in the value chain as something rigid. Indeed, they can evolve over time due to different factors such as learning, shift in business strategy, acquisition of specific skills internally or externally and change in the market parameters. Following Barrientos et al (2011), we can define economic upgrading as a move to higher value added activities which can take different forms such as i) process upgrading, e.g. change in the production process aiming at increasing efficiency, ii) product upgrading, e.g. the introduction of more advanced products, iii) functional upgrading, e.g. the evolution in the activities or segments of the value chain performed by the enterprise and iv) chain upgrading, e.g. the shift to a more technologically advanced value chain. In this part, we will discuss two examples of rises in firms and nations’ competitive advantages. The first example is the rise of certain contract manufacturers’ capabilities in Taiwan from ODM model to OBM model and the second is the development of domestic mobile phone companies in China.

One of the major issues discussed in this part is the role of modularity in the development of firms. In a seminal article, Carliss Baldwin and Kim Clark (1997) have defined modular systems as “composed of units (or modules) that are designed independently but still function as an integrated whole”. In such a system, the information is partitioned between visible design rules (architecture, interfaces and



standards) and hidden design parameters (which can be secured by firms through intellectual property). Concretely, modularity has enabled companies to break up products into subsystems (the modules) and consequently permits enormous gains in terms of flexibility. The introduction of modularity in the ICT hardware sector dates from 1964 and the creation of the System/360 computer by IBM. Before this model, designs were always unique and computers used to function on their own operating system, processor, peripherals etc. The pros and cons of modularity for firms' development have been an intense subject of debate among scholars in the 2000s (Ernst 2005). We'll see in the next two examples that the modular characteristics of the ICT hardware industry permitted to extend the value chains globally and to attract new players by reducing entry-barriers but also includes limits which are somewhat difficult to overcome for certain firms as it can lead to lock-in, or "modularity traps".

### **The case of Taiwan's ODM companies: from learning with customers to competing with them**

The rise of Taiwanese ODM companies originates in the mid-1990s from the lowering of entry barriers in the notebook PC industry. This was partly due to strategic moves by Intel which began to offer chipsets for mobile uses which integrated its Pentium brand CPUs, coupled chips and second-level cache memory on a single board as a turnkey solution (Kawakami 2011). US firms such as Dell or Compaq used this opportunity to increase their market share in comparison with Japanese firms and exploited the increase modularity by outsourcing the manufacturing to Taiwanese ODMs to concentrate on conception, marketing and distribution. Thereafter, the Taiwanese market share in PC shipment rose constantly to reach 92 per cent in 2008. Another critical factor was the decision taken by the Taiwanese government in 2001 to authorize the relocation of production activities to China PRC. In 2008, production activities had finished their complete migration to China, especially in the Pearl River Delta and the Yangze River Delta.<sup>13</sup>

As discussed by Kawakami (2011), the original shift of production from US (and later Japanese) firms to Taiwanese firms in the 1990s has been facilitated by intensive technical training and knowledge transfer. For example, leading firms sent teams of engineers to train ODM suppliers in the areas of R&D, parts procurement, production management and later in product development services and logistics to adapt to build-to-order requests. ODMs also learned by serving different types of customers from different markets and for different products segments. When ODMs started to concentrate in the early 2000s after the move of production to China, the relationship between lead firms and ODMs began to somewhat rebalance and became a little more stable. This led to thicker and bidirectional exchange of knowledge on final markets and latest technologies.

One should also mention the active role of the State in implementing a national innovation strategy including multiple stakeholders (Ernst 2013). The government started to organize various fora at different levels involving academia, industry and civil society, from the National Science and Technology Conference to more specialized innovation dialogues in order to adjust short and mid-term strategies. Over time, this innovation policy has supported investment in education, infrastructure and institutional development. One of the instruments used by the government was tax incentives enabling firms to recruit highly skilled workers and develop in-house technological capabilities.

However, ODM firms are often put in an uncomfortable situation vis-à-vis the OBM leading firms and vis-à-vis the EMS. With regard to OBM leading firms, even if ODM firms managed to develop an

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<sup>13</sup> As smaller Taiwanese companies were not able to make this move to China, the migration of production has also led to a rapid concentration of PC manufacturers in Taiwan from 40 firms in the 90's to only 19 in 2008.

