THE AFTERMATH OF THE "NEW ECONOMY" BUST: A CASE STUDY OF FIVE OECD COUNTRIES

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Abstract

Few things have been said about the nature of the aftermath of the "new economy" bust. This paper aims to add to the debate. Our study focuses on five OECD countries: the United States, Ireland and Finland for their obvious status of leader ICT countries; the Netherlands for its similarities with the above mentioned countries, and France as a national reference. For a better understanding of how each country has been performing since the Internet bubble burst, we first describe the importance of the ICT sector in these countries through a set of variables: the contribution of the ICT sector to GDP growth and productivity growth; the surge in information processing equipment and software investment; the contribution of the ICT sector to jobs growth and the ICT share in foreign trade. We then describe the timing of the downturn in terms of synchronisation between the countries and in terms of adjustment of macroeconomic variables. The ICT sector has been strongly hit by the correction of the excesses of the sunnier days of the second half of the nineties, and is still restructuring. But its growth potential is also still high.

Theme: New Economy
Keywords: New Economy, ICT, Productivity
JEL Classification *: O3, O4*

Introduction

The "new economy" concept is essentially based on stylised facts outlined during the last American business cycle. The American economic performance challenged the business cycle approach, and the terminology "new economy" has been coined because this virtuous business cycle was broad and prolonged. However, despite a large consensus on macroeconomic features, confusion still arises around the true meaning of this terminology. The title of this paper profits from this confusion. But in fact, the "new economy" term is misused and so misleading! The present study tackles the "new economy" measure through a broad set of statistical indicators, describing the role of Information and Communication Technologies (ICT) in five OECD countries (Finland, France, Ireland, the Netherlands and the United States) in order to gauge the economic impact of the ICT reversal.

This paper aims to be more descriptive than problematic because the reversal is still recent and its impact has certainly not been fully felt. The economic world is too complex to attribute to one cause (the ICT reversal) the general slowdown of activity. GDP world growth slowed to a low 2,3 % in 2001, after having increased by 4,4 % in 2000. One explanation of this global slowdown is the Internet bubble burst at the beginning of 2000. But the oil price also increased threefold between 1999 and mid-2000, and threw some sand in the world growth machine. Finally, September 11 terrorists attacks directly affected economic activity. Fortunately, massive and rapid policy responses contributed to restrain their impact. The slowdown mainly affected the manufacturing sector and was broad based: globalisation is not an empty word.

The choice of the five countries is not completely arbitrary. These countries are well-known for their leading role in the ICT world. Two more concrete elements support this choice. The first one is a classification established by Forrester Research (1997) to gauge the e-commerce potential of various countries. Each of our countries falls in a different category: the United States belongs to the "superpowers" group (the only country in this group), the Netherlands to the "gateways" group, Finland to the "sprinters" group, Ireland to the "wild cards" group, and France to the "stragglers" group. This diversity of situation is both welcome and problematic: it makes the present study more interesting but more complex. The economic impact of the ICT reversal will greatly vary from one country to another. The second element is the quality of the empirical results on ICT contribution to output and labour productivity growth.

For a better understanding of how each country has been performing since the Internet bubble burst, we first describe the importance of the ICT sector[2] in these countries through a set of variables: general indicators of ICT intensity; ICT share in foreign trade; ICT share in investment and GDP; ICT-producing and ICT-using industries shares in output and employment. The second part of the paper completes this review with growth accounting results and highlights which country could, like the United States, satisfies the "new economy" criterion. We finally describe the economic downturn, its timing and its characteristics, insisting more on the United States thanks to a large set of variables and because of its leading role in the downturn. We conclude on a positive note, justifying why the "new economy" is not dead.

Four Indicators of ICT Intensity in Five OECD Countries

Four types of indicators are presented, giving a broad panorama of ICT in each country: indicators of broad specialisation; ICT share in foreign trade; indicators of specialisation by products through the ICT share in investment and GDP; indicators of specialisation by sectors through the decomposition of the ICT sector between ICT-producing and ICT-using industries.

Indicators of Broad ICT Specialisation

While the Finnish, Irish, Dutch and French ICT sectors do not match the size of their American counterpart, some similarities are evident. Within the European Union, Finland and Ireland are clearly leading countries in the ICT sector (table 1). The United States does not always rank first in our measures of ICT intensity. For instance, the ICT employment share is nearly the smallest of the five countries; the R&D share and the exports share are smaller than the Finnish and Irish ones. Finland and Ireland are the only countries among our sample to show a positive ICT trade balance. The United States' leadership is "only" supported by the importance of its ICT sector in total value added comparison to other countries. And when one considers ICT share in manufacturing output, this leadership has even been shaken by some European countries, such as Ireland, Finland and Sweden (graph 1).

2. In most cases, the OECD definition of the ICT sector is used (in its full extent or in a narrower sense). See Appendix A for further details.

