

De Prato, Giuditta; López Cobo, Montserrat; Simon, Jean Paul

**Conference Paper**

## Dynamics of ICTs: assessing investments in R&D. A global cross-comparison

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**Paper prepared for the 14 the ITS Asia Kyoto, June 2017,  
« ICT and Economic Growth” session”**

**Dynamics of ICTs: assessing investments in R&D. A global cross-comparison<sup>1</sup>.**

*Giuditta De Prato, EC JRC Dir B, Montserrat López Cobo, EC JRC Dir B, Jean Paul Simon,  
JPS Public Policy Consulting, Spain*

*Abstract:* The paper describes the dynamic features of the ICT sector today, through a comparison among countries of the evolving role of investments in R&D in ICT. 41 geographical areas are analysed: 28 European member states, the EU as a whole, the United States, Canada, Australia, five Asian countries (Taiwan, South Korea, Japan, China and India), three European countries not belonging to the EU (Russia, Norway and Switzerland) and one Latin American country (Brazil). The analysis has been made possible by the development of comparable long time series (from 1995 to the most recent year, 2014 or 2015 depending on the indicator), based on official sources and covering an array of indicators related to the ICT content of economic activities, with a focus on R&D.

*Key words:* *Business R&D expenditures (BERD), ICT share of the economy, labour productivity, employment, international comparisons, specialisation in ICT production, R&D personnel, value added, digital transformation.*

In a global economy rapidly becoming digital, Information and Communication Technology (ICT) industries are at the core of innovation and the transformation of economic systems. While the digital economy sector has been resilient to the crisis, ICT enterprises have higher survival rates than their counterparts in manufacturing and services and the ICT sector outperformed the rest of the economy in terms of net business population growth between 2009 and 2012, with higher than average shares of medium and high-growth firms (OECD, 2014). As shown in the paper, the ICT sector productivity per person employed was higher than for total economy in all the countries of the sample used. Besides, ICT industries lead the globalisation of value chains, Apple’s iPhone being a notorious example (De Prato & al, 2013). ICT sector related goods are indeed amongst the more globalised with now ICT services growing faster than ICT goods.

Besides, as emphasized in the Global Innovation Index (2016), the re-emergence of China and India as large markets and manufacturing powers has been one of the most significant events of the beginning of the 21st century. As of 2015, China and emerging Asia became the global growth engines with 2/3 of global GDP growth (63% of the total), as opposed to North America, Europe, and Japan in 1985 (KPCB, 2016, IMF, 2017). This, by and large, is predicated on the role of the ICT within their economies (Simon, 2017a). For instance, the

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<sup>1</sup> Disclaimer: The views expressed in the present work are purely those of the authors and may not under any circumstances be regarded as stating an official position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this work.

OECD 2012<sup>2</sup> report recalls how the participation in global ICT trade networks and global ICT value chains has been pivotal to China's economic success.

A comparatively high R&D intensity and productivity level are distinctive features of the ICT sector common to all the countries analysed in this paper, which qualify the sector as strategic for innovation and productivity growth. One way to assess the role of the ICT industry and to gauge the size of the digital economy is to concentrate on some indicators. Therefore the paper looks at the following indicators: business R&D expenditures (BERD), ICT share of the economy (in terms of value added), labour productivity, employment, specialisation in ICT production (manufacturing, telecommunications, and services), R&D personnel, intangible assets and trade, and value added.

Indeed, the research project "Prospective Insights on ICT R&D" (PREDICT) provides indicators in a wide variety of topics, including value added, employment, labour productivity and BERD, distinguishing fine grain economic activities in ICT and media and content industries (up to 22 individual activities, 14 of which at the class level, i.e. at 4 digits in the ISIC<sup>3</sup> classification)<sup>4</sup> and at a higher level of aggregation for all the other industries in the economy. It also produces data on Government financing of R&D in ICTs, and total R&D expenditure at the country level.

PREDICT<sup>5</sup> is a joint research project of the European Commission (EC) Joint Research Centre (JRC) and of DG CONNECT, which since 2006 has been carried within the Information Society Unit first and then the Digital Economy Unit. The PREDICT project has become a unique source of information on the ICT sector and on ICT R&D in the EU and its global competitors. It has produced annual reports, marshalling data and documenting trends. PREDICT relies on the latest available official statistics delivered by countries, Eurostat and the OECD. The project has been designed to help policy makers understanding dynamics in the ICT sector and fostering its growth.

The 2017 PREDICT Dataset is based on the latest data available from official sources (mostly National Accounts and R&D statistics), and it includes the novelty of backwards reconstruction of the series from 1995, thus covering the period from 1995 to 2014. Therefore, it allows a long-term analysis of the EU ICT sector and its R&D, covering a whole cycle since the initial expansion years, the double recession that began in early 2008, and the most recent evolution up to 2014.

The paper draws on the 2017 PREDICT Key Facts Report, but concentrates on the first two sections<sup>6 7</sup> of the report: the global overview and the comparison of the EU with other economies.

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<sup>2</sup> For India see OECD (2010).

<sup>3</sup> United Nations' international standard classification of economic activity ISIC: ISIC rev.4; United Nations, 2007.

<sup>4</sup>

<http://www.oecd.org/science/scienceandtechnologypolicy/38217340.pdf>

<sup>5</sup> More information, data and reports produced by the PREDICT project are available online at the project website: <https://ec.europa.eu/jrc/en/predict>

<sup>6</sup> Section 3 (pp.44-103) deals with the analysis of the ICT sector and sub-sectors and its R&D in the EU and Member States.

<sup>7</sup> The classification followed in section 2, departs from the OECD (2007) classification as it does not include the ICT trade industry (NACE Rev. 2 465) and Manufacture of magnetic and optical media (NACE Rev.2 268).

The PREDICT report show that the European ICT sector maintained its value added overall share in the European GDP around 4% through the crisis years, that the amount of resources devoted to R&D in the ICT sector is still about 4 times the economic weight of the sector, and its labour productivity is about 50% higher than the economy-average. A comparatively high R&D intensity and productivity level are distinctive features of the ICT sector common to all countries analysed,<sup>8</sup> which qualify the sector as strategic for innovation and productivity growth.

### **1. The ICT sector: With US leading and China moving upwards, where does Europe stand?**

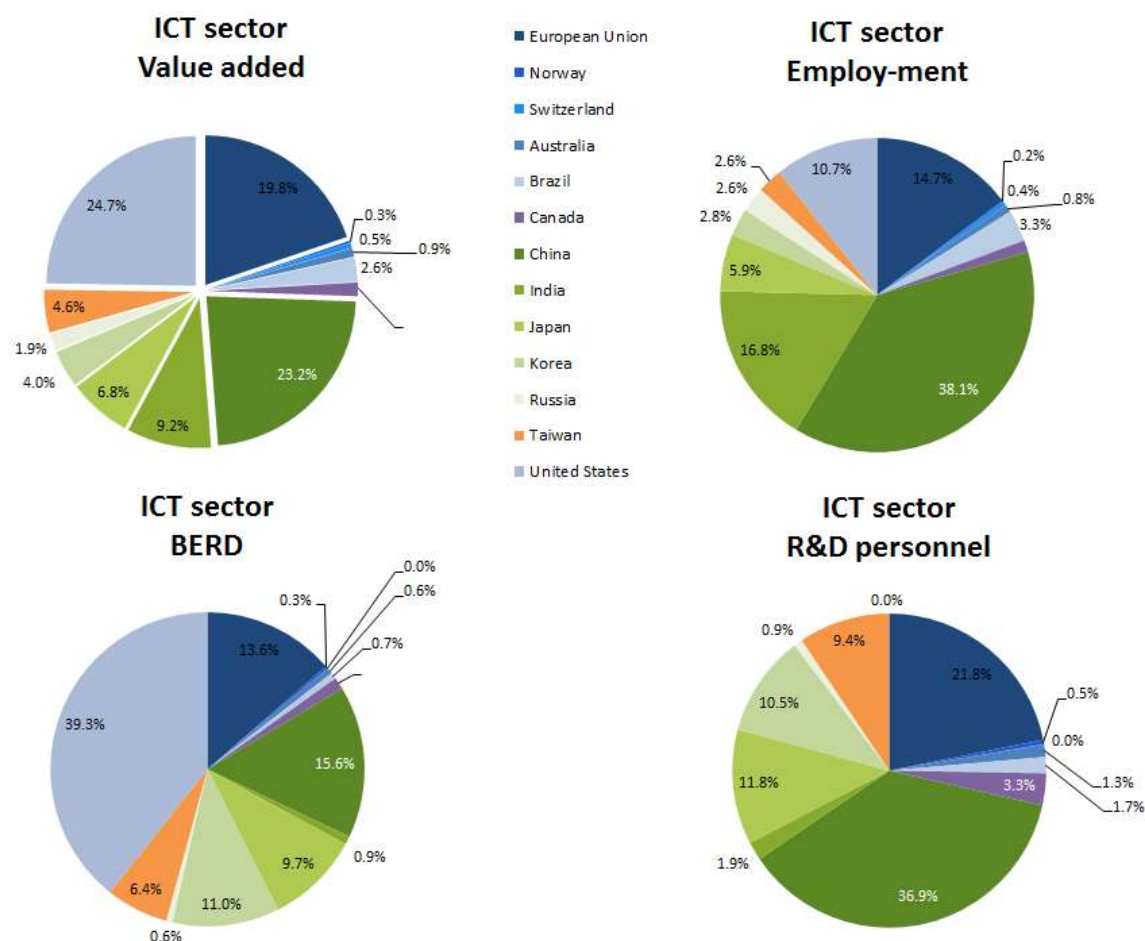
For some indicators used (ICT value added, ICT employment, and R&D workforce) the size of a country influences the share of the country in the aggregate. A large country is more likely to have a large share in the sample aggregate. However, this may not account for the efficiency level at which ICT assets are used within each domestic productive system. Therefore, intensity ratios (e.g. ICT R&D spending/Value added) are introduced to further refine the first glimpse provided by country levels. Figure 1 gives an overview of some of these indicators in the selected countries.