“intrinsic core” of knowledge, their profitability did not increase substantially<sup>14</sup> because the main product terms are decided by the leading firm and because of their remaining high level of substitutability. The market power of Taiwanese ODMs towards OBM leading had remained weak and prevented them from raising price and increase profitability. Ernst (2013) presents the Taiwanese ODMs position as a “commodity price trap” which does not allow them to support enough investment in R&D and intellectual property. Consequently, these enterprises concentrate exclusively on incremental innovation within existing product architectures defined by OBMs. Moreover these companies have limited market power over suppliers of parts and components because those are either purchased specifically on behalf of their customers or negotiated directly between lead firms and semiconductor companies (Sturgeon et al., 2010). On the other side, with regard to EMS, ODM generally focused on a considerably smaller set of products, mainly notebook PCs. According to Lüthje et al. (2013), it can cause a higher vulnerability to economic fluctuations for ODM as they are less able to mitigate through diversification. For these reasons and also because Taiwan gradually lost its cost-competitiveness in comparison with latecomer economies such as China or India during the decade, several Taiwanese companies tried to switch their business models from ODM to OBM and consequently develop their own brand. Such an evolution has been nevertheless hazardous for most of them as it put the firms in competition with their more powerful customers (Sturgeon et al., 2010) and imposes to establish distribution channels and develop marketing capacities (Yan, 2012).

In order to face the competition dilemma, several Taiwanese firms have been obliged to dissociate legally their OBM activity from the former ODM contract manufacturing arms. The first company which engaged in this path was Acer which developed two spin-off businesses in 2000-2001: Wistron for contract manufacturing and BenQ for customer electronic equipment and phones (after the acquisition of Siemens’ mobile branch). Asustek did the same in 2008 when it spun off Pegatron. These success stories have also been made possible thanks to the successful launch of ultra-low cost portable PCs (netbook) such as the EeePC developed by Asustek and the relative slow adaptation of traditional US or Japanese PC leading firms to this new demand. According to Shin et al. (2012), Acer’s financial performance improved substantially after the spinoff (return on investment climbed from 0.9 in 2001 to 7.9 per cent in 2002 while the net margin went from 0.9 to 8.1 per cent) and largely outperformed its spun-off firm, Wistron. In 2009, Acer managed to reach the second rank in terms of total selling behind HP but before Dell (Gartner, 2010).<sup>15</sup> According to Sturgeon et al. (2010), Acer’s success has to do with its geographical and cultural proximity with ODMs which allows the firm to bargain over trade and with its excellent knowledge of business conditions on component availability and costs.

Another example of a successful shift from ODM to OBM was the company HTC. In the early 2000’s, HTC was the first ODM producer of PDA for leading international brands. The company entered the then emerging market of smartphones thanks to its agreements with important international communication operators for the supply of operator-branded cell phones. This new alliance was a means for operators to circumvent their established brand-name partners (Lüthje et al. 2013). HTC has been chosen by Microsoft and Deutsch Telekom for the development of a new operating system for mobile phones aiming at competing with the global alliance led by Nokia for the development of Symbian. Later, in 2007, HTC took part in the international consortium with Google, Sony and Samsung set up to develop open standards for mobile devices. At the beginning, investors were doubtful about this new strategy which positioned HTC in competition with its own customers, and company’s stock price more

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<sup>14</sup> For example, the return on assets ratio (ROA) of one of the leader on the market, Quanta, decreased from 50 per cent in 1997 to less than 10 per cent in late 2000’s (Kawakami, 2011).

<sup>15</sup> Acer have since disappeared from the top five (Gartner, 2016a).



than halved between the end of 2006 and the beginning of 2007. However, in the same year, HTC launched its first own branded phone and in October 2008 was the first company to make commercially available a smartphone running Android, the HTC Dream. The firm managed thereafter to gain substantial market shares until the early 2010's. According to Yan (2012), the success of HTC has been globally built on the close cooperation with the providers of open sources operating systems, Microsoft and Google, and large investment in R&D.

### **The case of domestic phone companies in China: beyond the modularity trap?**

The development of a domestic mobile phones industry in China attracted the attention of several scholars in the last years (Zhu et al. 2010, Imai et al. 2011, Kimura 2014, Brandt et al. 2011). Following a first phase till the end of the 1990s during which the market was almost entirely dominated by foreign firms, domestic firms expanded rapidly in a fast-growing market, from 5.3 per cent of the market share in 1999 to 52.9 per cent in 2003. This phase has been defined by Brandt et al. (2011) as an era of “state-managed development”. The rapid expansion of domestic firms can be explained by two main reasons. The first reason is the adoption of an industrial strategy by the government in order to favor domestic firms (introduction of license system as an entry barrier, subsidies for R&D, local content requirements to foreign firms). The second reason comes from the comparative advantage of domestic firms in the sales stage. In particular, domestic firms were more involved in the distribution channels allowing them to better control distribution margins and prices. One should mention that unlike many western markets, the Chinese market remained open (not operator-driven) until recently. As explained by Kimura (2014), domestic firms developed their own sales channels with a strong presence at the provincial and local levels while foreign firms used to work with national distributors. It permits these firms to gain markets shares in small and medium-sized local cities and rural areas where the demand for low-end mobile phones was high. Yet, almost 2/3 of the mobile phones sold locally by domestic firms were in fact produced by Korean or Taiwanese ODMs under white-brand. Because of the lack of development capabilities of domestic firms, these foreign enterprises could get around the protectionist measures adopted by the government. This era came to an end when foreign firms started to change their strategies by providing low-end handsets and to reorganize their distribution channels. Subsequently, foreign firms regained market shares.