Table 1: General ICT intensity indicators in 1997

ICT share in each aggregate, percent

	Employment	Value Added	R&D	Exports*	Imports*
Finland	5.6	8.3	51.0	19.6	16.1
France	4.0	5.3	26.4	9.4	11.1
Ireland	4.6		47.7	32.6	33.9
Netherlands	3.8	5.1	19.6	14.6	16.7
United States	3.9	8.7	38.0	15.2	16.4

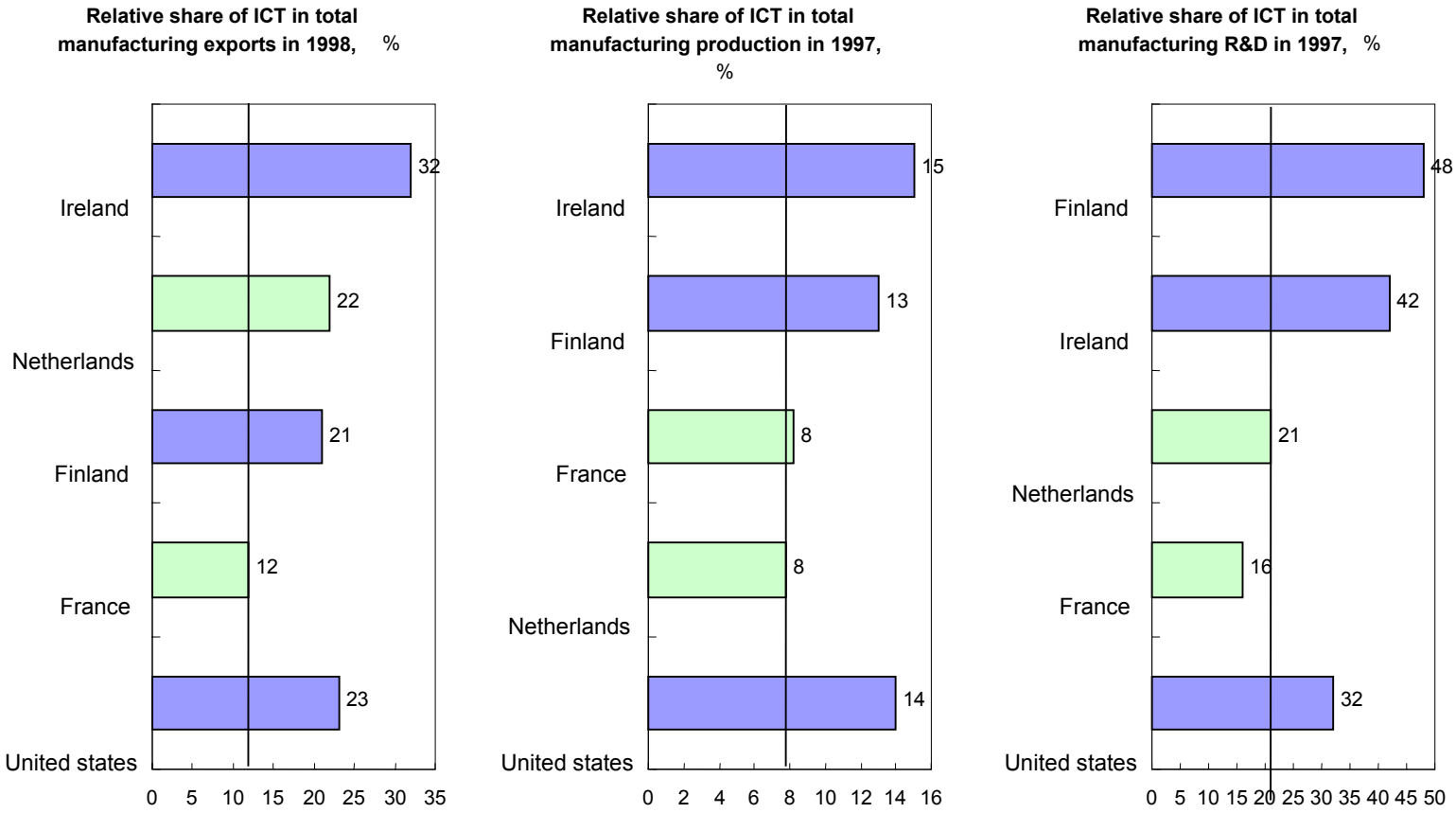
* In 1998.
Sources: OECD (2000b), Koski *et al.* (2001).

Koski *et al.* (2001) study three measures of ICT specialisation[3]: the relative shares of ICT in total manufacturing exports, in total manufacturing production and in total manufacturing R&D. Their study indicates that only Finland and Ireland are consistently specialised, i.e. are above the (unweighted) EU average according to all three measures. The Netherlands is very close to this consistent specialisation, but France really deserves its "stragglers" label. French data are always below the EU average. The United States is of course consistently specialised. Ireland has been the most ICT export oriented country since 1995. The country that has most prominently risen within the ranks is Finland: in 1991, it was the least specialised country but by 1997, it had reached the fourth place (see box 1 for further information about the rise of the Finnish ICT cluster).

3. Due to data limitations, ICT specialisation is only based on ICT manufacturing data. However, the "General ICT intensity indicators in 1997" table also includes ICT services data.

Graph 1: Relative share of ICT in the total manufacturing exports, production and R&D

Percent



Source: Koski *et al.* (2001).

Box 1

What is Behind the Finnish Miracle ?