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Due to lack of data for these two sectors, particularly for non-EU countries, the operational classification allows the comparison of the data in a long term perspective and with non-EU countries. See Appendix 1: List of NACE Rev. 2 ICT sub-sectors. Operational definition.

<sup>8</sup> The 41 geographical areas analysed in the 2017 PREDICT report are the 28 European member states, the EU as a whole, the United States, Canada, Australia, five Asian countries (Taiwan, South Korea, Japan, China and India), three European countries not belonging to the EU (Russia, Norway and Switzerland) and one Latin American country (Brazil).

**Figure. 1: Economies percentage shares in ICT sector value added, employment, and BERD (PREDICT geographical coverage, 2014)**



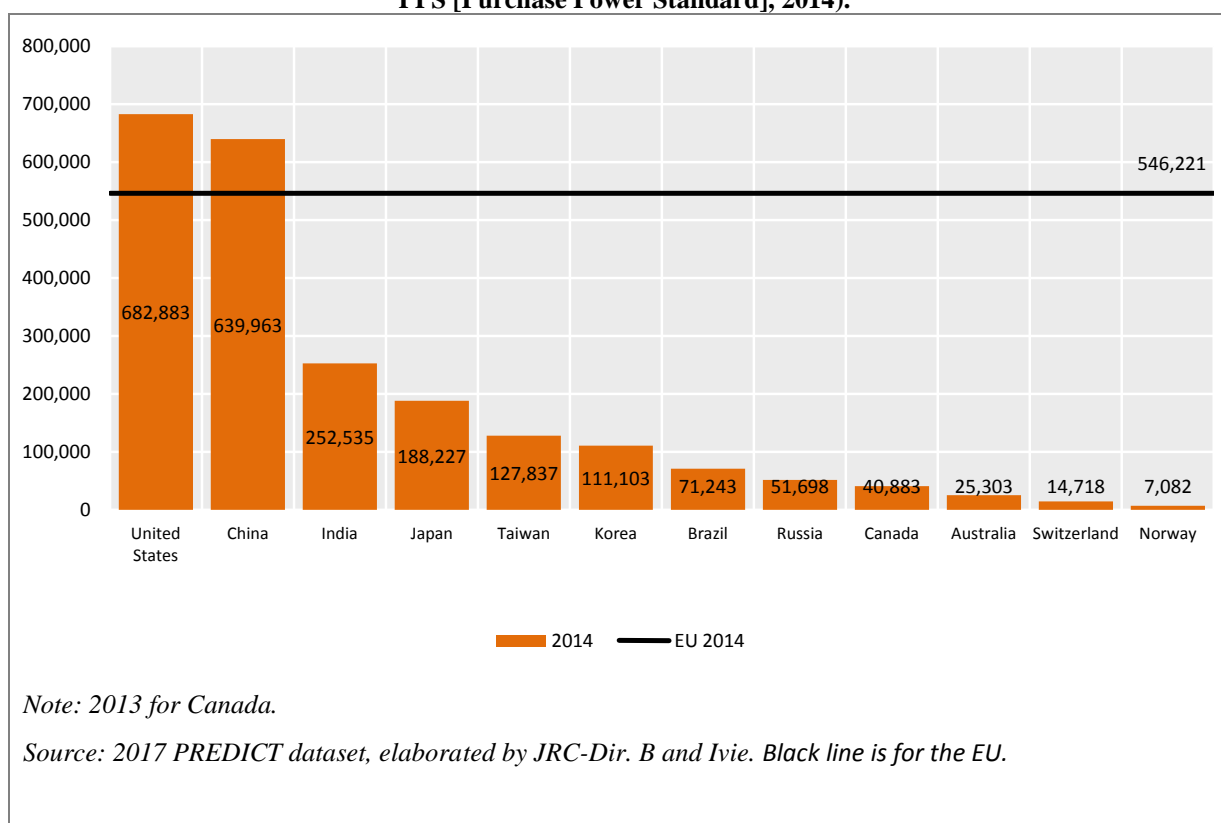
ICT value added: 2013 for Canada. ICT R&D personnel and BERD: 2011 for Brazil, 2012 for Switzerland and India and 2013 for Australia. ICT R&D personnel: United States not included because of lack of homogeneous data. ICT Totals correspond to the operational definition.

Source: PREDICT Key Facts Report 2017.

### *Value added*

Among the countries analysed in the 2017 PREDICT report, the US enjoys the highest share in ICT sector value added (ICT VA weight on total economy: 5.3%) in 2014. China has been quickly moving upward since 2001 (4.7 % ), and in total ICT VA is now ranking second in millions of current euros (PPS), overtaking Japan since 2001, and the EU since mid-2011, earlier than for the VA for the total economy as China overpassed the EU in 2013. Both countries exceed 600 billion euros PPS. EU ranked third with over 546 billion euros long away from the rest of Asian countries. US, China and the EU together represented two-thirds of total ICT VA for the sample of countries. Australia, Switzerland and Norway were the lowest in the ranking (Figure 2).

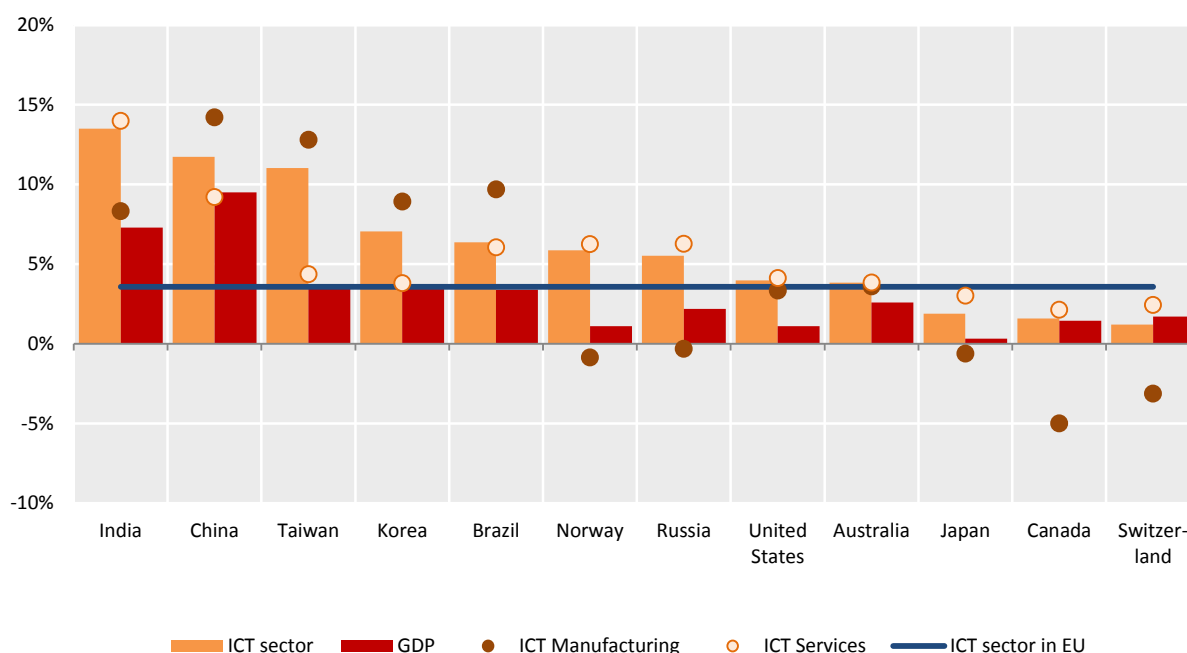
**Figure 2: ICT sector VA in the European Union and other non-EU economies (millions of current EUR PPS [Purchase Power Standard], 2014).**



Between 2006 and 2014, the Asian countries, except Japan, led the real growth rate of ICT sector VA (and also GDP). India, China and Taiwan grew sharply, over 10%, whereas ICT sector growth in Japan, Canada and Switzerland did not exceed 2%. EU had a similar growth as the United States and Australia, around 4%. All the sample countries presented positive ICT sector growth.

Additionally, all the countries experienced positive growth rates in ICT services, ranging from 14% in India and 9.2% in China to 2.2% in Canada. However, the ICT manufacturing sector VA decreased in Norway, Russia, Switzerland and Canada (Figure 3).