The second phase which begun in the mid-2000s, is undoubtedly marked by the rapid expansion of unlicensed enterprises called “Shanzhai”<sup>16</sup>. These firms are generally unauthorized by the government as they do not have a legitimate network identity numbers and do not pay taxes. They also often violate intellectual property rights, copying world-leading mobile brands, and neglect tests and certification. According to Brandt et al. (2011), these unauthorized firms managed to recover more than 20 per cent of the market share in the late 2000s. During this second phase, both legal and illegal domestic enterprises started to compete seriously with foreign firms thanks to an increase in the modularity of the value chain resulting from the technological progress made by a Taiwanese semiconductor firm called Mediatek (MTK). In 2004, MTK managed to integrate the baseband platform and multimedia data processing on a single chip which resulted in a reduction of their size and their price and allowed to add other functions to the phone (such as a MP3 player). The company also provided software for multimedia functions (music and video) with its platform. The easy-to-use MTK platform has been largely adopted by domestic firms<sup>17</sup> and lowered the barrier to entry for small firms because it provided

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<sup>16</sup> According to Zhu et al. (2010), “Shanzhai literally means “mountain village” in Chinese. The origins might stem from the medieval period when illegal products were produced far away in a remote mountain village, away from the law, as an act of rebellion against the emperor”.

<sup>17</sup> According to Kimura (2014), the acceptance of MTK platforms among Chinese mobile firms surged from 13

a complete solution for manufacturers and allowed them to rapidly change the functionality of the products. Domestic firms could create their own products and save on costly R&D investment. Domestic firms became more reactive to market demand than foreign firms and could better exploit market niches. These niches were not attractive for volume-oriented foreign firms with high fixed-costs. However, an intense competition in the low-end phone market resulted from this technological shift.

Some have seen the increase in modularity permitted by the adoption of the MTK platform and the expansion of Shanzhai firms as a great chance for the development of the Chinese industry (Zhu et al. 2010, Gao 2011). Nevertheless, following Brandt et al. (2011), we can express strong reservations about this opinion as regards to the sustainability of this production model. These authors see the MTK solution as a “double-edged sword” at the same time allowing firms to overcome the technology gap and intensifying the competition. In such a situation, the key of success lies in the capacity to differentiate the products which is only possible if there are sufficient internal capabilities inside the firms to shape the look and the functions of the handset. Foreign firms and a few leading domestic enterprises have been able to change the nature of their relation with MTK, from a purely modular transaction to a relational transaction, and consequently adapt the platform to their needs. Moreover, due to their limitations in hardware, software and internet capabilities, most of domestic phone companies were not able to accompany the movement towards an improvement of customer’s experience (slimmer phones, better battery life, screen resolution etc.).

In addition, another element has since worked to the detriment of the smallest domestic firms: the increasing share of the operator-driven market in China (which is supposed to become predominant in the coming years). This change has deep implications for small domestic firms whose competitive advantage was their flexibility to market demand. It is unquestionably raising entry barriers on the market as few communication operators<sup>18</sup> are more able to put pressure on prices and quality than a myriad of individual customers. Telecom operators are also generally unwilling to work with too many handset makers. This new situation has been largely advantageous for new domestic players such as Huawei, Xiaomi or Oppo who emerged in the late 2000s and early 2010s. Huawei who was initially a telecommunication and networking equipment manufacturer with important R&D capacities, has already a long experience with operators. The company first entered the mobile phone market as an ODM providing unbranded device for communication operators such as Vodafone or Orange (recalling the previous success of Taiwanese HTC). The company started to sell branded phones in Europe in 2009. Since then, and because of a continuous improvement in the quality of the products and large investment in marketing, the sales have never stopped to grow to reach the third rank for smartphones after Samsung and Apple in 2016 (Gartner, 2016b).

Several lessons can be drawn from these two cases. First, certain comparative advantages can be only temporary such as the advantage of Chinese mobile phone companies on sales stage and market knowledge in the early 2000s. Second, the adoption of external technology facilities such as Intel or MTK chipsets can foster the development of local competitors as it lowers the entry barriers on the market. But it might also turn out to be a disadvantage, or a “modularity trap”, in the longer term for the less technology-capable firms when market conditions change such as the shift to an operator-driven market and when local demand and the increasing competition push for more product differentiation. Third, the shift from a low-margin ODM activity to a potentially more profitable OBM activity is risky at it often takes place in a situation of competition with its own customers. So far, the successful

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per cent in 2004 to 71 per cent in 2005.

<sup>18</sup> At that time, there were only three mobile communication operators in the country : China Mobile, China Telecom, and China Unicom

companies have been obliged to legally separate their manufacturing activities from their branded activities and to rely on favorable market circumstances such as the boom in netbooks or smartphones markets or strategic alliances with communication operators.

