

Measuring “Indirect” Investments in ICT in OECD Countries

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ABSTRACT

ICT components, such as microprocessors, may be embodied in other capital goods not recorded as ICT in National Accounts. We name ‘indirect ICT investment’ the value of embodied ICT components in non-ICT investment. The paper provides estimates of ‘indirect ICT investment’ based on detailed and unpublished Supply-Use tables (SUT) in 12 OECD countries: Australia, Belgium, Canada, Chile, Czech Republic, Denmark, France, Germany, Japan, Israel, Mexico, New Zealand, the United Kingdom, and the United States.

Our main finding is that ICT investment appears significantly higher when considering its indirect component, the average increase being about 35%. The inclusion of indirect ICT investment, excluding software (for which firms’ expenditures are difficult to measure), changes significantly the relative position of countries with respect to the ICT intensity of their investments. The inclusion of software further increases indirect ICT investment but the increase is smaller (in percentage) than without this inclusion. A final result, but concerning only three countries, is that the diagnosis of a stabilisation, or even a decrease, of ICT investment in percentage of GDP or of total investment, observed from the beginning of the century, is not modified if we take into account the indirect ICT investment.

Keywords: Investment; ICT; Technology

JEL classification: D24; E22; O33

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NON-TECHNICAL SUMMARY

ICT is one of the main drivers of the third industrial revolution. The performance gains of ICT have been huge over the last decades, as shown by the decline of ICT price relative to GDP price in the US national accounts. An abundant literature has been devoted to the evaluation of ICT contribution to growth in the main developed countries. Some main results, among others, are that: i) this contribution is significant, but seems transitory with the main productivity impact during the decade 1995-2005; ii) the US benefit from a higher ICT diffusion than the other developed countries.

ICT diffusion seems to now have stabilized in developed countries, after a multi-decade increase, which is puzzling and does not receive consensual explanation. In 2014, ICT investments accounted for 2.7% of GDP in the OECD, down from 3.5% in 2001. In most countries, the ratio of ICT investment to GDP decreased in nominal terms, i.e. after adjusting for the relative decrease in ICT prices. While the long-lasting effects of the crisis have certainly contributed to this downward trend, in many countries the relative decrease in ICT investment seems to have started well before 2007. Nevertheless, within global investment nominal spending, the ICT share seems stable over the 2000-2015 period, on average among OECD countries, but with differences between countries. It means that ICT investment growth is, on average, more or less identical to global investment growth over that period.

This paper examines a specific channel that may lead to underestimate ICT investments in the System of National Accounts (SNA 2008). According to the SNA 2008, if a firm purchases some ICT equipment, such as a microprocessor or a piece of software, to be used repeatedly in production processes for more than a year, the purchase is recorded as ICT investment. However, if the firm purchases the same piece of equipment or software embodied in other capital goods not recorded as ICT, e.g. a harvester or a metal cutting machine, its value will not be recorded as ICT investment. We label the value of ICT assets embodied in non-ICT investment as “ICT indirect investment”, as opposed to the direct purchase of ICT assets that is already recorded in the SNA as ICT investment. The SNA accounting convention implies that, while the overall investment levels may be correctly measured, the ‘actual’ contribution from ICTs may be masked to the extent that ICT capital is embodied in non-ICT assets. Furthermore, if the ICT embodiment grows over time, the stabilisation, or even the decrease, of ICT investment relative to GDP or total investment, observed from the beginning of the century, could mask an increase in total (direct plus indirect) ICT investment.

The paper investigates the above hypothesis for a selection of OECD countries. We use Supply-Use tables (SUT), which provide information on the supply and use of intermediate inputs by industry, to measure the value of ICT assets embodied in non-ICT investment. The OECD countries considered in the analysis are the twelve ones from which SUTs have been collected at a sufficient level of detail: Australia, Belgium, Canada, Czech Republic, Denmark, France, Germany, Japan, Israel, New Zealand, the United Kingdom, and the United States. The empirical analysis is carried out for the years when SUTs are available, and can differ among countries. Country differences in data availability explain why the comparison is proposed over 12 countries for indirect ICT investment when we do not include software, but only 4 countries when we include software, and even 3 countries for a robustness check taking into account the share of imports within equipment investment products. Our empirical approach is carried out with data at current prices and not constant ones. From this, we avoid all the numerous problems of quality measurement, which are acute concerning ICT products.

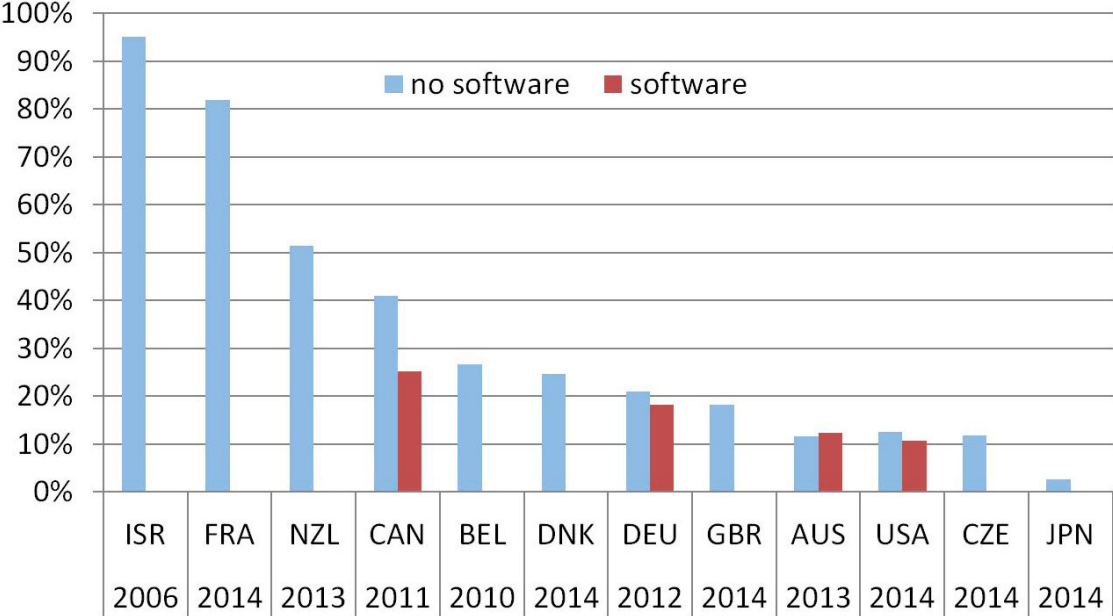
The main result is that ICT investment appears significantly higher when considering its indirect component, the average increase being about 35%. The inclusion of the indirect component - excluding software - raises ICT investment by 95% in Israel, 82% in France, 51% in New Zealand and 41% in Canada. The rise is lower than 30% in the other countries. The inclusion of indirect ICT investment, excluding software, changes significantly the relative position of countries with respect to the ICT intensity of their investments. Israel, which has the fourth lowest share of direct ICT investment in GFCF (4.2%), shows the highest shares of total (direct plus indirect) ICT investment (8.2%), together with the Czech Republic. Similarly, New Zealand and Canada move up in the ranking, from 5.2% to 7.8% and from 4.8% to 6.7%, respectively. In Denmark, indirect ICT investment brings the share of total ICT investment from 5.2% to 6.4%. The inclusion of software, which was possible for only four countries, further increases indirect ICT investment but the increase is smaller than from ICT capital goods: ICT investments are raised by 2.4 percentage points in Canada and by 1.7

percentage points in both the United States and Germany and by 0.9 percentage points in Australia. Finally, from our results, the diagnosis of a stabilisation, or even a decrease, of ICT investment in percentage of GDP or of total investment, observed from the beginning of the century, is not modified if we take into account indirect ICT investment.