**Figure 3: Mean annual real growth rate of ICT sector VA and GDP in the European Union and other non-EU economies (2006-2014).**

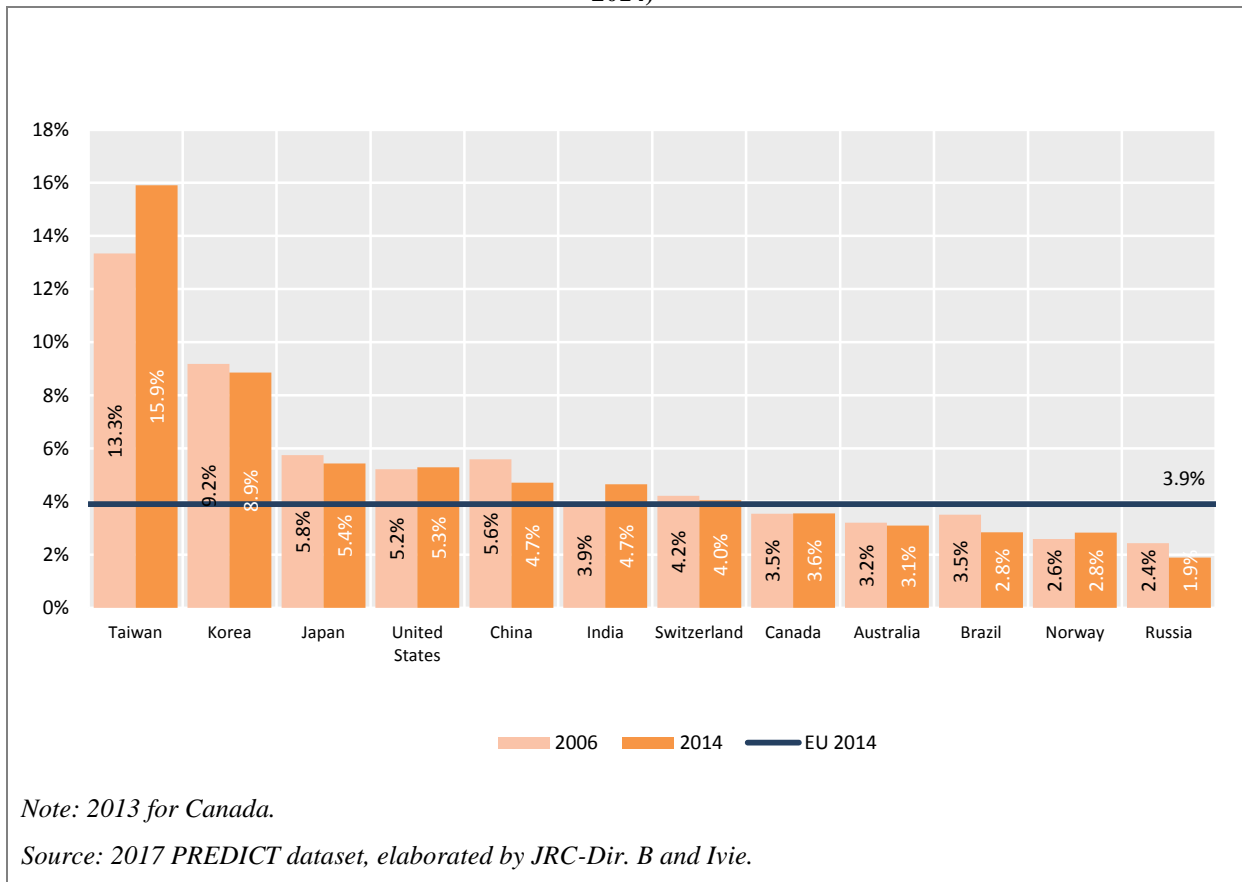


*Note: 2006-2013 for Canada.*

*Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.*

The importance of the ICT sector is very unequal among the countries considered. The five Asian countries, together with the US, have the highest share of ICT sector VA in their GDP. It confirms the role of the ICT sector in their economies. Taiwan and India experienced the strongest growth in this share. The EU ICT VA share was 3.9% in 2014, which represents an intermediate position among the countries shown (Figure 4). In seven countries, this share decreased between 2006 and 2014 (Switzerland, South Korea, Japan, China, Australia, Brazil and Russia). However the reason for such a decrease may quite vary, for instance in the case of China it may signal a reshuffling of the ICT industry. The case of Russia may be more difficult to account for as the Russian IT market is still developing even in the context of a significant reduction in total sales amount, according to Russoft (2016).

**Figure 4. ICT sector VA share of GDP in the European Union and other non-EU economies (2006 and 2014)**



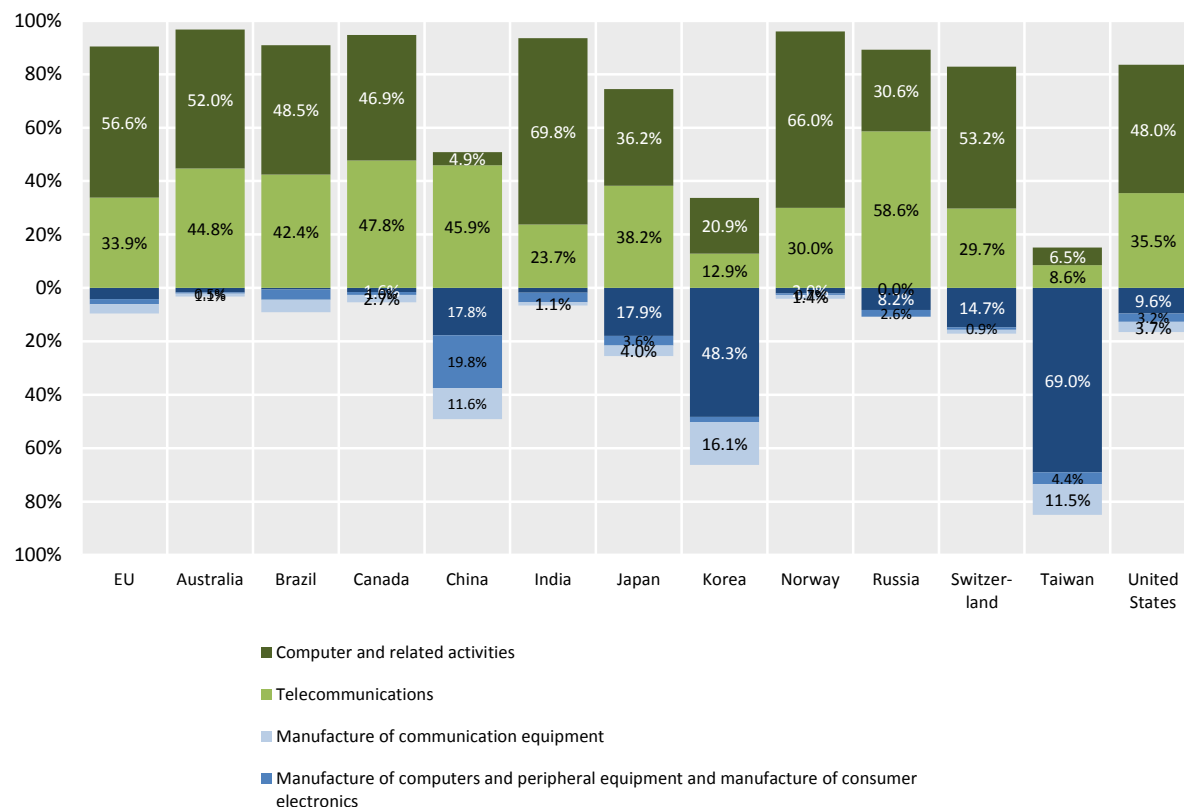
### *Specialisation in ICT production.*

The dynamics of ICT industries are displaying regional differences between manufacturing and services, and an uneven weight of the ICT sector throughout countries. Figure 5 shows the degree of specialisation measured in terms of percentual disaggregation of VA by sub-sectors. The weight of the ICT manufacturing sector is highest in Taiwan and South Korea.

Taiwan, South Korea and China have a strong specialization in ICT manufacturing (communication equipment, computers, consumer electronics, and electronic components) as illustrated by figure 5 (blue sections at the bottom), Japan to a lesser extent. . ICT services instead gained ground and prevail in Europe, the USA and Japan.

**Figure 5. ICT sector VA by sub-sectors (%) in the European Union and other non-EU economies (2014).**





Note: 2013 for Canada.

Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.

Computer related services (software, programming, data processing...) is the leading activity in India, and in Norway. It also became the leading ICT industry in the EU, while telecommunication services and ICT manufacturing lost importance over the last years. As of 2014, the EU has a relatively high share in “computer and related activities”, together with a rather low share when compared with the US in “manufacture of electronic components and boards”. Besides, computer services are more labour intensive than telecom or IT manufacturing but with lower R&D intensity than IT manufacturing.

As said above, ICT manufacturing and telecommunications are losing weight in the EU and the US, while in China they still have the lion's share.<sup>9</sup> Telecommunications dominates in China, which has been the world's largest mobile market since over a decade (Simon, 2017a). As India became the world's second-largest mobile market (Simon, 2017a), the relative importance of this sub-sector is likely to grow. In terms of specialisation, China is still very diverse from Europe and the US.