During the last decade, Finland become one of the world's most technology-intensive economies, built largely around the telecommunications giant Nokia. In 1999, Nokia alone accounted for a full 1,2 percentage point of Finnish GDP growth of 4 %, for just under 4 % of GDP and for 24 % of total exports (Ali-Yrkkö and *al.* , 2000). Success in the ICT sector cannot be considered either as an internal phenomenon of that sector or as an independent event. This is especially true for Finland, where the growth of Finnish telecommunications industry to its present dimension must be explained within the context of a cross-sector cluster concept. Clusters are networks of organisations in which competitive advantage grows from dynamic interaction between actors. The competitiveness of a cluster is dependent on the political, institutional, cultural and also international environment within which it operates. Indeed, Finnish ICT companies' co-operation networks stretch far into other industries, into the world of R&D and into universities. Finland's transition to a high-tech economy has not taken place as suddenly as it seems. In the background, we find a long process of developing institutions, organisations and society towards more competitive markets.

First of all, the structure of Finnish telecom markets has always been competitive to some degree, providing a favourable foundation for further equal competition once the markets were fully liberalised in 1994. Competition pressed prices down and led to a mass market for wireless communication and a test laboratory for the equipment industry. Finnish technology policy began to emphasise information technology in the eighties. The liberalisation of capital markets and the ensuing rapid increase of risk financing then gave a decisive impetus to the growth, diversification and internationalisation of the ICT Finnish cluster. Finally, it is worth mentioning the Finnish fascination with technology, inherited from the university world. In the 1980s, the Internet, still a largely unknown concept, was first brought from the United States to Finland by students. The recession of the early nineties, simultaneously with the well timed first GSM licence (which coincided with the beginning of world telecom market liberalisation), caused the labour force to move swiftly into the new growth sector. In fact, the electronic equipment industry was the only sector where there was a significant increase in the number of employees between 1993 and 1998. The commercial expansion of the Internet also coincided with this cycle, thus providing a new development platform for Finnish technology innovations. The integration of mobile and Internet technologies has turned Finland into a digital icon.

The rise of the Finnish ICT cluster has been accompanied by major changes in the economy, the most visible being the high level of market capitalisation as a percentage of GDP. Close to 300 % of GDP as of 30 June 2000, it is one of the highest in the world, just ahead of the United States (whose market capitalisation nearly reached at that time 200 % of GDP). The increased diversification of exports is also a major consequence. In 1999, the electronic equipment sector accounted for nearly 30 % of total Finnish exports, which is almost as large as the share of the forest industries. This has contributed to another change in the Finnish economy: its transformation towards a knowledge-based economy.

Koski *et al.* show that "even though the production and innovation of ICT manufacturing is increasingly concentrated-clustered in certain countries, trade of ICT products is more evenly distributed [...] The trade of ICT products, intermediate goods and components has rapidly increased as a consequence of the new production models and distribution systems. [...] Export specialisation may or may not be an indication of comparative advantage in ICT-related goods". A good example of clusterisation of ICT production is Europe. One major zone, called the "great central banana", covers an area from London via the Netherlands to the industrial areas in Germany, Switzerland and northern Italy. Two other major regions are the "small Nordic potato" zone (drawn around Helsinki and Stockholm) and Paris. The major difference between the two European areas is that ICT activities in the "banana" (extended to Ireland) are more focused on information technology (as is the United States) whereas the "potato" is primarily focused on communications technology. In the United States, the most well known area is Silicon Valley. In addition to Silicon Valley another important area for ICT is the suburban area around Boston, sometimes known as the "Route 128" corridor. Of lesser importance is the Seattle area (home of Microsoft) and for telecommunications, the suburban area of Northern Virginia, outside of Washington, DC.

ICT Share in Foreign Trade

OECD International Trade by Commodity Statistics provide ICT share in foreign trade statistics on an homogeneous basis. ICT here include: office machines and automatic data processing machines (SITC[4] 75); telecommunication and sound recording apparatus (SITC 76); electrical machinery, apparatus and appliances (SITC 77). It does not correspond exactly to previous definitions of the ICT sector, but it is nevertheless a useful indicator and shows how dependant some countries are on this type of trade (table 2), and what kind of trade relations link them (table 3). Ireland exhibits with no surprise the highest ICT shares both in imports and exports (around 30 %, see also box 2 for other illustrative figures), and France the lowest (around 13 %). Finland, the United States and the Netherlands exhibit roughly the same shares, close to 25 % both for imports and exports. Shares in all countries have increased between 1995 and 2000. The exception is the United States, for which, surprisingly, the ICT share in imports slightly decreased. These shares are illustrative of the sectoral decomposition of foreign trade, and of industrial specialisation choices, but tell nothing about the dynamic of foreign trade. Finland and Ireland exhibit both higher average annual growth rates for exports than for imports during the second half of the nineties and a trade surplus,

4. Standard International Trade Classification.

while this is the opposite in France and in the Netherlands. For the United States, average annual growth rates are misleading. Between 1995 and 1998, the higher rate of growth for exports than for imports has allowed the trade deficit to shrink, but the situation has been reversed since 1999.