The methodology of this paper relies on five hypotheses, namely that *i)* the ratio of ICT intermediates to output is the same for capital assets and final consumption; *ii)* for each product, domestic output has the same ICT embodiment as imports; *iii)* ICT intermediates are not consumed in the production process but “transferred” into the final output; *iv)* no secondary production takes place; and *v)* distribution margins and taxes on investment expenditures are negligible. The sensitivity check on hypothesis *ii)* presented in the paper suggests that its effects may be limited. The remaining hypotheses, however, need to be qualified through the collection of complementary information about the use of ICT intermediates in production within each industry.

This figure shows the ratio of indirect to direct ICT investment by country in the latest year available. The ratio measures the increase in total ICT investment when indirect ICT investment is accounted for. ICT investment appears significantly higher when considering its indirect component, the average increase being over 33%. There are large differences among countries, ranging from Israel, where indirect ICT investment is almost as large as direct ICT investment, to Japan, where indirect ICT investment raises total ICT investment by 2.6% only.

Ratio of indirect to direct ICT investment by country (latest available year)



Source: Authors’ calculations, 2017.

1. Introduction

ICT is one of the main drivers of the third industrial revolution. The performance gains of ICT have been huge over the last decades, as shown by the decline of ICT price relative to GDP price in the US national accounts⁵. An abundant literature has been devoted to the evaluation of ICT contribution to growth in the main developed countries.⁶ Some main results, among others, are that: i) this contribution is significant, but seems transitory with the main productivity impact during the decade 1995-2005; ii) the US benefit from a higher ICT diffusion than the other developed countries. Numerous studies provide explanations for these international differences in ICT diffusion, including the level of post-secondary education among the working age population as well as labour and product market rigidities. An efficient use of ICT requires a higher degree of skilled labour than the use of other technologies. The required reorganization of a firm for effective ICT adoption can be constrained by strict labour market regulations. And low levels of competitive pressure, resulting from product market regulations, can reduce the incentive to exploit the most efficient production techniques. Empirical analyses have confirmed the importance of these factors.⁷

Investment in ICT digital infrastructure remains critical to support growth and innovation in the digital economy. Over the period 1990-2012, the price for ICT capital services in OECD countries is estimated to have decreased, on average, 50% more than for non-ICT capital services⁸ (OECD Productivity Database, 2015). High-quality and affordable ICT infrastructure in all sectors, including high-speed fixed and mobile broadband, is needed to support the fast growing requirements of cloud applications and big data. More fundamentally, the innovations spurred by the ICT sector hold great potential for boosting new growth trajectories and driving societal improvements, with the biggest impact coming with the application of ICTs across the economy and society, including in public administration, health, education and research. ICT investments, therefore, are essential throughout all economic activities.

The productivity slowdown observed in developed countries, since the beginning of the century, i.e. before the Great Recession, has raised the question of a possible exhaustion of ICT performance improvements. Such an exhaustion seems to be confirmed by the slowdown of the ICT price decline in the US national accounts from the same moment. But Aizcorbe, Oliner and Sichel (2008) and Byrne, Oliner and Sichel (2013/2015) stress that the decline of the ICT price decrease, since the early 2000s, could be, at least partly and particularly for microprocessors, a consequence of statistical mis-measurement. Nevertheless, ICT diffusion seems to now have stabilized in developed countries,⁹ after a multi-decade increase, which is puzzling and does not receive consensual explanation. In a recent paper, Van Ark (2016) explains that a change in ICT content could be in action, and more precisely: *“rapidly declining ICT prices, a shift from ICT investment to ICT services, and a continued increase in knowledge based-assets supporting ICT. However, the New Digital Economy is still in its ‘installation phase’ and productivity effects may occur only once the technology enters the ‘deployment phase’”*.

⁵ In perfectly competitive product and input markets, the decrease in the output price equals the increase in multifactor productivity.

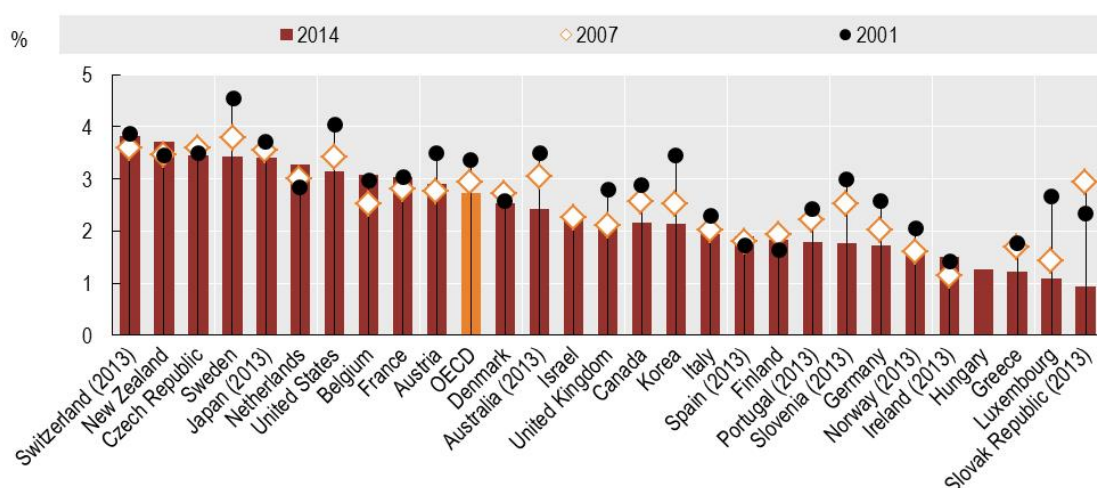
⁶ See for example for the US Jorgenson (2001), Jorgenson, Styroh and Ho (2006/2008) and for international comparisons Schreyer (2000), Colecchia and Schreyer (2001), Pilat and Lee (2001), Van Ark, O'Mahony and Timmer (2008) and Timmer, Inklaar, O'Mahony, and Van Ark (2011).