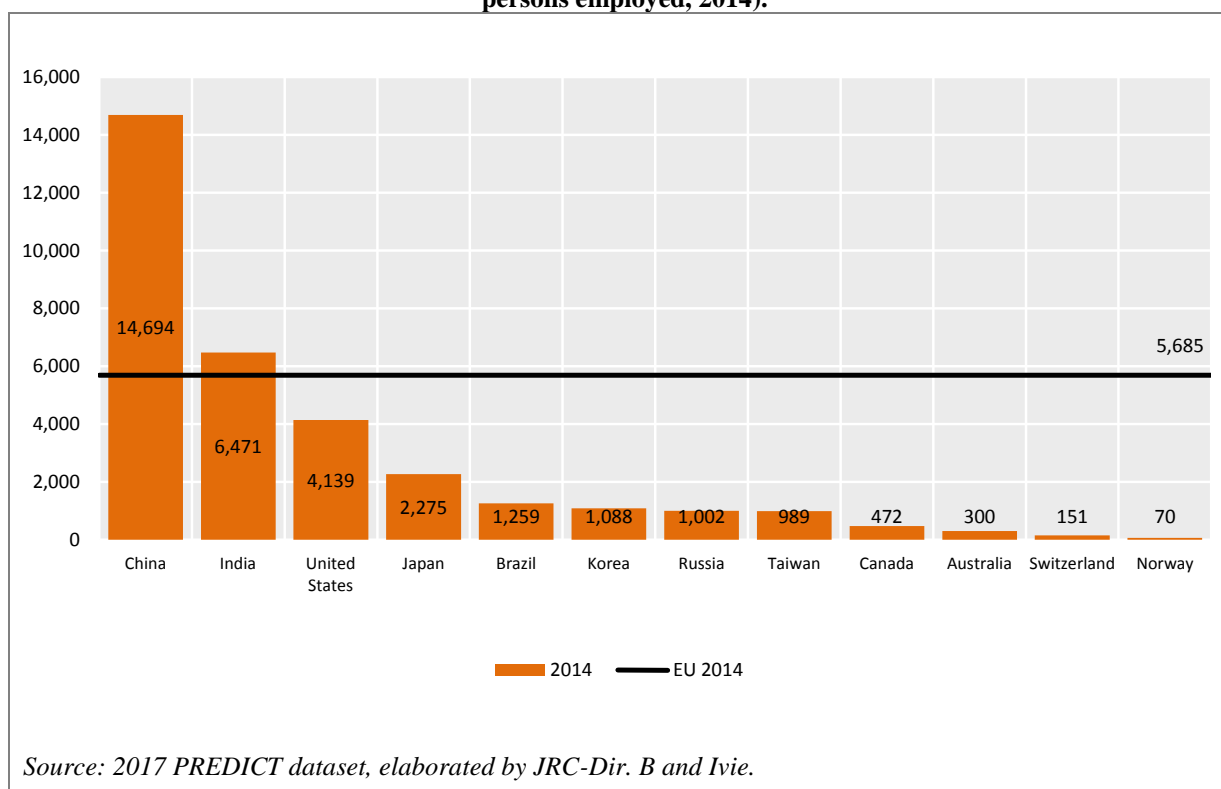
## 2. ICT employment and ICT sector labour productivity

<sup>9</sup> Also in South Korea, and Taiwan, not illustrated here.

## Employment

The distribution of employment follows a different pattern: in this case, the highest contribution in 2014 corresponded to China (Figure 6). China was the country with the highest ICT sector employment among the analysed countries, followed at a large distance by India, EU and the United States. The sum of these four amounts more than 80% of ICT sector employment in the sample. China is indeed leading in employment since 2000<sup>10</sup>, the EU, Japan, South Korea and the US remained almost flat over the same period (2000-2014). However, China presents a lower level of productivity (Figure 8). The same holds for India. However one should add that labour productivity has been growing steadily and faster in China than in the EU or the US.

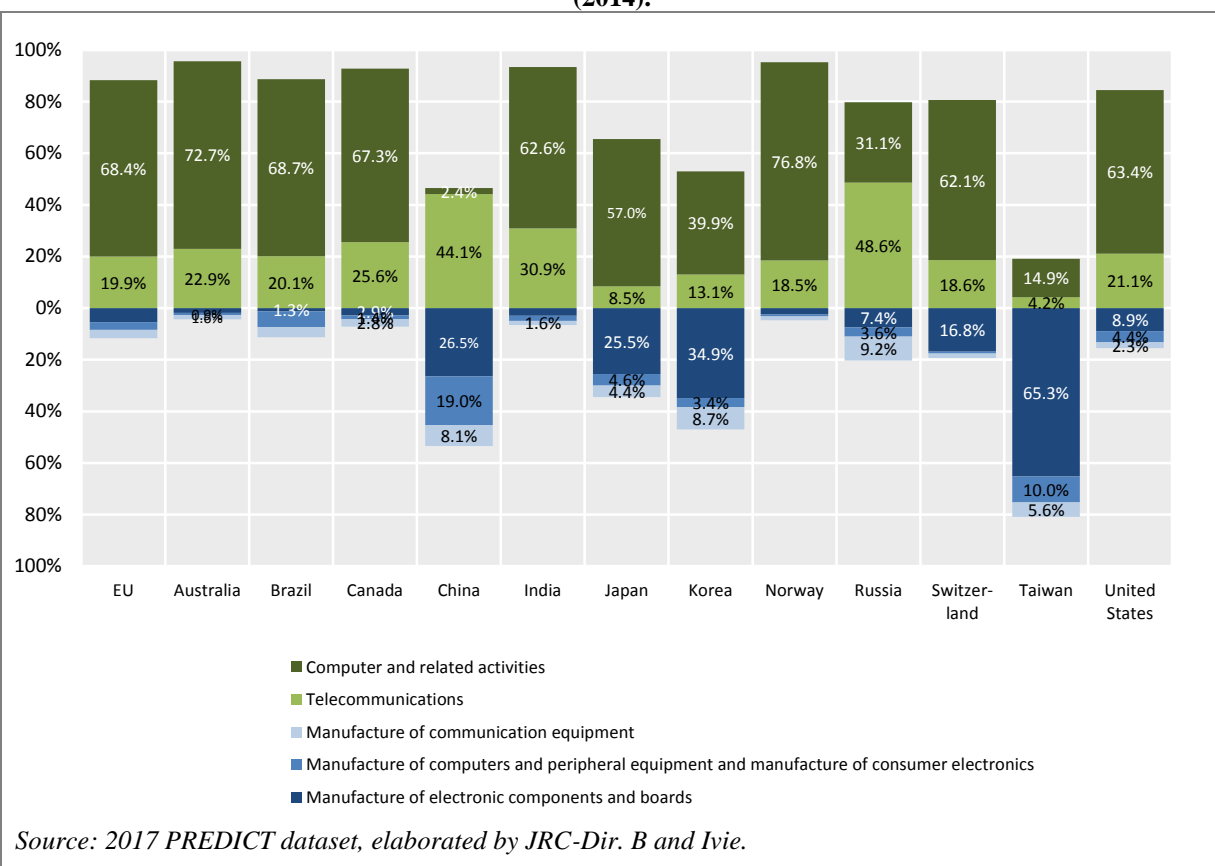
**Figure 6. ICT sector employment in the European Union and other non-EU economies (thousand of persons employed, 2014).**



Three ICT sub-sectors showed the highest share in total ICT sector employment, as illustrated by Figure 7: “manufacture of electronic components and boards” (especially relevant for Asian countries: Taiwan, South Korea, China and Japan), “computer and related activities” (Norway, Brazil, Canada and Australia) and telecommunications (especially high in Russia, China and India).

<sup>10</sup> To be noted, no data available before 2000 for China.

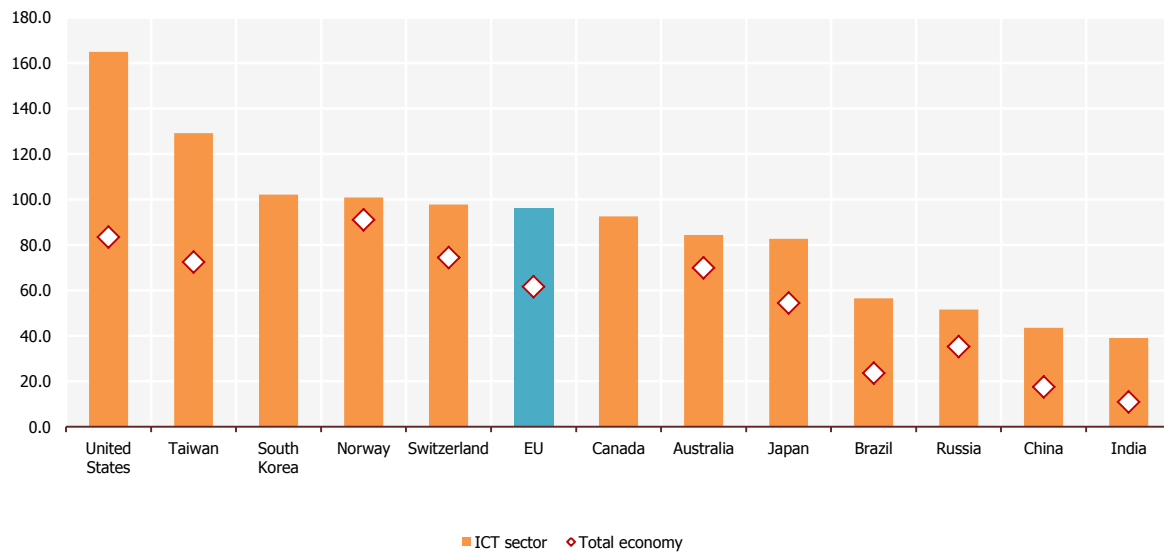
**Figure 7. ICT sector employment by sub-sectors (%) in the European Union and other non-EU economies (2014).**



### *Labour productivity*

Productivity levels vary across countries. However, it is worth stressing that everywhere, productivity in the ICT sector is much higher than the average (Figure 8) for total economy in all the countries in the sample.