Table 2: ICT share in foreign trade of goods and other indicators

In percent, except when indicated

	1995		2000				Average annual growth rate 1996-2000	
	exports	imports	exports	imports	trade balance (US$ billions)	trade balance in % of GDP	exports	imports
Finland	15.8	19.8	27.8	24.0	5	3.7	14.9	7.3
France	12.3	13.5	15.6	16.4	– 4	– 0.3	5.8	6.3
Ireland	30.7	30.2	37.1	37.8	9	9.6	16.1	14.8
Netherlands	15.1	17.1	25.0	27.2	– 3	– 0.7	11.0	12.1
United States	19.8	22.8	25.7	22.3	– 70	– 0.7	13.3	9.3

Sources: OECD (International Trade by Commodity Statistics), WITSA (2002) for GDP data, OFCE.

Table 3: ICT trade partners in 2000

	Finland		**France**		**Ireland**		**Netherlands**		**United States**	
	exports	imports	exports	imports	exports	imports	exports	imports	exports	imports
Finland	-	-	12	9	0.9	2	3	4	4	13
France	1.1	1.5	-	2	2	4	5	4	7	14
Ireland	0.6	0.9	8	5	-	1.5	8	3	10	20
Netherlands	1.1	0.9	9	3	0.8	4	-	-	4	15
United States	0.3	0.1	2	1.0	2	0.8	4	0.4	-	-

Row: trading country; column: destination or origin of trade. For instance, France exports 7 % of its ICT products to the United States and imports 14 % of them from the United States. Some countries, such as France and Ireland, also import goods from themselves: this corresponds to re-imports or goods return.

Sources: OECD (International Trade by Commodity Statistics), OFCE

The United States is in most cases the main trade partner of the countries in this group[5]. An adjustment of American ICT trade flows should then be directly felt by these countries. On the contrary, the four European countries here presented are negligible providers of the United States. France is an exception: it is the most important destination for Finnish and Dutch ICT

5. Other countries could be more important trade partners. For instance, according to Statistics Finland (which present statistics for "high technology" products), the main trade partner of Finland in 2000 was indeed the United States on the side of imports but it was the United Kingdom on the side of exports (the United States being in seventh place). "High technology" products include: aerospace; computers and office machinery; electronics and telecommunications equipment; pharmaceuticals; scientific instruments; electrical machinery; chemicals; non-electrical machinery and armaments.

exports. The Netherlands also appear as an important partner. In particular, they are the most important market for American ICT exports (within our sample of countries).

Box 2

Foreign Direct Investment and Ireland's Success Story

A very good illustration of the importance of trade links is Ireland's success story. Real GDP growth averaged 9,5 % per cent during 1995-2000, after an average of 4,3 % from 1990 to 1994 and 3,1 % in the eighties. This remarkable turnaround of the Irish economy was driven to a large extent by the huge flows of foreign direct investment (FDI) in the ICT sector into Ireland. The credibility and sustainability of the macroeconomic policy and favourable labour supply conditions have helped in attracting FDI. With a low 10 % corporate tax rate, a well educated labour force and a flexible business environment, Ireland has long been a preferred location for foreign owned companies, mainly US-owned.

One out of three computers sold in Europe is said to be made in Ireland. But while PC manufacturing is undoubtedly important to the Irish economy, the high tech sector as a whole is reasonably diversified. It is for instance more diversified than in Finland, where the sector depends largely on the health of one firm. The counterpart is that the high tech sector largely depends on United States capital flows that may be more volatile than Irish capital. Broadly defined (electronics, pharmaceutical, software, communication and financial services), the ICT sector accounts for about one quarter of GDP (in real terms) and a little bit more than 5 % of total employment. The electronics, pharmaceutical and software industries are the main exporting industries and represent more than 60 % of all Irish exportations. Production in these sectors is predominantly driven by foreign-owned firms. Indeed, about 80 % of FDI flows that stem from the United States are focused on these sectors, and Ireland accounts for a third of all United States electronics investment in Europe. Many American firms have used Ireland as an export platform for an access to the European market. The Irish software sector has become one of the top three industries in terms of employment and exports. The performances of this sector make Ireland the largest exporter of software in the world, thanks to its preferred access to the European market, overtaking the United States in 1999. Over 40 % of all pre-packaged software sold in Europe is produced in Ireland. An increasing number of companies have also located their technical and hot line support-centres in Ireland. Firm size in this sector remains small. Only 27 of the 500 firms in this sector have more than 50 employees (O'Sullivan, 2000).

The important exposure of the ICT industry, as evidenced in the high share of exported output, and also in the high share of foreign-owned firms in output and employment, across a wide range of industries (table A), make the Irish small open economy vulnerable to the variations of world trade and world economy.

Table A : Output, employment and export shares of manufacturing industries in 1998 (percent)

	Exports share in output			Output share			Employment share		
	total	Foreign	Irish	total	Foreign	Irish	total	Foreign	Irish
Electrical equipment	93	95	47	28.5	26.5	2	25	20	5
Chemicals	97	99	48	24	23	1	9	7	2
Machinery and equipment	80	95	54	2.5	1.4	1.1	6	3	3

Sources: CSA, Census of Industrial Production 1998, ESRI

While a large share of the American production of ICT products is oriented towards the domestic market, which is larger than the European market itself, most of Irish production is oriented towards the world market, as evidences by figures in table B. Though a "very" small economy, Irish ICT share in world exports is higher than the one for bigger European countries.