#### 4. Factors of future changes in the sector

The ICT hardware industry is mainly characterized by low production cost and fast innovation (Lüthje et al 2013). This model has implied a large vertical disintegration of firms and massive relocations of jobs and productions to cheaper countries. How is this production regime going to evolve in the next years? The answer will stem from several factors which need to be monitored.

The first series of factors are related to the evolution of demand for ICT hardware in the next years. The growth in the sector has been mainly fuelled in the past decade by the demands for components and communication equipment such as smartphones while demands for computer and domestic electronic equipment have globally stagnated. A few years ago, analysts observed a divide in phone market between two large segments, one high-end and another low-end<sup>19</sup> (Dediu 2012). These two sub-markets allowed both well established firms to grow in the high-end market and new entrants from emerging market, especially China, to progressively grab market shares. The situation is changing now and analysts foresee a prolonged deceleration in the smartphones market.<sup>20</sup> Global smartphones sales should exhibit for the first time a single-digit growth in 2016 and the worldwide shipment for ICT devices in general is forecasted to increase by only 0.6 per cent. The demand for smartphones will continue to grow at a slower pace in emerging markets and will be mainly alimanted by the Indian market where three of the five biggest sellers are already domestic firms (Micromax, Intex and Lava)<sup>21</sup>. At the same time, analysts expect an increase in the lifetime of mobile phones in mature countries. The demand for PC computers is expected to decrease slowly at the global level in the coming years.<sup>22</sup> These evolutions of final goods will in turn affect the demand for components. Consequently, certain ICT leaders such as Samsung are already looking for new growth drivers such as the car industry.<sup>23</sup> Progresses in Advanced Driver Assistance Systems (ADAS) could be a source of growth for these firms which could become in a few years credible competitors for automotive equipment makers.

The second series of factors are related to evolutions in the supply chains. According to Lee and Gereffi (2013) and Raj-Reichert (2015), the geographical concentration of contract manufacturers has already increased their influence in GVCs. Other factors such as the upgrade in their capabilities organically or through acquisition and the diversification to other final markets should also have an impact on their relation with leading firms. It will be interesting to see if it changes in the future the distribution of gains in the value chain. Besides, even if the relocation to cheaper location has been globally the rule for production activities in the last decades, outsourcing practices have remained quite different across firms. As we saw earlier, business strategies can be completely different for equivalent devices (Samsung vs Apple). However the nationality of the leading firm also matters for outsourcing relationships. Sturgeon et al. (2011) have shown that US and Japanese lead firms have generally

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<sup>19</sup> Asymco.com, 2012, The phone market in 2012: a tale of two disruptions, May 3

<sup>20</sup> Gartner, 2016, Gartner says global smartphone sales to only grow 7 per cent in 2016, Press Release, March 31

<sup>21</sup> Source : Canalys

<sup>22</sup> VIPress.net, 2016, IDC abaisse ses prévisions de croissance pour les PC et les smartphones, Press release, June 13

<sup>23</sup> Jullien, B., 2015, L'automobile: nouvel eldorado pour l'électronique mondiale, Le blog du Gerpisa, 14/12/2015

different outsourcing policies, in terms of durability for example, which in turn results in different learning or upgrading opportunities for suppliers.

Evolutions in demand and in supply chains should both impact the geography of the industry in the future. The concentration of production towards East Asia, and especially China, have been rapid in the last decade. The upgrade in capabilities of Chinese contract manufacturers and the emergence of domestic global leaders such as Huawei and Lenovo will continue to impact other actors from the United States, Europe and Japan but also from Korea and Taiwan. The development of cheaper locations, such as Viet Nam, should also be monitored to see if these countries benefit from the increase in Chinese production workers' wages in the future. It will also be interesting to see the evolution of the industry in countries such as Mexico and Central Europe which are highly dependent on their close neighbors. Recent studies have shown that the transformation of these national industries to a model of higher value added and lower volume of production has not led to a parallel upgrading in local suppliers (Plank et al 2013, Sturgeon et al. 2010). This may compromise the development of Mexican and central European ICT industries in the longer term. Finally, the case of the Indian industry should be specifically scrutinized. Even if this industry relies at the moment too much on imported parts from overseas (Pratap 2013, Saripalle 2015), the country is already a global leader in IT services (software and business services). Will the Indian firms be able to seize the opportunities of a rapidly growing domestic market and expand their influence abroad in the future?

Finally, the last series of factors are related to the organization of work itself. One of the biggest challenges in this domain concerns the potential for automation in the most labour intensive activities such as assembly. In 2011, the largest company in the sector in terms of employees, Foxconn, announced that it would replace progressively its workers by robots. The company expected the automation to account for 70 per cent of the assembly work in three years.<sup>24</sup> With a reduction of 60,000 jobs reported in May 2016<sup>25</sup>, this expectation has not been met due primarily to technical reasons. The robots created by Foxconn itself, the Foxbots, are not precise enough, especially for high-end devices such as the iPhone.<sup>26</sup> Nevertheless, the automation strategy has not been abandoned and further technological progresses may lead to a reduction in the precision gap in the future. Nonetheless, the volatility of the ICT hardware market imply a high level of flexibility for contract manufacturers. This requirement may slow down their path to automation as it necessitates important and repeated investments over time.