⁷ See among others Aghion, Askenazy, Bournès, Clette and Dromel (2009); Clette and Lopez (2012) and Guerrieri, Luciani and Meliciani (2011).

⁸ The capital service price is defined as the price for employing or obtaining one unit of capital services over one period of time. A decrease in the capital service price, therefore, reflects higher efficiency of the underlying capital asset.

⁹ See for example on this point Clette, Clerc and Bresson (2015).

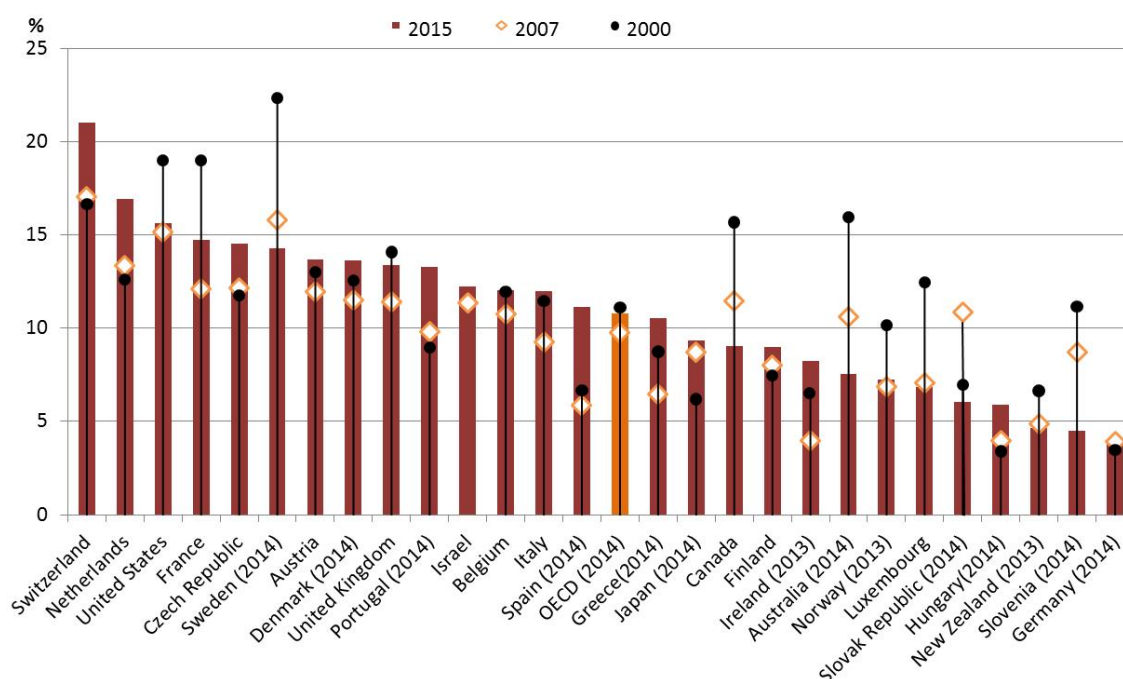
Figure 1. ICT investment as a percentage of GDP – 2001, 2007 and 2014



Source: OECD (2016a), based on the OECD Productivity Database and National

ICT investment seems to be lagging behind (Figure 1). In 2014, ICT investments accounted for 2.7% of GDP in the OECD, down from 3.5% in 2001. In most countries, the ratio of ICT investment to GDP decreased in nominal terms, i.e. after adjusting for the relative decrease in ICT prices. While the long-lasting effects of the crisis have certainly contributed to this downward trend, in many countries the relative decrease in ICT investment seems to have started well before 2007. Nevertheless, within global investment nominal spending, the ICT share seems stable over the 2000-2015 period, on average among OECD countries, but with differences between countries (Figure 2). It means that ICT investment growth is, on average, more or less identical to global investment growth over that period.

Figure 2. ICT investment as a percentage of investment - 2000, 2007 and 2015



Source: Authors' calculations, 2017.

Booming opportunities in digital technologies and low investment in ICTs may look like a paradox. Some explain it by arguing that new technological development in ICTs have lower economic value (e.g. Gordon, 2014-2015) while others suggest that the value of the digital economy, notably ICT investment, is underestimated in official statistics (Byrne and Corrado, 2016; OECD, 2016b; Piekkola, 2017).

This paper examines a specific channel that may lead to underestimate ICT investments in the System of National Accounts (SNA 2008). According to the SNA 2008, if a firm purchases some ICT equipment, such as a microprocessor or a piece of software, to be used repeatedly in production processes for more than a year, the purchase is recorded as ICT investment. However, if the firm purchases the same piece of equipment or software embodied in other capital goods not recorded as ICT, e.g. a harvester or a metal cutting machine, its value will not be recorded as ICT investment. We label the value of ICT assets embodied in non-ICT investment as “ICT indirect investment”, as opposed to the direct purchase of ICT assets that is already recorded in the SNA as ICT investment. The SNA accounting convention implies that, while the overall investment levels may be correctly measured, the ‘actual’ contribution from ICTs may be masked to the extent that ICT capital is embodied in non-ICT assets. Furthermore, if the ICT embodiment grows over time, the stabilisation, or even the decrease, of ICT investment relative to GDP or total investment, observed from the beginning of the century, could mask an increase in total (direct plus indirect) ICT investment.

The aim of this paper is to investigate the above hypothesis for a selection of OECD countries. We use Supply-Use tables (SUT), which provide information on the supply and use of intermediate inputs by industry, to measure the value of ICT assets embodied in non-ICT investment. The OECD countries considered in the analysis are the twelve ones from which SUTs have been collected at a sufficient level of detail: Australia, Belgium, Canada, Czech Republic, Denmark, France, Germany, Japan, Israel, New Zealand, the United Kingdom, and the United States. The empirical analysis is carried out for the years when SUTs are available, and can differ among countries. Country differences in data availability explain why the comparison is proposed over 12 countries for indirect ICT investment when we do not include software, but only 4 countries when we include software, and even 3 countries for a robustness check taking into account the share of imports within equipment investment products.

Our empirical approach is carried out with data at current prices and not constant ones. From this, we avoid all the numerous problems of quality measurement, which are acute concerning ICT products.

The main result is that ICT investment appears significantly higher when considering its indirect component, the average increase being about 35%. The inclusion of indirect ICT investment, excluding software, changes significantly the relative position of countries with respect to the ICT intensity of their investments. Israel, which has the fourth lowest share of direct ICT investment in GFCF (4.2%), shows the highest shares of total (direct plus indirect) ICT investment (8.2%), together with the Czech Republic. The inclusion of software further increases indirect ICT investment but the increase is smaller (in percentage) than without this inclusion. A final result, but concerning only three countries, is that the diagnosis of a stabilisation, or even a decrease, of ICT investment in percentage of GDP or of total investment, observed from the beginning of the century, is not modified if we take into account the indirect ICT investment.