Table B : Share in world exports in 1999 (percent)

	Computer equipment	Electronic components	Telecommunications equipment
Export country			
United states	**12.3**	**18.9**	**14.2**
European Union	32.5	19.3	44.7
France	**3.4**	**3.5**	**5.9**
Germany	4.8	4.3	7.9
Italy	1.2	1.1	2.1
United Kingdom	8.0	3.1	7.7
Ireland	**5.8**	**1.2**	**1.8**
Finland	**0.3**	**0.2**	**4.6**
Sweden	0.3	0.2	8.1
Japan	9.4	15.2	7.9
Emerging Asia	37.3	39.6	19.9
World	100	100	100

Sources: CEPII, Euren.

ICT Share in Investment and GDP

At the beginning of the eighties, the ICT share in nonresidential investment in the United States (15 %) was already double the ICT share in France and even in Finland (table 4). But at the end of the nineties, the picture was quite different: ICT share in Finland was very close to the share in the United States (close to 30 %), while the gap between France and the United States was still close to a factor of two. In twenty years, the share of ICT in nonresidential

investment nearly multiplied by a factor of four in Finland, but "only" by a factor of two both in France and the United States. In France and in the United States, the share of software in nonresidential investment increased more than the two other types of investment between 1980 and 2000. Communication equipment was quite logically the most dynamic part of investment in Finland. The ICT investment boom did not start at the same time in every country. The United States has been strongly investing in ICT equipment since the eighties. Two stages can be distinguished. The first one is linked to the development and diffusion of personal computers at the beginning of the eighties. The second one is linked to the emergence of the Internet from the middle of last decade. The first wave does not appear either in French statistics or in Finnish ones. The second wave has been evident in French statistics only since the end of the nineties. The second wave in Finland is a bit different since it is supported both by the emergence of mobiles phones at the beginning of the nineties and by the diffusion of the Internet. Finland has indeed the highest penetration of mobile phones and the Internet in the world.

Table 4: Share of ICT investment in total non-residential investment

Percent, current prices figures**

Types of ICT investment	Date	**France**	**Finland**	**United States**
IT equipment	1980	2.5	2.0	5.1
	1990	3.5	3.6	7.0
	1995	3.9	4.0	8.7
	2000	4.4	2.9*	8.3
Communications equipment	1980	2.9	3.2	7.1
	1990	3.2	3.9	7.5
	1995	3.5	9.3	7.3
	2000	3.9	15.3*	8.0
Software	1980	1.3	2.6	3.0
	1990	2.6	5.2	8.0
	1995	3.5	9.2	10.1
	2000	6.1	9.8*	13.6
ICT equipment and software	1980	6.8	7.8	15.2
	1990	9.4	12.7	22.5
	1995	10.8	22.5	26.1
	2000	14.4	28.0*	29.9

* 1999 for Finland.

** Current prices figures are more meaningful than constant prices figures because of chain weighted indices.

Source: Colecchia-Schreyer (2001), table 2.

Similar national accounts data are not available for Ireland and the Netherlands. Private sources data can nevertheless be mobilised, for instance the ones collected by IDC (International Data Corporation). Though available on a shorter period of time, those data confirm and complete the preceding ones. What is striking is that Ireland exhibits both the lowest ICT share in GDP (less than 3 % in 2000) and the smallest increase of this share, while the Netherlands has leapfrogged the United States between 1993 and 2000, with a share slightly higher than 4 %, thanks to a significant increase of the share of software (table 5).

Table 5: Share of ICT investment in GDP*

Percent, current prices figures (expressed in US$ millions)

Types of ICT investment	date	**Finland**	**France**	**Ireland**	**Netherlands**	**United States**
IT hardware	1993	0,5	0,4	0,4	0,5	0,7
	2000	1,0	0,7	0,8	0,9	1,1
	2001	0,9	0,6	0,7	0,8	0,9
Software	1993	0,6	0,6	0,4	0,9	1,0
	2000	1,7	1,5	0,9	2,3	1,8
	2001	1,7	1,6	0,9	2,3	1,8
Telecommunications	1993	0,6	0,7	0,9	0,8	0,7
	2000	0,9	1,0	1,1	1,1	1,2
	2001	0,9	1,0	1,0	1,1	0,9
Total ICT	1993	1,6	1,7	1,7	2,2	2,5
	2000	3,5	3,1	2,8	4,3	4,1
	2001	3,5	3,3	2,6	4,2	3,6

*Figures are based on WITSA data for European countries and NIPA data for the United States. Because of the method used to derive investment data from spending data, and contrary to WITSA data, total ICT only include the IT hardware, software and telecommunications equipment components. WITSA ICT definition is a bit broader: it also includes IT services, internal ICT and other office equipment.

Detail may not sum to totals due to rounding.

Sources: WITSA (2002), OFCE.