## Conclusion

This paper explores the evolutions in the ICT manufacturing sector since 2000 and takes stock of the distribution of jobs and value added across firms and across countries. During this period, due to an increasing product modularity, this industry has deepened the ongoing trends of vertical disintegration, specialization, outsourcing and relocation of production to cheaper countries. Most of the production activities have migrated to East Asia and particularly China and firms in North America, Western Europe and Japan have specialized in more strategic and high-level skills such as design, development and marketing. This trend has also later impacted Korean and Taiwanese firms. The growing interlinkages of economies have greatly benefited to East Asian economies which became a major supplier for final goods but also for components.

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<sup>24</sup> Computerworld.com, 2015, Foxconn's CEO backpedals on robot takeover at factories, June 26

<sup>25</sup> Fortune.com, 2016, iPhone maker Foxconn has replaced 60,000 human jobs with robots, May 26

<sup>26</sup> Extremetech, 2014, Foxconn's robotic workforce isn't precise enough to assemble iPhones, December 8

The evolution in terms of employment has been much contrasted across countries. Two thirds of all jobs in the industry are now located in China. Aggregate and firm level data show large relocations between developed and emerging economies. Nevertheless, these changes have not led to a shift in the distribution of value added of the same magnitude. This apparent paradox is largely explained by the vertical specialization of firms and countries. Leading brand-name firms and platform leaders providing key and often non-substitutable components still capture a large share of the value added. On the contrary, the level of value added captured by labour intensive activities such as assembly remain minor.

However, the position of a firm or a country in the value chain can improve (or deteriorate) over time. Conditions for economic upgrading are often specific to products or industries. The two examples of Taiwanese contract manufacturers and Chinese mobile phones manufacturers give a good overview of pros and cons of the ICT product modularity. Increased modularity helped to lower the entry barriers for local new comers but also turned to be a disadvantage for some of them in the longer-term because they were not able to technologically upgrade or adapt to new market realities. Migrating from a status of contract manufacturer to a status of brand-name leader also involves risks. The successful companies had been often obliged to split the two activities and rely on new partnerships with external stakeholders such as communication operators.

This article has been mainly focused on the role of enterprises in the economic development. Future research should however give a special attention to the changing role of public authorities in this new phase of globalization where the logic of industrialization shifted from the sectorial level to the stages of production level (Baldwin 2011 and 2013). According to Milberg et al. (2013), the prominence of global value chains “alters the terrain of action for developmental states”. For governments of industrializing economies, one of the question is, of course, to know how to better accompany firms to take advantage of global value chains for economic upgrading. This implies to take into account the role of lead firms, facilitate the creation of national and transnational networks of suppliers, allow positive spillovers between sectors and invest in the relevant skills. Another key question for governments is also to enable a joint economic and social upgrading through global value chains. The link between the two processes is not necessarily positive (Barrientos et al. 2011). For example, the evolution to higher value added segments of production could often be at the expense of employment or sometimes not lead to better wage and working conditions. At the moment, available case studies provide a mixed picture on this issue, including in the ICT hardware sector<sup>27</sup>.

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<sup>27</sup> At the moment, the relation between economic upgrading and social upgrading in the ICT hardware sector has only been very partially analysed. To our knowledge, the only quantitative studies carried out are related to the manufacturing of mobile phones. All of them are based on the methodology developed by Bernhardt et al. (2013) whereby economic upgrading is defined by the simultaneous increase in export unit value and export market share and social upgrading by a simultaneous increase in employment and real wages. In the latest study (Bernhardt et al. 2015) which covers the 35 main producers between 2000 to 2012, the authors identify only six countries where economic upgrading was parallel to social upgrading (Hungary, Czech Republic, Taiwan, Romania and Morocco). In the main producing sector, China, these authors detect a social upgrading and economic downgrading caused by a decrease in the export unit value.