Section 2 discusses the methodology and the data while Section 3 presents the results. A sensitivity check on the ICT intensity of imports is carried out in Section 4. The conclusions and the directions for further work are summarised in Section 5.

2. Methodology and data

The methodology is based on Beretti and Cette (2009). Investment (I) consists of ICT products and non-ICT products. The ICT and non-ICT components of investment are called, respectively, ‘direct ICT investment’ (DI_{ICT}) and ‘direct non-ICT investment’ (DI_{NICT}):

$$I = DI_{ICT} + DI_{NICT} \quad (1)$$

Some of the capital assets, classified in the System of National Accounts (SNA) as non-ICT, embody ICT products, e.g.: microprocessors in machine tools, which are an integral part of the capital services provided by these assets. Direct non-ICT investment, therefore, can be split in two components that reflect the contribution in value terms of each component: *indirect ICT investment* (II_{ICT}), i.e. the value of ICT products embodied in direct non-ICT investments, and non-ICT investment (I_{NICT}), i.e. the value of the overall investment in non ICT products, excluding the value of the embodied ICT:

$$DI_{NICT} = II_{ICT} + I_{NICT} \quad (2)$$

It also follows that an alternative measure of ICT investment, capturing in addition the indirect contribution of ICTs, is the sum of direct and indirect ICT investments:

$$I_{ICT} = DI_{ICT} + II_{ICT} \quad (3)$$

While total investment can be rewritten as the sum of ICT and non-ICT investment

$$I = I_{ICT} + I_{NICT} \quad (4)$$

Supply-Use tables (SUT) provide information on the supply and use of intermediate inputs by industry. This information can be used to measure the value of ICT products embodied in non-ICT assets. Table 1 shows a simplified SUT for an economy with N products (rows) and N industries (columns). $IC_{i,i}$ denotes the intermediate use of product i by industry i and, in particular, $IC_{ICT,i}$ the intermediate use of ICT products by (non-ICT) industry i . All other notations are self-explanatory. By construction, intermediate use includes both products produced domestically and products imported from abroad.

The value of direct ICT investment (DI_{ICT}) is reported on the line ‘‘ICT product’’ in the column ‘‘Investment’’ of Table 1 while direct non-ICT investment (DI_{NICT}) equals the sum of all other values in the same column:

$$DI_{NICT} = \sum_i DI_i, \text{ for } i \neq ICT. \quad (5)$$

Table 1. Simplified supply-use table in an economy with N industries

		Industries				Total inter mediates	Final Con sumption	Investment	Exports	Imports	Total Use
		1	i	ICT	N						
Products	1						DI_1				
	i		$IC_{i,i}$				DI_i	EXP_i	IMP_i		
	ICT		$IC_{ICT,i}$				DI_{ICT}				
	N						DI_N				
Output		P_1	P_i	P_{ICT}	P_N						
Total ressources											

Source: Authors' compilation, 2016.

In order to compute indirect ICT investment, five hypotheses are necessary.

- First, in each industry, the value of ICT intermediate inputs of is assumed to be the same both for capital goods and for goods produced for final consumption, *i.e.* for households and the government. This hypothesis follows from the fact that SUTs do not provide a breakdown of intermediate inputs per unit of output between capital and consumption goods. As capital goods tend to be more ICT-intensive than final consumption goods, e.g. a home sewing machine embodies less ICT than a manufacturing weaving machine, this hypothesis is likely to underestimate the embodiment of ICT products in non-ICT capital, and therefore, the amount of indirect ICT investment.
- The second hypothesis assumes that, for each product i , imports have the same ICT embodiment as domestic output. As imported capital goods are likely to be more ICT-intensive than domestically-produced ones, this hypothesis may also lead to underestimating ICT embodiments in non-ICT capital, thus the level of indirect ICT investment. A sensitivity check to the effects of this hypothesis is reported in Section 4 below.
- The third hypothesis, which may overestimate indirect ICT investment, is that ICT intermediates are not consumed in the production process but embodied into the final output of each industry i . This is the case, for example, if the industry producing machinery buys microprocessors and installs them in the machines produced. The hypothesis does not hold, however, if the microprocessors are bought to replace old microprocessors in the equipment, e.g. some robots, used for production of machines. In general, however, this expenditure, especially if large, will be

included directly as investment so that the share of ICT intermediate products not transferred into the final output is likely to be of marginal significance.

- The fourth hypothesis assumes, implicitly, that products i are produced by the same industry i and that no secondary production takes place.
- Finally, as SUTs record production in basic prices and consumption in purchasers prices, the fifth hypothesis assumes that any distribution margins and taxes (or subsidies) on investment expenditures are zero, which would bias estimates upwards.

Based on the five hypotheses above, indirect ICT investment in product i ($II_{ICT,i}$) can be computed as:

$$II_{ICT,i} = (IC_{ICT,i}/P_i) * DI_i \quad (6)$$

And indirect ICT investment in the all economy as the sum of (6) across all products except ICT:

$$II_{ICT} = \sum_i [(IC_{ICT,i} / P_i) \cdot DI_i], \text{ for } i \neq ICT \quad (7)$$

ICT products are defined according to the OECD classification (OECD, 2011) shown in Annex A. The classification is based on the Central Product Classification (CPC Rev.2) at the 5-digit level, but also provides the (approximate) correspondence to the International Standard Industry Classification (ISIC Rev. 4) at the 3-digit level.

As SUTs commonly released by national statistical offices (NSOs) are too aggregated to identify ICT intermediates according to the OECD definition, a request was sent to each OECD NSO to share more detailed SUTs, which are normally confidential. To date, 12 countries have provided SUTs for at least one year and at a level of product or industry detail that allows the measurement of ICT intermediates: Australia, Belgium, Canada, Czech Republic, Denmark, France, Germany, Japan, Israel, New Zealand, the United Kingdom, and the United States. For two countries, Chile and Mexico, the provided SUT data were too aggregated for the purpose of the present study.

The information available in the SUTs collected varies significantly among countries. Not all countries provide equally detailed information; some collect ICT data by detailed products and others release industry aggregates at 2 or 3-digit level. For some countries, correspondence tables from their national classification to the international ones might not be available, imposing a discretionary selection of ICT products/industries. As a result, the figures presented below must be compared with caution across countries: small differences should not be considered as necessarily effective and we comment below only the ones large enough to correspond to actual country hierarchy.. The country-specific list of products or industries used to measure ICT intermediate products is presented in the Annex A.