**Figure 8. Labour productivity, ICT and total economy**  
(thousand PPS per person employed, 2014)

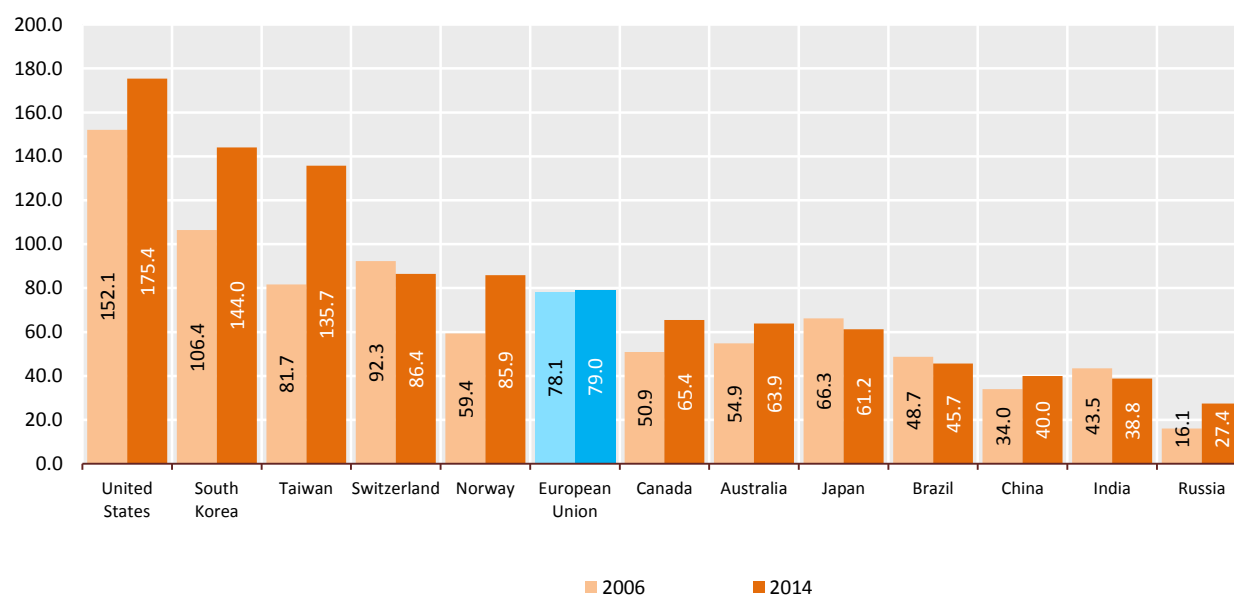


Source: 2017 PREDICT Dataset, own elaboration

Considering productivity in the ICT sector component industries (in Purchasing Power Standard (PPS) per person employed), in 2014, United States had the highest productivity per person employed in the ICT sector. Taiwan came in second place, followed by South Korea, Norway and Switzerland. Brazil, Russia, China and India are on the opposite side of the spectrum. EU was situated in the sixth position ahead of Canada, Australia and Japan (Figure 8), but below the five leading countries.

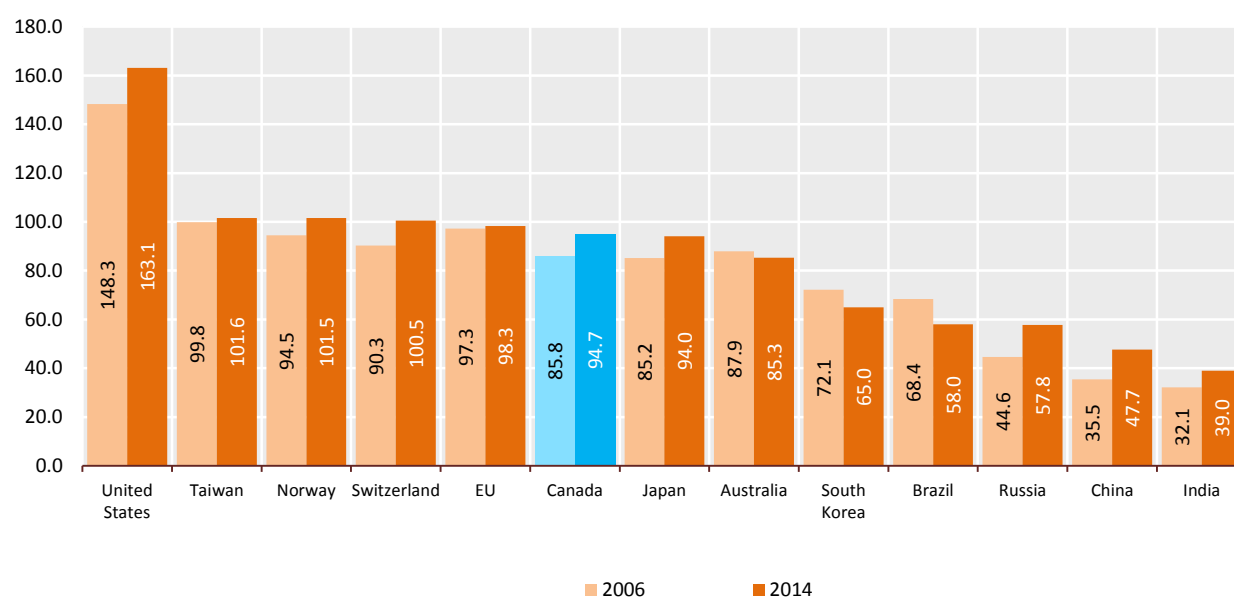
If one takes a look at the subsectors, the United States leads in both ICT manufacturing and ICT services, followed by leading Asian economies; the EU is in an intermediate position, and BRICS in the bottom ranks (Figures 9 & 10).

**Figure 9. Labour productivity in ICT manufacturing (thousand PPS per person employed, 2016 and 2014)**



Source: 2017 PREDICT Dataset, own elaboration.

**Figure 10. Labour productivity in ICT services (thousand PPS per person employed, 2016 and 2014)**

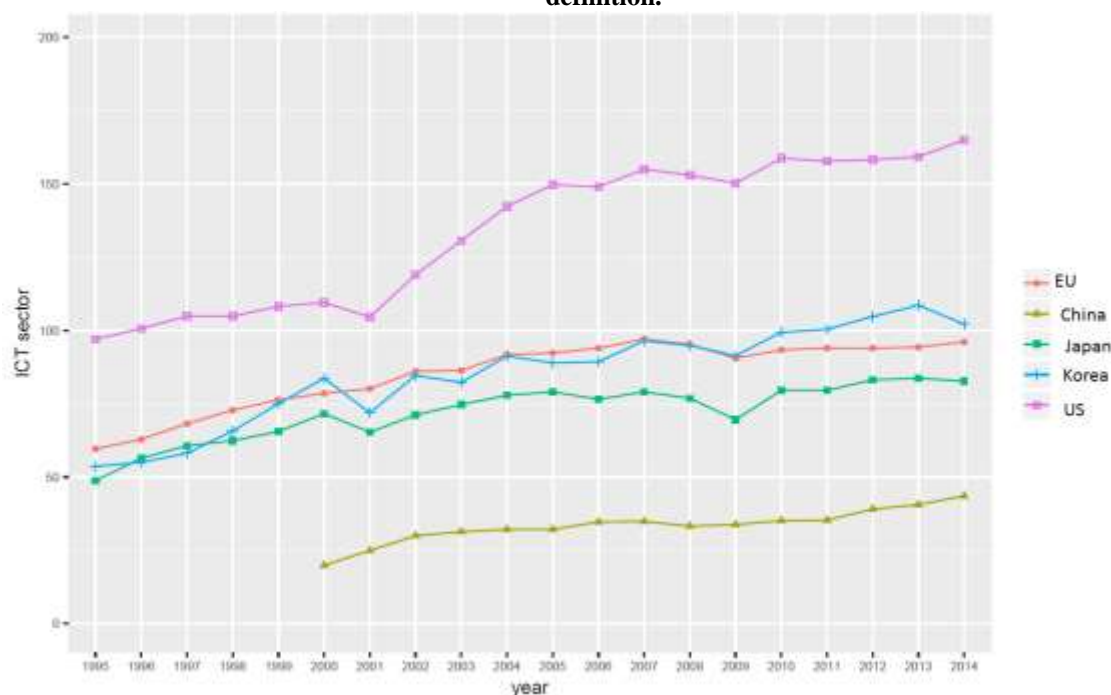


Source: 2017 PREDICT Dataset, own elaboration.

As a whole, the rate of growth of labour productivity in the EU has been modest. With a 1% average growth ratio, the EU remained below the 2.3% growth average of the other 12 countries over the period 1995-2014. Differences in ICT productivity between the EU and the

US continue to grow since 2001: US productivity in ICT industries combined was twice that of the EU in 2014 (Figure 11).

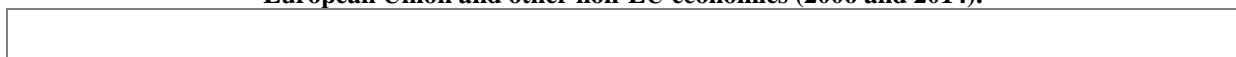
**Figure 11. ICT sector Labour Productivity (thousands of current euros PPS per person), operational definition.**