In spite of different positions in the business cycle and differences in ICT specialisation, Finland, France and the United States all witnessed a rapid increase of real ICT investment during the last twenty years (table 6). The growth rate even accelerated in the second part of the nineties. The figures are all the more impressive when an harmonised price index is used to deflate current prices data, especially in the case of Finland. The similarity in the rhythms of growth is noteworthy: according to these figures, the United States no longer appears as a special case and France as a "straggler". Figures for Ireland and the Netherlands are not comparable and have to be read with great caution. They nevertheless give an idea of the high rhythms of growth.

Table 6: Average annual percentage growth of real investment of the business sector

Percent

Types of ICT investment	Periods	**Finland**	**France**	**United States**	**Ireland**	**Netherlands**
			National price index			
IT equipment	1980-1990	12.1	18.8	18.9		
	1990-2000	– 7.6	15.4	27.5		
	1990-1995	– 11.3	9.1	22.5		
	1995-2000	– 2.9	21.7	32.4		
Communications equipment	1980-1990	8.6	4.6	3.9		
	1990-2000	10.7	7.3	11.2		
	1990-1995	4.9	3.3	6.2		
	1995-2000	17.9	11.2	16.2		
Software	1980-1990	8.5	11.6	14.6		
	1990-2000	4.3	9.4	14.1		
	1990-1995	1.2	4.7	11.6		
	1995-2000	8.1	14.0	16.6		
			Harmonised price index			
IT equipment	1980-1990	25.4	22.5	18.9		
	1990-2000	15.1	23.5	27.5		
	1990-1995	9.4	15.4	22.5		
	1995-2000	22.3	31.6	32.4	53.4	42.9
Communications equipment	1980-1990	8.6	7.3	3.9		
	1990-2000	18.4	7.9	11.2		
	1990-1995	12.2	4.3	6.2		
	1995-2000	26.2	11.4	16.2	11.3	10.8
Software	1980-1990	14.4	15.0	14.6		
	1990-2000	10.0	12.1	14.1		
	1990-1995	6.9	5.7	11.6		
	1995-2000	13.9	18.6	16.6	21.1	17.4

Sources: Colecchia-Schreyer (2001) table 3 for Finland, France and the United States; WITSA (2002) for Ireland and the Netherlands; OFCE.

The Useful Distinction between ICT-producing and ICT-using Industries

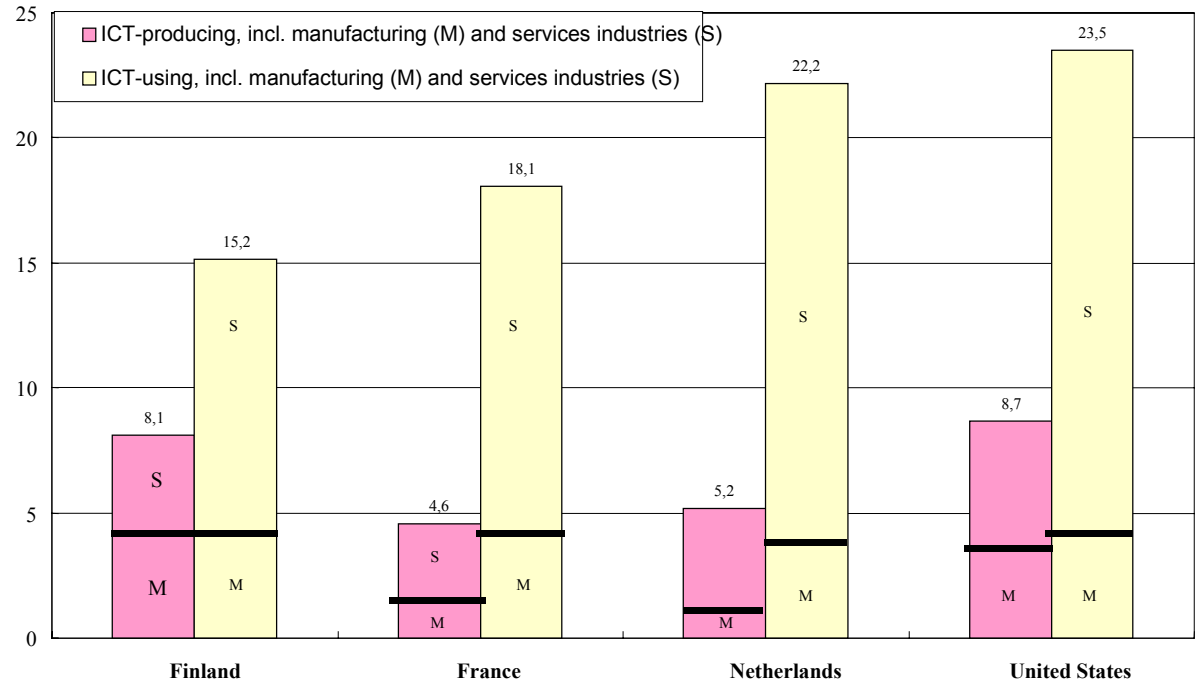
The characteristics of each country's ICT specialisation can be seen by splitting the ICT sector into four sub-categories: ICT-producing manufacturing; ICT-producing services; ICT-using manufacturing; ICT-using services[6]. The output shares of the ICT-producing sector are quite low. Even for the United States, the output share is less than 10 %. When measured in real terms, these shares have all increased during the last decade, and Finland experienced the strongest increase. But when measured in nominal terms, the increase is naturally less