A final comment is in order about the consistency between investment data from the SUTs and the national accounts. The two sets of information are drawn from different sources and, in most countries, SUT data are adjusted to be made consistent with national accounts but only at the higher level of aggregation at which they are published. This is not always the case for the more detailed SUTs that are not for public release. To avoid inconsistency between SUTs and national accounts, SUTs have been used to compute the ratio of indirect ICT investment to total investment and this ratio has been applied to the investment data from National Accounts to estimate ICT indirect investments:

$$II^{NA}_{ICT} = (II^{IO}_{ICT} / IO) * I^{NA} \quad (8)$$

Where the superscript indicates whether investments were computed based on SUTs or national accounts (NA).

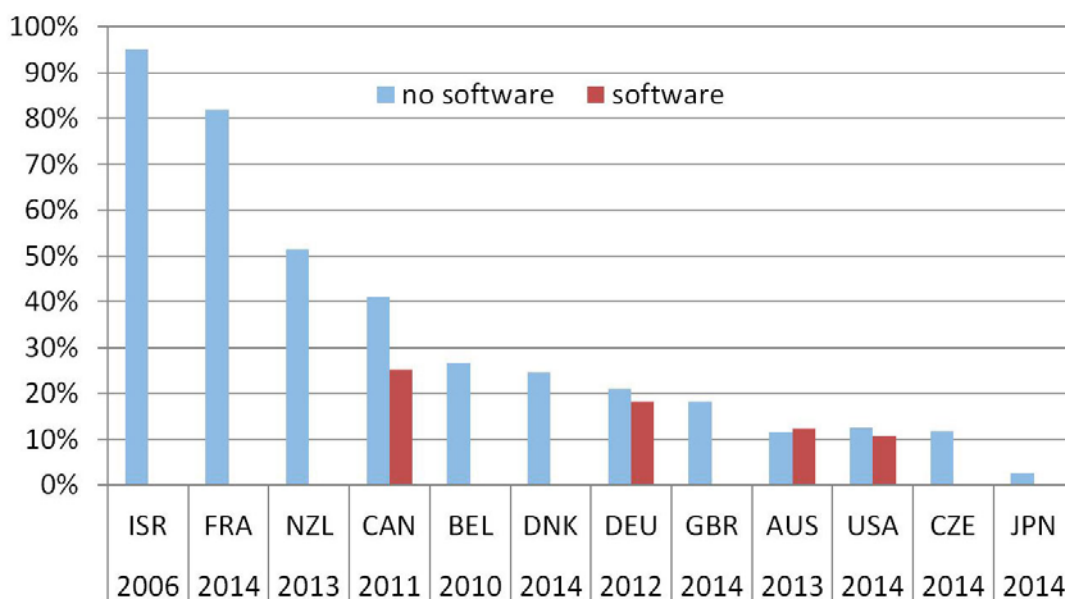
3. Indirect ICT investment

This section presents estimates for twelve out of fourteen countries from which SUTs have been collected: Australia, Belgium, Canada, Czech Republic, Denmark, France, Germany, Israel, Japan, New Zealand, the United Kingdom and the United States. In the remaining two countries - Chile and Mexico - SUT data were too aggregated for the purpose of the present study. For the reasons discussed above, the estimates are not fully comparable across countries.

In addition, the available data for Australia, Canada, Germany and the United States make it possible to include software in the estimates of indirect ICT investment while this was not possible for the remaining

countries.¹⁰ For France, the United Kingdom and the United States, it was also possible to compare estimates over time.

Figure 3. Ratio of indirect to direct ICT investment by country (Latest available year)



Source: Authors' calculations, 2017.

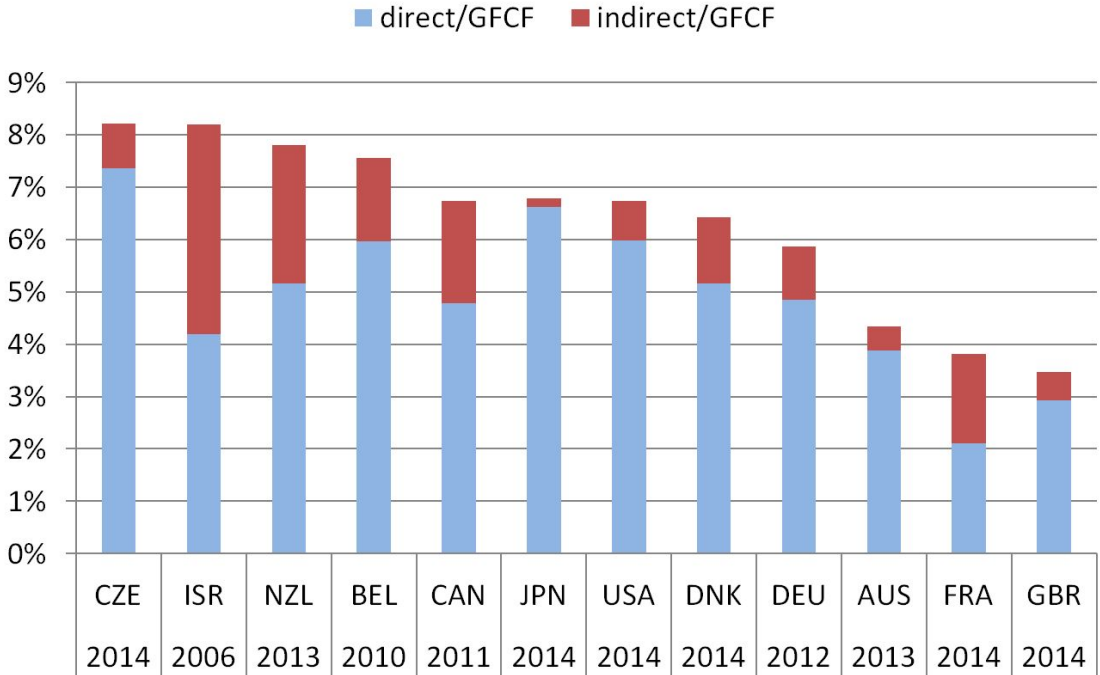
Figure 3 shows the ratio of indirect to direct ICT investment by country in the latest year available. The ratio measures the increase in total ICT investment when indirect ICT investment is accounted for. ICT investment appears significantly higher when considering its indirect component, the average increase being over 33%. There are large differences among countries, ranging from Israel, where indirect ICT investment is almost as large as direct ICT investment, to Japan, where indirect ICT investment raises total ICT investment by 2.6% only. The large differences among countries could have several explanations, and we raise here only two of them. A first one is that, to build branch statistics, national accounts break down the firm activities, using for that conventions which could differ among countries. Some auto-product ICT components of a firm which produces equipment may be allocated in an ICT branch in one country and on the other hand may be located in the equipment product branch in another one. A second possible explanation is that differences in indirect ICT investment could correspond to real differences in production segmentation: in some countries equipment production firms may produce themselves large parts of the ICT components of their production and, in other countries, these components may be bought from other firms located in the same country or from foreign firms and then imported. In these two explanations, ICT investment data including the indirect ICT components should be considered as more relevant to build comparisons among countries than ICT investment data which do not include these indirect ICT components. The inclusion of the indirect component - excluding software - raises ICT investment by 95% in Israel, 82% in France, 51% in New Zealand and 41% in Canada. In the remaining countries the increase is smaller and below 30%. In Germany, Canada and the United States, the inclusion of software reduces the ratio of indirect to direct ICT investment, i.e. the ratio of indirect to direct investment is higher for ICT goods than for software. The opposite occurs in Australia, although the increase is very small (0.4 percentage points).