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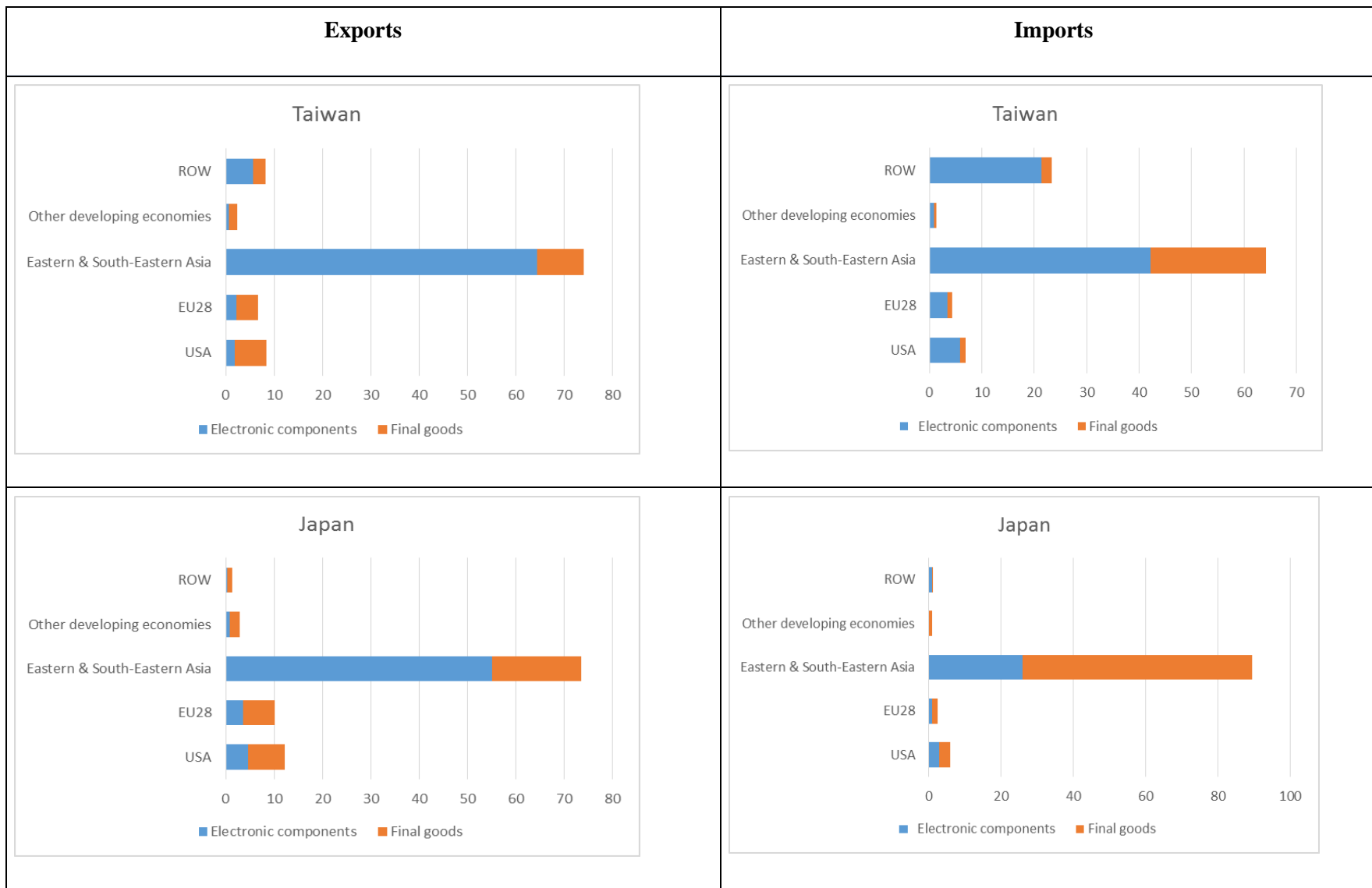
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## Appendix

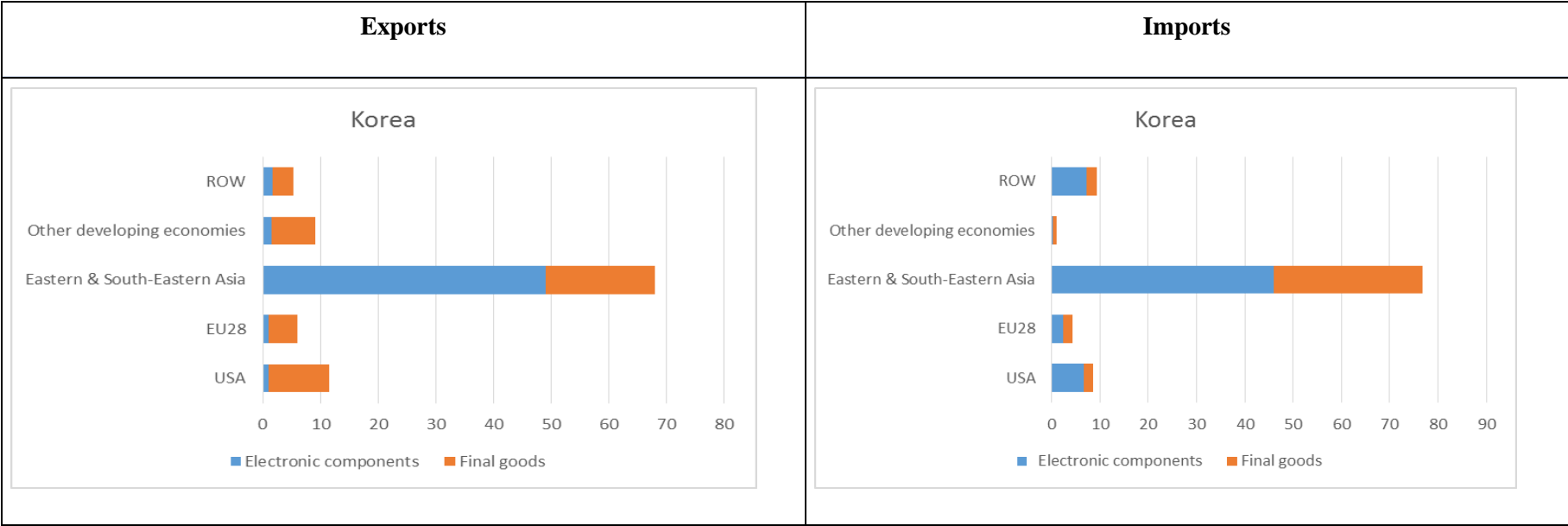
**Table A1 – ICT products included in employees estimate**