6. See Appendix A for the composition of these sub-sectors.

important, and even non-existent in France. The United States and Finland exhibit notably larger shares for ICT-producing manufacturing industries (around 4 %), while the Netherlands exhibits a very low share (graph 2). The United States and the Netherlands[7] exhibit larger shares for ICT-using services industries (between 18 and 19 %). The output share of ICT-using manufacturing is close to 4 % for the four countries. No special pattern emerges in this particular sector. During the last decade, the output shares of ICT-using industries (either in real or in nominal terms) have increased only in the United States and in the Netherlands (boosted by the development of the ICT-using services sector), while decreasing in Finland and in France. Finland is the sole country for which the output share of ICT-producing manufacturing industries is higher than the output share of ICT-producing services industries. The ICT specialisation of Finland relies heavily on the manufacturing component of the ICT industry, while the ICT specialisation of the Netherlands relies more on the services component. France is in between.

Graph 2: ICT share in GDP in 1998

Percent



Sources: GGDC database, the Conference Board, van Ark (2001), OFCE.

7. In the Netherlands, the high output share of ICT-using services industries is due to the large business services sector in this economy.

Differences in contributions to GDP growth have to be read accounting for the differences in ICT-production and ICT-use (table 7). When there is no difference (*e.g.* the output shares of ICT-using manufacturing industries), there is no significant difference in growth contribution. A few results have to be kept in mind. The relative contribution to output growth is often higher than the share in output. The United States experienced the highest contribution to growth of ICT-using industries over 1996-1999. The ICT-producing sector contribution to growth is higher in Finland (both in absolute and relative terms) than in the United States, though the ICT-producing sector is larger in the United States. Finland also witnessed the largest increase of contribution between the first and the second half of the nineties. Finland is the sole country for which the contribution to growth of ICT-producing industries is higher than the contribution of ICT-using industries, though this latter is already quite important. The contribution of the ICT-producing sector are similar in France and in the Netherlands, but this hides structural differences. In France, the contribution is equally supported by the ICT-producing manufacturing and the ICT-producing services sector. This equal contribution is also true for the ICT-using industries. This reflects the "in-between" status of France. In the Netherlands, the contribution to growth is disproportionally supported by the ICT-producing and ICT-using services industries. Compared to the other countries of van Ark's sample, Finland, France, the United States are the only countries with large growth contributions from ICT-producing manufacturing industries.

Table 7: Contributions to GDP growth

Percentage points (except for GDP growth in percent)

	ICT-producing		ICT-producing manuf.		ICT-producing services		**ICT-using**		ICT-using manuf.		ICT-using services		**GDP growth**	
	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999
Finland	0.3	1.5	0.2	1.0	0.1	0.5	-0.5	1.0	0.0	0.2	-0.5	0.8	-0.5	5.1
France	0.2	0.5	0.1	0.2	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.2	0.9	1.9
Netherlands	0.1	0.6	0.0	0.0	0.1	0.6	0.5	1.3	0.1	0.1	0.4	1.2	2.1	3.7
United States	0.4	0.8	0.2	0.5	0.2	0.3	0.6	1.9	0.0	0.2	0.5	1.7	2.3	4.7

The contributions are computed by weighting the annual change in each sector's GDP growth at constant prices at the GDP share of that sector of the previous year.

Detail may not sum to totals due to rounding.

Source: van Ark (2001).

In every countries, the ICT sector contributed to the acceleration of employment growth between the first half and the second half of the nineties (table 8). But, except in the United States, the bulk of the employment growth occurred in the non-ICT sector.

Table 8: Contributions to employment growth

Percentage points (except for employment growth in percent)

	ICT-producing		ICT-producing manuf.		ICT-producing services		**ICT-using**		ICT-using manuf.		ICT-using services		**employment growth**	
	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999
Finland	0.03	0.4	0.1	0.2	– 0.1	0.2	– 0.5	0.2	– 0.1	– 0.01	– 0.4	0.2	– 3.8	2.2
France	– 0.02	0.03	– 0.03	– 0.01	0.01	0.04	0.0	0.1	– 0.1	– 0.01	0.02	0.2	– 0.2	0.6
Netherlands	– 0.05	0.3	– 0.1	0.00	0.04	0.3	0.2	0.7	– 0.1	– 0.03	0.3	0.7	0.8	2.7
United States	0.03	0.2	– 0.03	0.03	0.1	0.2	0.2	0.6	– 0.02	0.00	0.2	0.6	1.1	2.1

The contributions are computed by weighting the annual change in each sector's employment growth at the employment share of that sector of the previous year.

Detail may not sum to totals due to rounding.

Sources: GGDC database, the Conference Board.