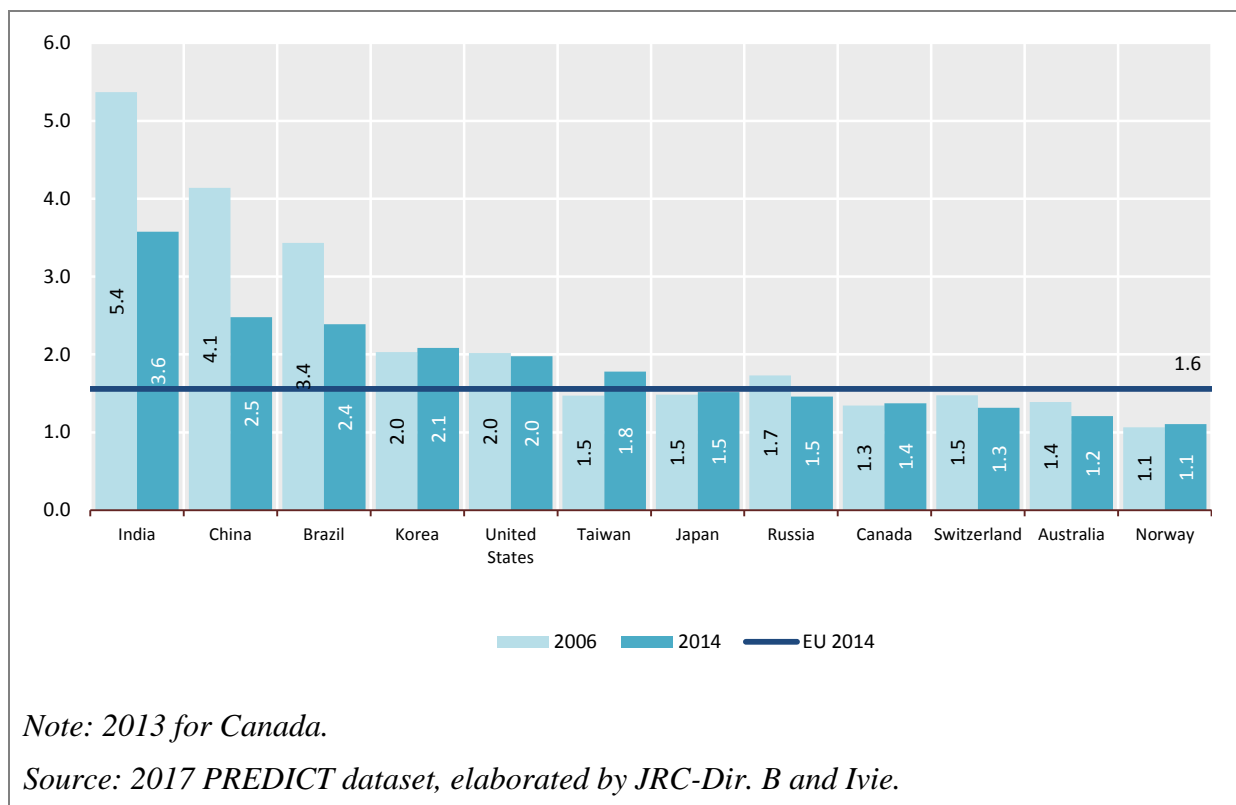


Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.

The ICT sector productivity was almost four times higher than total economy's productivity in India, around 2.5 times higher in China and Brazil, and twice as high in South Korea and United States. However, for China and India the ratio is decreasing, and it may signal a catch-up period while the rest of the economy may be still lagging behind from a technological viewpoint, as illustrated by the declining ratio of labour productivity in terms of ICT over the total economy (see Figure 12). In Switzerland, Australia and Norway, the ICT sector productivity was very similar to that of total economy. The EU, with a 1.6 ratio, was in the seventh position, with a very similar ratio to Japan and Russia. Compared to 2006, the ratio went down for the majority of the countries analysed, especially for the three leading countries in 2014.

**Figure 12. ICT sector productivity per person employed ratio over total economy productivity in European Union and other non-EU economies (2006 and 2014).**

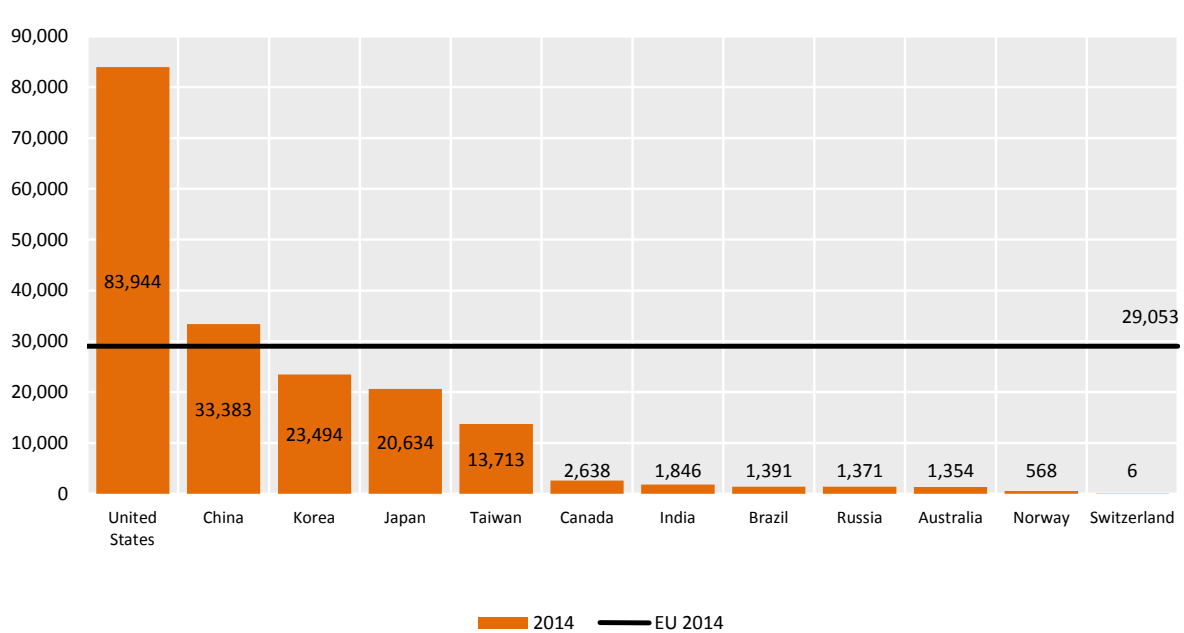




### 3. Business expenditure in R&D (BERD)

ICT sector BERD is concentrated in a small number of countries (Fig.13): 39% of total ICT sector BERD is made in the United States. The EU follows representing 14% of the total, close to China with 16%, and followed by the smaller contributions of South South Korea (11%) and Japan (10%). These five geographical areas represented, in 2014, nearly 90% of total ICT sector BERD undertaken by the 40 individual economies considered within PREDICT.

**Figure 13. ICT sector BERD in the European Union and other non-EU economies (million of current EUR PPS, 2014).**



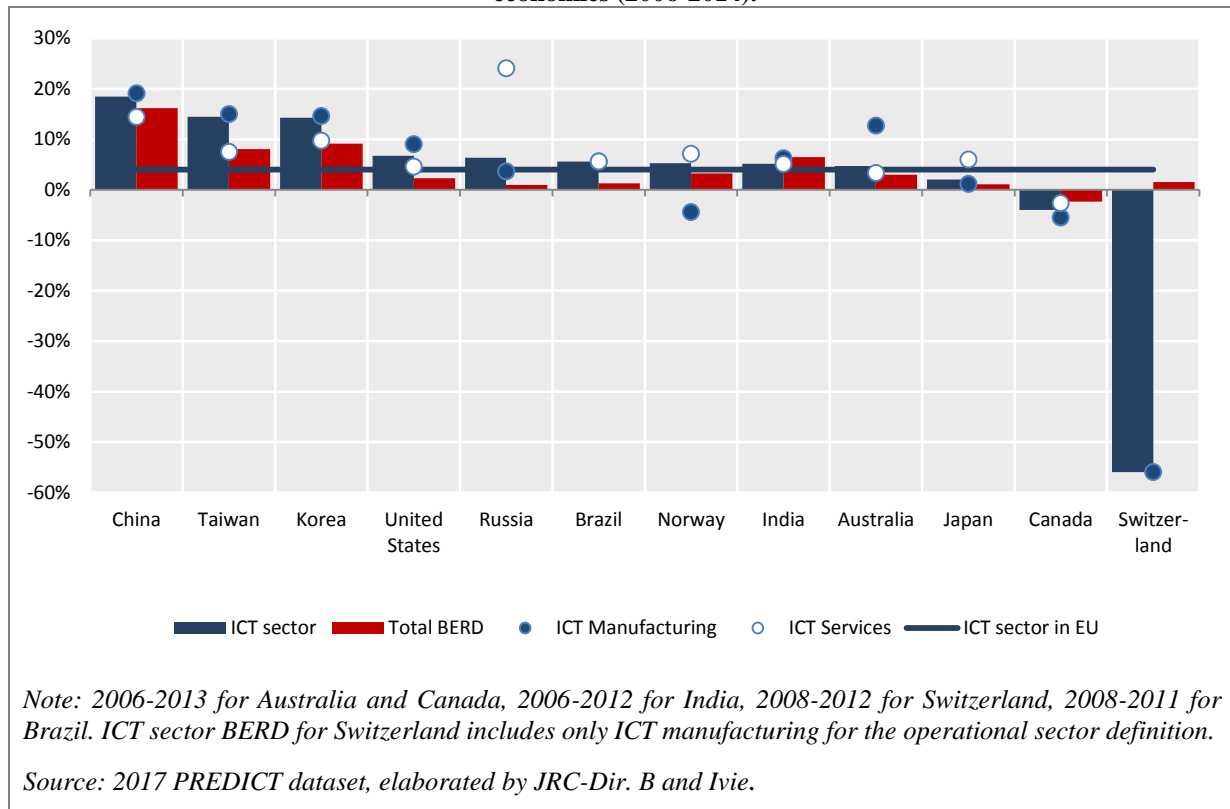
*Note: 2013 for Australia, 2012 for India and Switzerland and 2011 for Brazil. ICT sector BERD for Switzerland includes only ICT manufacturing for the operational sector definition.*

*Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.*

Between, 2006 and 2014, the ICT sector BERD grew rapidly in real terms in three Asian countries, China, with a mean annual growth rate of 18.5%, Taiwan (14.5%) and South Korea (14.3%), followed at a large distance by United States and Russia, both with growth rates over 6% per year. On the other hand, ICT sector BERD decreased in Canada and rather strongly in Switzerland. The annual real growth of ICT services sector BERD ranged from 24.1% in Russia to 3.3% in Australia and a negative rate in Canada (-2.6%). The highest growth rates in ICT manufacturing BERD took place in China, Taiwan and South Korea. China has been catching up at a fast pace since 2005, overtaking the EU in 2012, Japan in 2008. Three countries showed negative records: Norway, Canada and Switzerland. In addition, Canada was the only country with negative growth rates in all the variables (Figure 14).