Classification	Code	Definition
ISIC Rev 3.1	3000	Manufacture of office, accounting and computing machinery
	3210	Manufacture of electronic valves and tubes and other electronic components
	3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
	3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
ISIC Rev 4	2610	Manufacture of electronic components and boards
	2620	Manufacture of computers and peripheral equipment
	2630	Manufacture of communication equipment
	2640	Manufacture of consumer electronics

**Figure A1 - Bilateral trade of Taiwan, Japan and Korea by main partners (per cent of the total)**

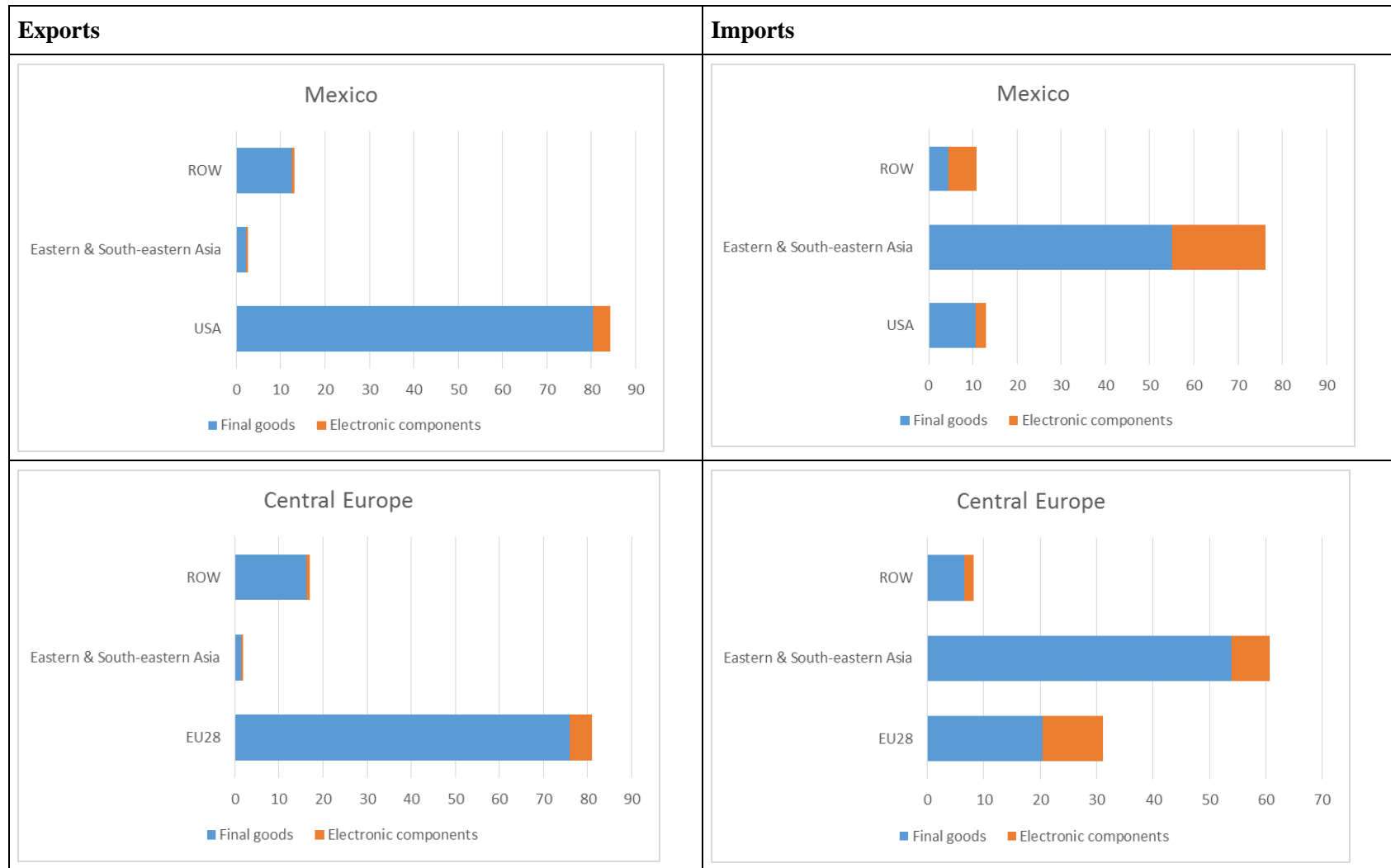