Three groups of countries stand out considering the corrected ICT investment rate (including indirect ICT components), which was not so clear with the original investment rate (not including indirect ICT components). In a first group, which includes the Czech Republic, Israel, New-Zealand and Belgium, the corrected ICT investment rate is the highest, and above 7%. On the other hand, in Australia, France and Great-Britain the corrected ICT investment rate is the lowest and below 5%. An intermediate group is composed by Canada, Japan, the US, Denmark and Germany where the corrected ICT investment rate is between 5% to 7%.

¹⁰ For sake of clarity, the inclusion or exclusion of software refers to indirect ICT investment only. Capitalised software is always included in total investment (GFCF) data, which are drawn from national accounts.

We cannot conclude too quickly from these differences that ICT capital diffusion would be higher in the first group of countries than in the two other ones: the high ICT investment rate in some countries may correspond to a catching-up process from a laggard position in terms of ICT diffusion. For example, the US which is here in the intermediate group for both corrected or non-corrected data, appears to be the large country with the highest ICT capital diffusion (see Cette and Lopez, 2012 or Cette, Clerc and Bresson, 2015).

Figure 4. Direct and indirect ICT investment by country - excluding software
As a percentage of GFCF (latest year available)

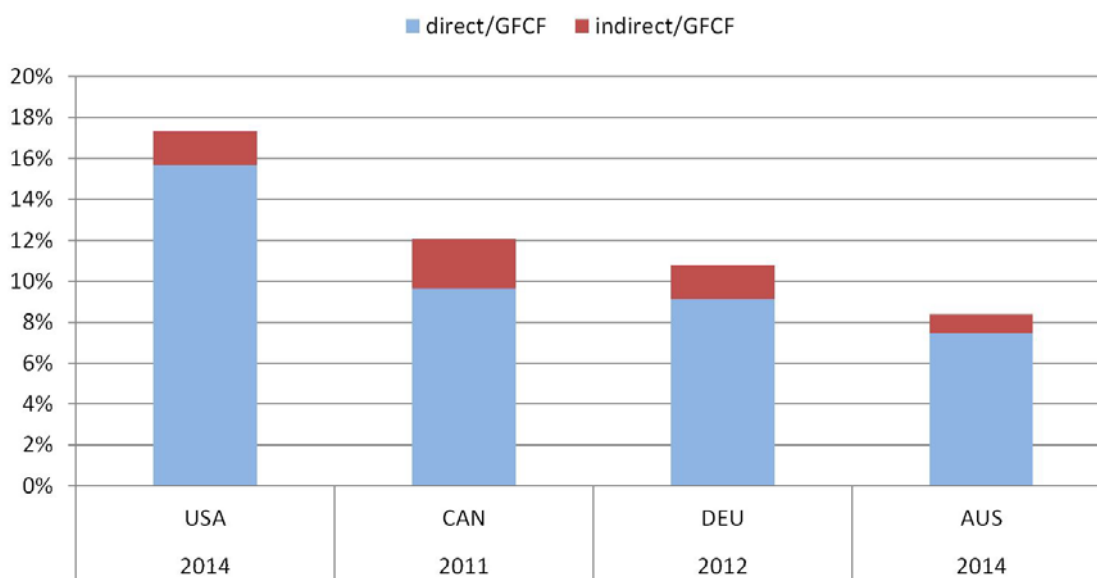


Note: Software is excluded in the indirect investment (numerator) but is included in GFCF (denominator).
Source: Authors' calculations, 2017.

Figure 4 shows the increase in the share of ICT investment in total investment (GFCF) when indirect ICT investment, excluding software, is accounted for. The inclusion of indirect ICT investment changes significantly the relative position of countries with respect to the ICT intensity of their investments. Israel, which has the fourth lowest share of direct ICT investment on GFCF (4.2%), shows the highest shares of total (direct plus indirect) ICT investment (8.2%), together with the Czech Republic. Similarly, New Zealand and Canada move up in the ranking, from 5.2% to 7.8% and from 4.8% to 6.7%, respectively. In Denmark, indirect ICT investment brings the share of total ICT investment from 5.2% to 6.4%.

Figure 5 shows the increase in the share of ICT investment in total investment (GFCF) when indirect ICT investment, including software, is accounted for. Accounting for indirect ICT investment increases ICT investment in Canada by 2.4 percentage points to 12.1%. Similarly, ICT intensity rises by 1.7 percentage points in the United States and Germany and by 0.9 percentage points in Australia.

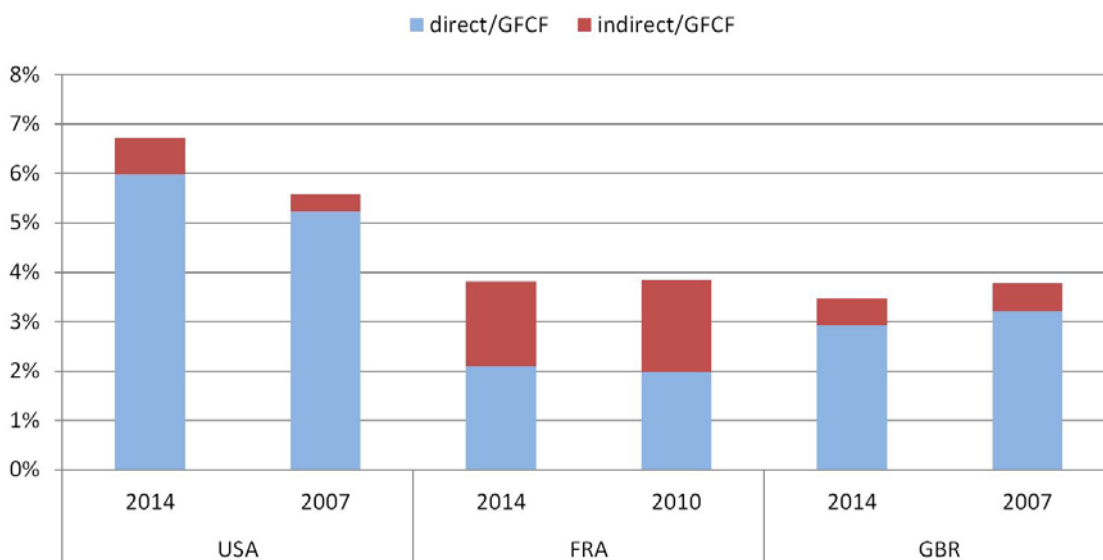
Figure 5. Direct and indirect ICT investment by country - including software
As a percentage of GFCF (latest year available)



Source: Authors' calculations, 2017.