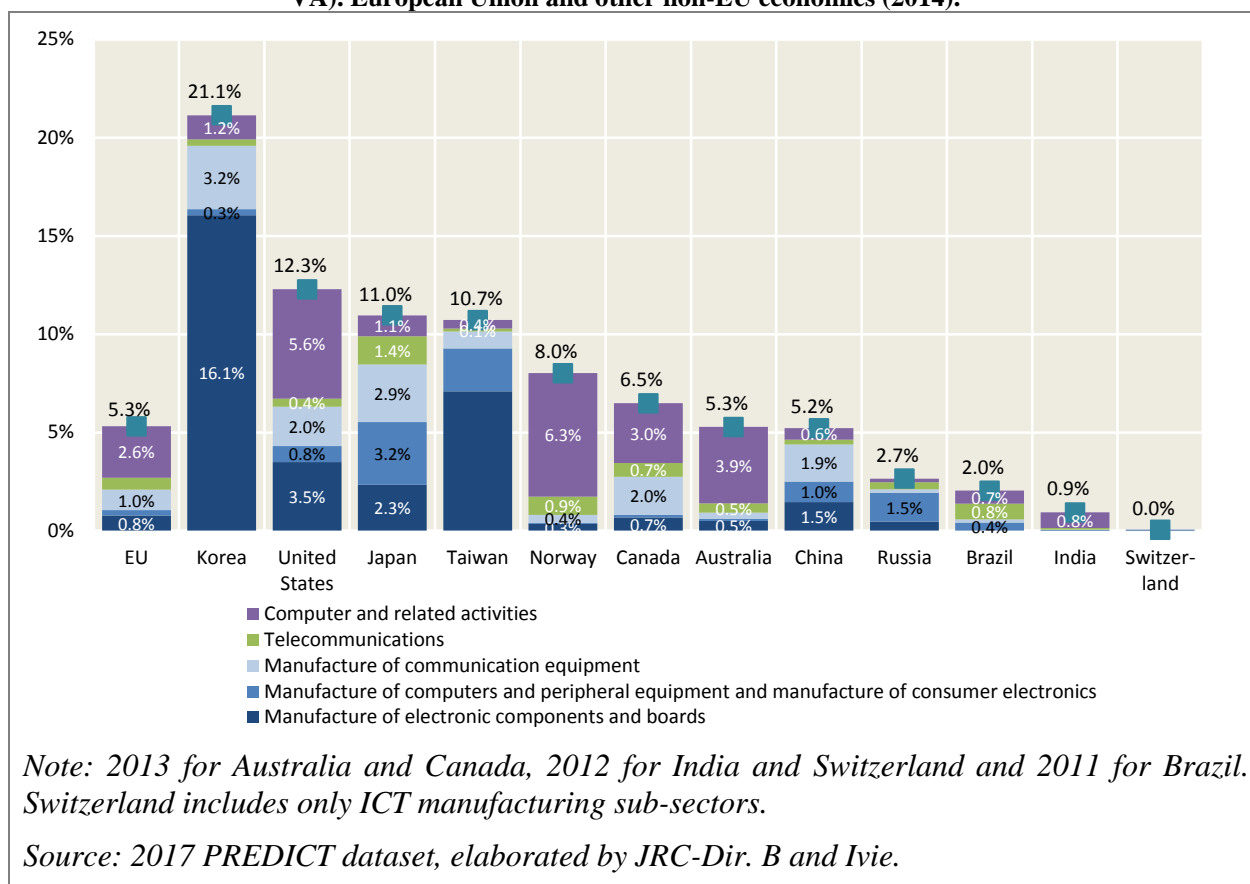


**Figure 14. Mean annual real growth rate of ICT sector BERD in the European Union and other non-EU economies (2006-2014).**

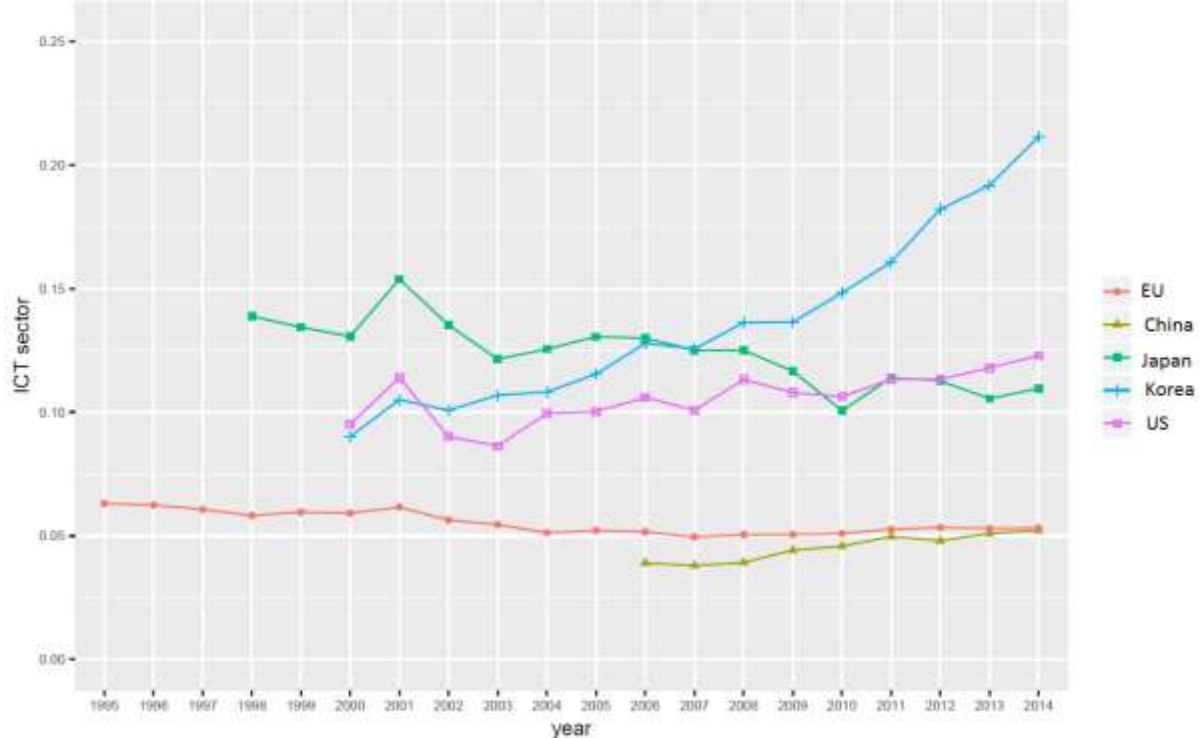


The ICT sector is characterised by a very high intensity of R&D on production, measured by BERD as a percentage of value added (ICT BERD/ICT VA) (Figure15). In the EU, this ratio is about 5%, to be compared with a total BERD intensity of 1.3% of EU GDP in 2014. The EU is clearly behind the US and three Asian countries (South Korea, Japan and Taiwan) in terms of both BERD intensity (BERD/GDP) and ICT BERD intensity. Taking a look at this intensity, also reveals that a small country like South Korea has the highest R&D intensity. This has been the case since 2007 when the country overtook Japan that was on a declining trend (Figure 16). Figure 18 also reveals that Taiwan is almost on pair with the US and with Japan.

**Figure 15: Contribution of ICT sub-sectors to ICT sector BERD intensity (ICT sector BERD/ICT sector VA). European Union and other non-EU economies (2014).**



**Figure 16: BERD Intensity. European Union and other non-EU economies (2014).**

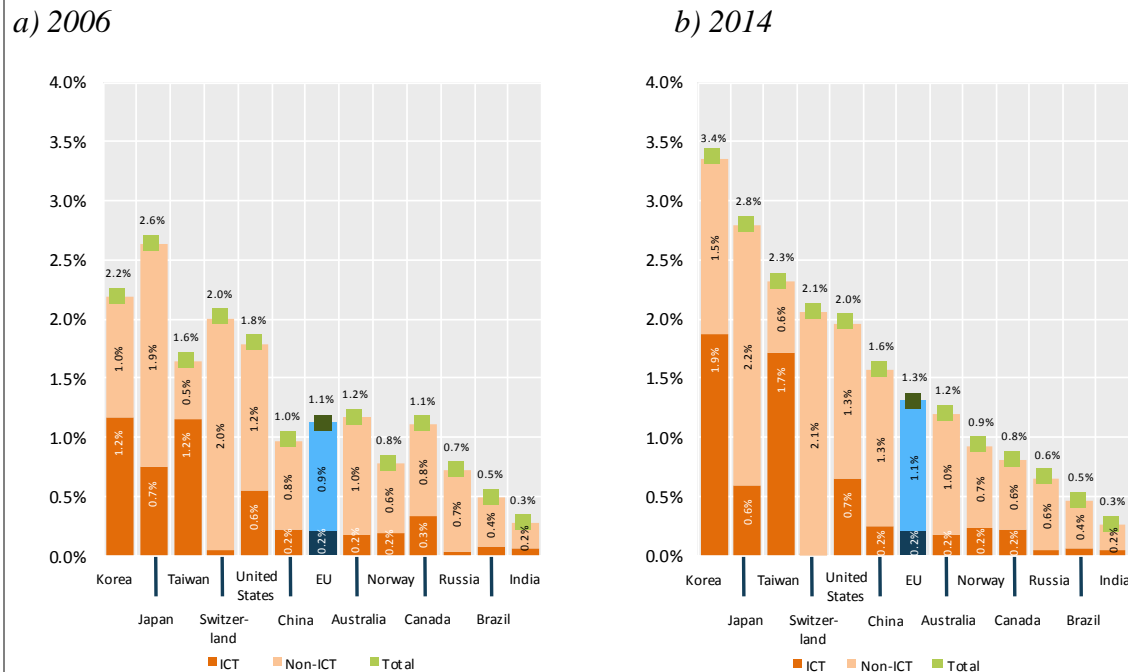


*Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.*

In South Korea and Taiwan, the ICT sub-sector with the largest contribution to ICT BERD intensity was “manufacture of electronic components and boards”. “Computer and related activities” was the most prominent sub-sector in Norway, US, Australia and Canada. This sub-sector also has the highest contribution to ICT BERD intensity in the EU, followed by “manufacture of communication equipment” (Figure 15).