**Figure A1 – continued**



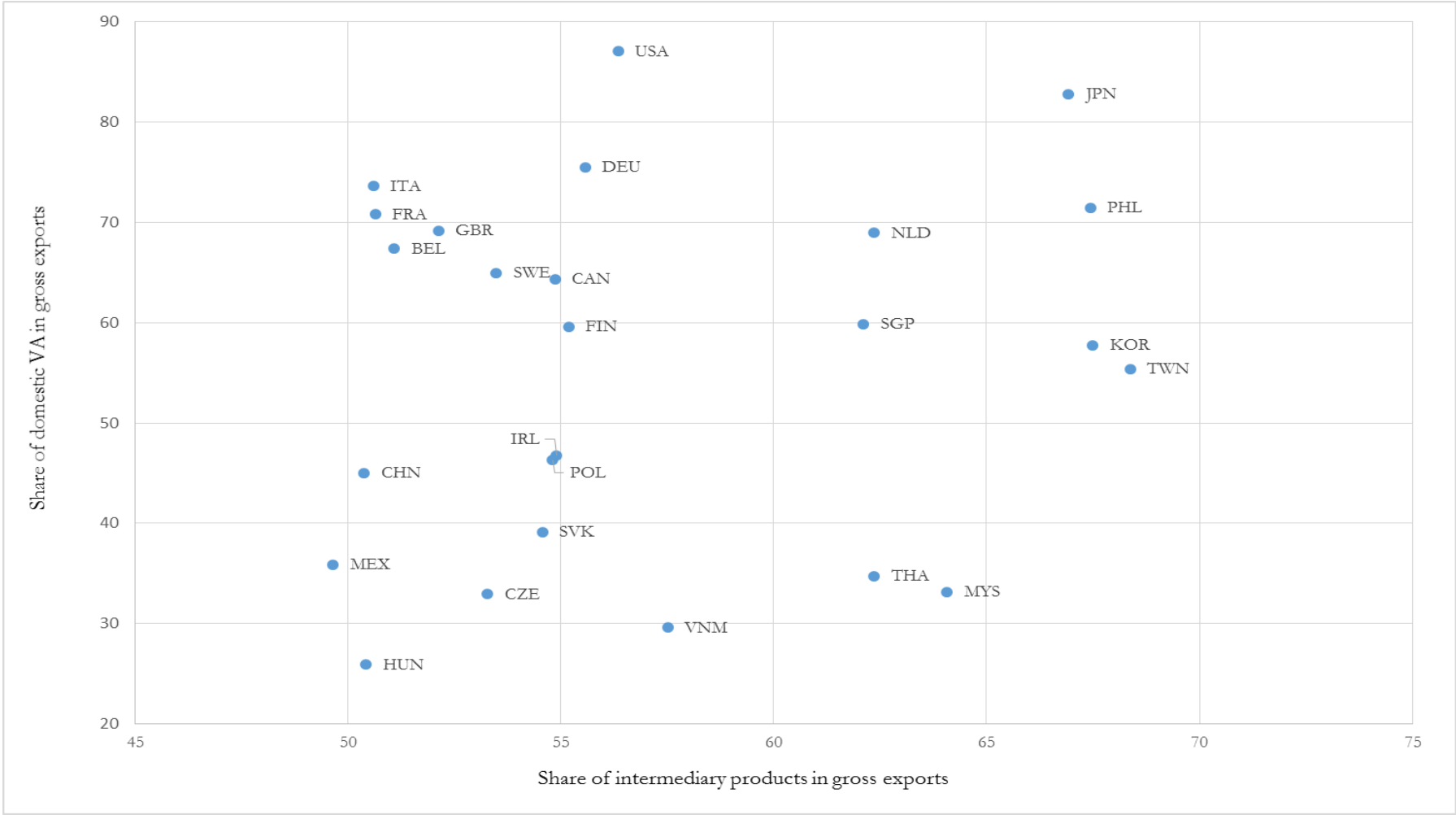
Source : Author’s own calculation based on UNCTAD.

**Figure A2 - Bilateral trade of Mexico and Central European countries by main partners (per cent of the total)**



Source : Author's own calculation based on UNCTAD

**Figure A3 - Shares of intermediary goods in exports and domestic value added in gross exports in Computer, Electronic and optical equipments (per cent)**



Source: Author's own calculation based on OECD TiVA database