Figure 6 compares total ICT investment in two years for a subset of countries for which data are available. The share of indirect ICT investment (excluding software) in total investment increased slightly in the United States (0.4 percentage points) over 2007-14, decreased in France (-0.2) over 2010-14 and remained constant in the United Kingdom over 2007-14. From these results, but concerning only three countries, it appears that the diagnosis of a stabilisation, or even a decrease, of ICT investment in percentage of GDP or of total investment, observed from the beginning of the century, is not modified if we take into account indirect ICT investment.

Figure 6. Changes in total ICT investment over time - excluding software
As a percentage of GFCF



Source: Authors' calculations, 2017.

4. A sensitivity check on imports

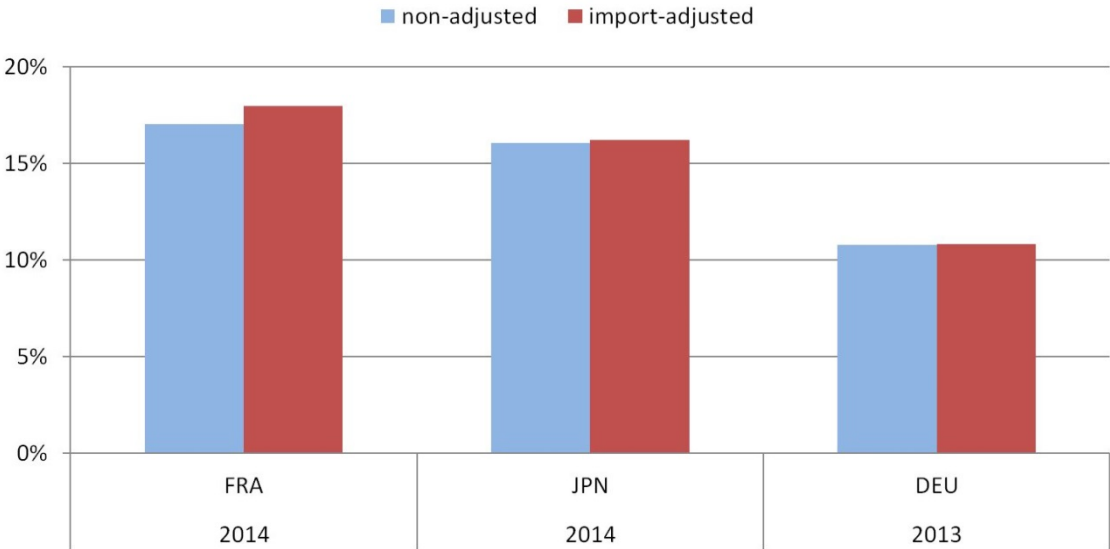
As discussed in Section 2, the above estimates are based on a set of hypotheses. In particular, it was assumed that, for each product i , imports have the same ICT embodiment as domestic output. As

imported capital goods are likely to be more ICT-intensive than domestically-produced ones,¹¹ this hypothesis may lead to underestimating ICT embodiments in non-ICT capital, thus the level of indirect ICT investment. And from this, we could underevaluate indirect ICT investment in the less advanced countries, with low ICT domestic production and where domestic equipment production includes fewer ICT components produced within the country, than in the most advanced countries.

To assess the implications of this hypothesis on the above estimates, a sensitivity check was carried out based on the alternative hypothesis that the ICT embodiment of imported non-ICT assets equals the share of ICT intermediates (including software) in output in the United States. As the United States has the highest ICT intensity of output among all countries in the sample, the estimates based on this hypothesis provide an upper bound for the value of indirect ICT investments. Details on the methodology used are reported in Annex B.

Figure 7. Non-adjusted and Import-adjusted ICT investment

As a percentage of total investment



Source: Authors' calculations, 2017.

Figure 7 shows the non-adjusted and import-adjusted ICT investment (direct plus indirect) in France, Germany and Japan. The blue bar shows the same estimates as in Figure 5, while the red bar shows the estimated ICT investment adjusted for capital imports. In Germany and Japan, the difference tends to be small because the value of ICT capital assets embodied in output is close to the value in the United States. In France, where ICT embodiments are lower, the import adjustment increases the share of indirect ICT investment by 0.9 percentage point. Overall, the sensitivity test suggests that the assumption that domestic output has the same ICT embodiment as imports does not have large effects on the estimates of indirect ICT investments reported above.

5. Conclusions and further work

This paper has tried to make a contribution to the current debate on why ICT investment has been low in recent years despite booming opportunities in digital technologies. The paper has investigated the hypothesis that the real contribution of ICT investment may be masked in official statistics because intermediate ICT expenditures embodied in non-ICT capital assets are not treated as ICT investment. Based on detailed SUTs collected in 12 OECD countries, the paper has presented estimates of *indirect ICT investment*, i.e. the value of ICT inputs embodied in non-ICT capital assets.

ICT investment appears significantly higher when considering its indirect component, the average increase being about 35%. The inclusion of the indirect component - excluding software - raises ICT investment by 95% in Israel, 82% in France, 51% in New Zealand and 41% in Canada. The rise is lower than 30% in

¹¹ This is because world exports of ICT capital goods are concentrated in a few countries with a strong comparative advantage in the production of ICTs.

the other countries. The inclusion of indirect ICT investment, excluding software, changes significantly the relative position of countries with respect to the ICT intensity of their investments. Israel, which has the fourth lowest share of direct ICT investment in GFCF (4.2%), shows the highest shares of total (direct plus indirect) ICT investment (8.2%), together with the Czech Republic. Similarly, New Zealand and Canada move up in the ranking, from 5.2% to 7.8% and from 4.8% to 6.7%, respectively. In Denmark, indirect ICT investment brings the share of total ICT investment from 5.2% to 6.4%.

The inclusion of software, which was possible for only four countries, further increases indirect ICT investment but the increase is smaller than from ICT capital goods: ICT investments are raised by 2.4 percentage points in Canada and by 1.7 percentage points in both the United States and Germany and by 0.9 percentage points in Australia.

Finally, from our results, the diagnosis of a stabilisation, or even a decrease, of ICT investment in percentage of GDP or of total investment, observed from the beginning of the century, is not modified if we take into account indirect ICT investment.