Considering total BERD, the highest BERD intensity corresponded to South Korea (3.4%) in 2014. Four other countries had BERD/GDP ratios above 2%: Japan, Taiwan, Switzerland and US. For the EU, the corresponding figure was 1.3%. ICT BERD over GDP accounted for 0.2% in the EU, as compared with 1.9% in South Korea and 1.7% in Taiwan, or 0.7% in the US and 0.6% in Japan. Also remarkable are the facts that in South Korea and Taiwan the ICT sector BERD intensity was higher than non-ICT sector BERD intensity, and that there were important gains in ICT sector BERD intensity between 2006 and 2014 (Figure 17).

**Figure 17: Contribution of ICT and non-ICT BERD to total BERD intensity (BERD/GDP). European Union and other non-EU economies (2006 and 2014).**



*Note: 2008 is the first year available for Brazil and Switzerland. 2013 is the last year for Australia, 2012 for India and Switzerland and 2011 for Brazil.*

*Source: 2017 PREDICT dataset, elaborated by JRC-Dir. B and Ivie.*

### 3. The global dynamics of ICT industries: specialisation, productivity, intangible assets (2006-2014)

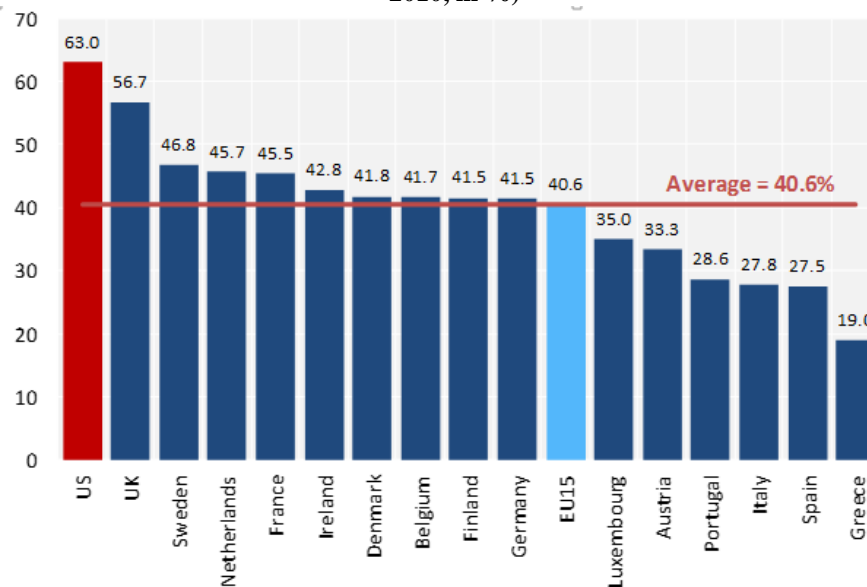
#### *Intangible assets*

The impact of ICT technologies should not be considered in isolation from a broader concept of investment, especially intangible assets<sup>11</sup>. ICTs, intangible assets and productivity (both labour and multifactor (MFP)) are closely related<sup>12</sup>. Again, the US lead, with the highest share of intangible assets in the total gross fixed capital formation (GFCF), followed by the UK. Greece, Portugal, Spain and Italy are on the lowest bound (Figure 21).

<sup>11</sup> Tangible assets include machinery, buildings, as well as ICT assets such as hardware and communication. Only recently National Accounts recognize some intangible assets such as software (ICT) and R&D.

<sup>12</sup> This is still a very broad statement that will be further investigated in future reports. By the same token, the report does not consider investment in fixed tangible assets with the exception of the 2011 report. For the link between the accumulation of fixed capital assets by telecom operators and innovation (aside from the R&D spending performed by Internet OTT players and IT equipment manufacturers) in the ICT ecosystem, see Simon (2011), and on a more macroeconomic scale, Comin & Mestieri (2010),

**Fig 18. Share of intangible assets over total gross fixed capital formation. EU-15 and US. (Average 2006-2010, in %)**



Source: Mas (2016)

### **Main observations**

The output of the research enabled us to document some trends in the ICT sector among which:

- the concentration of the shares of value added, employment and R&D expenditures among very few countries.
- the strong specialisation in ICT manufacturing (mostly Asian countries),
- the changes the ICT sector went through in the internal composition towards computer services in most countries.

The strength of the US, compared to the EU, appears to be in its high productivity levels, the capability of maintaining an ICT manufacturing basis, and high R&D resources committed to improve its competitiveness in the world markets. In more general terms, having a large ICT manufacturing sector – like China, Taiwan and South Korea – seems to be an important lever for growth, especially when it is combined with important resources devoted to R&D, both in terms of expenditures and of qualified personnel. Beyond the substantial progress achieved, the level of R&D expenditure remains modest for China.

Regarding ICT labour productivity, the EU level is lower than the US, Switzerland, Norway, Australia, Canada and Taiwan, and the gap with the US has widened steadily since 1995, and even worsened after 2009 (Predict, 2015 : 7). It should be highlighted that the EU labour productivity gap affects the ICT sector as well as most other sectors of the economy. Thus, the EU has not fully taken advantage of the efficiency gains enabled by the ICT revolution. As the EU underperformed in economic growth, it should not come as a surprise that its ICT sector underperformed.

However, the PREDICT reports show that the European ICT sector maintained its value added overall share in the European GDP around 4% through the crisis years, that the amount of resources devoted to R&D in the ICT sector is still about 4 times the economic weight of the sector, and its labour productivity is about 50% higher than the economy-average. A comparatively high R&D intensity and productivity level are distinctive features of the ICT sector common to all countries analysed, which qualify the sector as strategic for innovation and productivity growth.

## References

- Comin, D.A., Mestieri, M. (2010), "The Intensive Margin of Technology Adoption" (May 13, 2010). Harvard Business School BGIE Unit Working Paper No. 11-026. Available at SSRN: <https://ssrn.com/abstract=1676302> or <http://dx.doi.org/10.2139/ssrn.1676302>
- De Panizza, A. (2016), "ICT (industries) and the economy: An overview from the European perspective", *ICTs in the Economy: empirical evidence and measurement challenges - PREDICT workshop 2016*, <https://ec.europa.eu/jrc/en/event/workshop/predict-workshop>
- De Prato, G., Nepelski, D., and Simon, J.P., *Asia in the Global ICT Innovation Network. Dancing with the tigers*, (co-ed), Chandos, Whitney Oxforshire, 2013.
- IMF direct, (2017), "Asia's Ascent into the Global Economy". <https://blog-imfdirect.imf.org/2017/02/15/asias-ascent-into-the-global-economy/>
- KPCB (2016), *2016 Internet Trends*. <http://www.kpcb.com/internet-trends>
- The 2014 EU Industrial R&D Investment Scoreboard (2014). European Commission, JRC/DG RTD, <http://iri.jrc.ec.europa.eu/scoreboard.html>
- OECD (2012) : *China in Focus: Lessons and Challenges 2012*, OECD, Paris.  
<http://www.oecd.org/china/50011051.pdf>
- OECD (2010), "The Information and Communication Technology Sector in India: Performance, Growth and Key Challenges", No 174, OECD Digital Economy Papers from OECD Publishing, Paris.  
<http://www.oecd-ilibrary.org/docserver/download/5km4k7mf6b41-en.pdf?expires=1486037060&id=id&accname=guest&checksum=E35F5471D4DB081129B27F2E6546AC91>
- OECD, (2014), *Measuring the Digital Economy: a New Perspective*. OECD Publishing.  
<http://dx.doi.org/10.1787/97889264221796-en>
- Predict Reports, <http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html>, last report released in December 2016: <https://ec.europa.eu/jrc/en/predict/predict2016>
- Russoft, (2011) "Russinqa Software developing Industry and Software Exports", 8th Annual Survey, [http://russoft.ru/files/RUSSOFT\\_Survey\\_8\\_en.pdf](http://russoft.ru/files/RUSSOFT_Survey_8_en.pdf)
- Simon, J.P., (2017a), "IT in Asia. Asia comes into its own", EC JRC/ DG RTD Dir B, forthcoming.
- Simon, J.P., (2017b), "Dynamics of ICTs: Industries, R&D, Markets", *Communications & Strategies*, n° 105, 1st quarter 2017, pp. 121-138.
- World Intellectual Property Organization (WIPO), INSEAD Business School and Cornell University, (2016), *The Global Innovation Index 2016. Winning with Global Innovation*.  
<https://www.globalinnovationindex.org/gii-2016-report>

## Appendix

Appendix 1. List of NACE Rev. 2 ICT sub-sectors. Operational definition.

### Box 1. List of NACE Rev. 2 ICT sub-sectors. Operational definition

Nace Rev. 2	Description
<b>261-264, 582, 61, 62, 631, 951</b>	<b>ICT total (operational)</b>
<b>261-264</b>	<b>ICT manufacturing industries (operational)</b>
261	Manufacture of electronic components and boards
262	Manufacture of computers and peripheral equipment
263	Manufacture of communication equipment
264	Manufacture of consumer electronics
<b>582, 61, 62, 631, 951</b>	<b>ICT services industries</b>
61	Telecommunications
582, 62, 631, 951	Computer and related activities

Source: Predict 2017, p. 7.