The methodology of this paper relies on five hypotheses, namely that *i*) the ratio of ICT intermediates to output is the same for capital assets and final consumption; *ii*) for each product, domestic output has the same ICT embodiment as imports; *iii*) ICT intermediates are not consumed in the production process but “transferred” into the final output; *iv*) no secondary production takes place; and *v*) distribution margins and taxes on investment expenditures are negligible. The sensitivity check on hypothesis *ii*) presented in the paper suggest that its effects may be limited. The remaining hypotheses, however, need to be qualified through the collection of complementary information about the use of ICT intermediates in production within each industry.

BIBLIOGRAPHY

Aghion, P., Askenazy, P., Broulès, R., Cetto, G. and Dromel, N., (2009), "[Education, Market Rigidities and Growth](#)", *Economics Letters*, 102, 62-65.

Aizcorbe, A., Oliner, S. and Sichel, D., (2008), "[Shifting trends in semiconductor prices and the pace of technological progress](#)", *Business Economics*, 43(3), 23-39.

Beretti, P.-A. and Cetto, G., (2009), "[Indirect ICT investment](#)", *Applied Economics Letters*, 16:17, 1713-1716.

Byrne, D. and Corrado, C., (2016), "[ICT Prices and ICT Services: What do they tell us about Productivity and Technology?](#)", Paper presented at the Economics Program Working Paper Series #16-05 of The Conference Board, New-York.

Byrne, D., Oliner, S. and Sichel, D., (2013), "[Is the Information Technology Revolution Over?](#)", *International Productivity Monitor*, 25, Spring, 20-36.

Byrne, D., Oliner, S. and Sichel, D., (2015), "[How fast are semiconductor prices falling?](#)" (NBER Working Paper No. 21074) Cambridge, MA: National Bureau of Economic Research.

Cetto, G., Clerc, C. and Bresson, L., (2015), "[Contribution of ICT Diffusion to Labour Productivity Growth: The United States, Canada, the Eurozone, and the United Kingdom, 1970-2013](#)", *International productivity monitor*, 28, Spring, 81-88.

Cetto, G. and Lopez, J., (2012), "[ICT demand behaviour: an international comparison](#)," *Economics of Innovation and New Technology*, Taylor and Francis Journals, 21(4), June, 397-410.

Colecchia, A. and Schreyer, P., (2001), "[ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case?](#)" (OECD Science, Technology and Industry Working Papers No 2001/07), OECD Publishing, Paris.

Gordon, R.J., (2014), "[The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections](#)", (NBER Working Papers No 19895).

Gordon, R.J., (2015), "[Secular Stagnation: A Supply-Side View](#)", *American Economic Review, Papers & Proceedings*, 105(5), 54-59.

Guerrieri, P., Luciani, M. and Meliciani, V., (2011), "[The determinants of investment in information and communication technologies](#)," *Economics of Innovation and New Technology*, 20 (4), 387-403.

Jorgenson, D., (2001), "Information technology and the US economy", *The American Economic Review*, 91(1), March, 1-32.

Jorgenson, D., Stiroh, K. and Ho, M., (2006), "[Potential Growth of the US Economy: Will the Productivity Resurgence Continue?](#)" *Business Economy*, 41, January, 7-16.

Jorgenson, D., Stiroh, K. and Ho, M., (2008), "A Retrospective Look at the U.S. Productivity Growth Resurgence", *Journal of Economic Perspectives*, Vol. 22, Winter, 1, 3-24.

OECD, (2009), "[Handbook on Deriving Capital Measures of Intellectual Property Products](#)", OECD Publishing, Paris.

OECD, (2011), "[OECD Guide to Measuring the Information Society 2011](#)", OECD Publishing, Paris.

OECD, (2015), "[Science, Technology and Industry Scoreboard 2015](#)", OECD Publishing, Paris.

OECD, (2016a), [New Markets and New Jobs](#), (OECD Digital Economy Papers No. 255), OECD Publishing, Paris.

OECD, (2016b), *Measuring Investment in ICT Services Industries*. (A Methodological Note).

Piekkola, H., (2017), "[Broad-based intangibles as generators of growth in Europe](#)", *Economics of Innovation and New Technology*.

Pilat, D. and Lee, F., (2001). [Productivity growth in ICT-producing and ICT-using industries: a source of growth differentials in the OECD?](#), (OECD Science, Technology and Industry Working Papers No 2001/04), OECD Publishing, Paris.

Schreyer, P., (2000), [The contribution of Information and Communication Technology to Output Growth: A Study on the G7 Countries](#), (OECD Science, Technology and Industry Working Papers No 200/2), OECD Publishing, Paris.

M., Timmer, M., Inklaar, R., O'Mahony and Van Ark, B., (2011), "[Productivity and Economic Growth in Europe: A Comparative Industry Perspective](#)", *International Productivity Monitor*, Centre for the Study of Living Standards, 21, Spring, 3-23.

Van Ark, B., O'Mahony, M. and Timmer, M., (2008), "[The Productivity Gap between Europe and the United States: Trends and Causes](#)", *Journal of Economic Perspectives*, American Economic Association, 22(1), Winter, 25-44.

Van Ark, B., (2016), "[The productivity paradox of the new digital economy](#)", *International Productivity Monitor*, 31, Fall, 3-18.

La mesure de l'investissement indirect en TIC dans les pays de l'OCDE

RÉSUMÉ

Des composants TIC, comme les microprocesseurs, peuvent être incorporés dans d'autres biens d'équipements et ne pas être comptabilisés comme investissement TIC dans les comptes nationaux. Nous appelons 'investissement indirect en TIC' la valeur de ces composantes TIC des investissements non TIC. Notre analyse fournit des estimations de cet 'investissement indirect en TIC' basées sur des tableaux input-output détaillés et non publiés pour 12 pays de l'OCDE : Allemagne, Australie, Belgique, Canada, Chili, Danemark, États-Unis, France, Japon, Israël, Mexique, Nouvelle-Zélande, République Tchèque et Royaume Uni. Le principal résultat de l'analyse est que l'investissement en TIC est très nettement augmenté par la prise en compte de sa composante indirecte, l'augmentation étant en moyenne d'environ 35 %. Cette prise en compte de l'investissement indirect en TIC, hors logiciels (dont la mesure est particulièrement difficile), modifie sensiblement la hiérarchie des pays concernant l'intensité en TIC de leur investissement. La prise en compte des logiciels augmente encore davantage l'investissement indirect en TIC mais cette augmentation est plus faible (en pourcentage) que sans cette prise en compte des logiciels. Un autre résultat, mais qui ne concerne que trois pays, est que le diagnostic général d'une stabilisation (sinon même d'une baisse), depuis le début du siècle, de l'investissement TIC, exprimé en pourcentage du PIB ou de l'investissement total, demeure quand l'investissement indirect en TIC est pris en compte.

Mots-clés : Investissement ; TIC ; technologie

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