ICT Contribution to Output and Labour Productivity Growth

Once all these indicators of ICT intensity and ICT specialisation are in mind, a complementary and also more comprehensive way to gauge the importance of ICT is to compute contributions to output and labour productivity growth thanks to a growth accounting framework. The results partly reflect the ICT specialisation of each country and differences in ICT diffusion[8]. They above all give some clues about the dynamic of productivity growth and help understand to what extent each country could qualify to the "new economy" label.

What Tells the Traditional Growth Accounting Framework ?

Different studies are available: national studies, but they are not comparable because of differences of data and methods; international comparative studies offer the same methodology, but they also face data problems (see box 3 for some elements about these problems). Unfortunately, they do not cover the same set of countries. As for the countries of our sample, three studies are of particular interest: Colecchia-Schreyer (2001), European Commission (2000) and Daveri (2001). We consider their results as complementary.

8. Institutional elements and particular national economic policies (more precisely employment policies) also play an important role, but will not be discussed here. See for example on this subject OECD (2000a), OECD (2001), European Commission (2000), McGuckin and Stiroh (2001).

Box 3

Some Measurement Problems in International Comparative Studies

The measurement of output in intensive ICT-using industries, particularly in services, is the largest methodological puzzle: it has been a topic for statisticians for a long time and a huge literature exists on it. Our attention in this box is more focused on the measurement of the rapid price decline of ICT products because it strongly affects data comparability, depending on the use of hedonic techniques in national accounts. The introduction of hedonic price indices (in 1986) and chain indices (in 1995) in the National Income and Product Accounts (NIPA) had a strong upward effect on measures of real output and labour productivity growth in the United States (for some illustrative figures see Baudchon-Brossard, 2001). These adjustments raise point of criticism concerning *ad-hoc* changes in measurement methods. The preferable use of comprehensive methodologies, such as input-output tables and capital flows matrices, in combination with chain price and quantity indices has been an established practice in France and the Netherlands for some time[1].

Daveri (2001) directly applied hedonic prices for the United States to European countries. European Commission (2000) applied adjustments of 100 % as well 50 % of European prices with American deflators. But, as underlined by van Ark (2001), such a method may lead to biases for several reasons: "Firstly, as computer hardware production in the United States mainly consists of PCs and semiconductors, an adjustment of nominal ICT output in Europe, which is more strongly dominated by the production of peripheral equipment, with a US deflator may lead to an exaggeration of the price decline. Secondly, the application of hedonic price indices needs to be combined with the use of chain weights in the price index [...] Thirdly, it is questionable whether one can assume that the computer hardware producing industry in Europe is as competitive as in the United States, which implies again that the price decline in Europe might be overstated when using the US index". The harmonised index developed by Schreyer (2000) appears better suited. His harmonised index is based on the assumption that the difference between price changes for ICT capital goods and non-ICT capital goods in the United States is the same across countries and so is applicable (once smoothed) to the non-ICT deflator of other countries.

Another source of problems in international comparative studies is the lack of comparable detailed and long time series of different types of ICT investment. Most of the research on the importance of ICT has been carried out for the United States, where the NIPA provide such detailed statistics. International comparative studies came later. Schreyer's is the first extensive study, covering the G7 countries. He, and later Daveri (2001), used IDC data for current price expenditures on ICT goods (software expenditures are not covered in Schreyer study but are included in Daveri's). This is the only source of consistent ICT data for a large cross-section of countries in the nineties. IDC indeed undertakes the collection of ICT spending data for the fifty largest markets in the nineties, and WITSA (World Information Technology and Services Alliance) publishes them in its report *Digital Planet*. ICT spending data reflect the revenues paid to primary vendors and distribution channels for office machines, data processing systems, software and services by the final customer. Final customers include

corporations, households, schools and government agencies. To calculate business sector investment in ICT, government and households spending are substracted out of total spending. Unfortunately, within the broad WITSA/IDC spending item, the distinction between private and public spending, as well as between the household and the business sector, cannot be recovered. Daveri (2001) has chosen to impute a fraction of total spending to business sector investment, by computing the 1992-1999 average ratio between business sector investment and the corresponding WITSA spending item for the United States. According to more recent figures computed on the 1993-2001 average ratio, NIPA hardware investment turns out to be about 58 % of total hardware spending; NIPA communications equipment is about 34 % of total telecommunications spending; and NIPA software investment is about 207 % of the WITSA software item. These coefficients are then multiplied by the corresponding WITSA spending items for European countries to derive nominal ICT investment spending. Unfortunately, because of the distortions introduced by the use of these unofficial data, new measurement issues in fact add to those already emphasised in the literature.

Following and updating Schreyer, Colecchia (2001) have been able to use a newly compiled database of investment in ICT equipment and software based on the System of National Accounts 1993 for nine countries (G7 plus Australia and Finland), and available for the whole last decade (1990s). The study also covers software as an ICT asset. Colecchia and Schreyer (2001) extend Colecchia's work and include the year 2000 for several countries. The inclusion of software reflects the recognition of software as an intangible investment good in SNA93, but it carries some problems. For instance, Lequiller (2001) found significant cross-country differences in the allocation of software expenditure between fixed capital formation and intermediate consumption. In addition, there is a similar problem as with hardware investment of finding an appropriate price index for software.

1. Eurostat has also launched an initiative to develop harmonised hedonic deflators for computers across European countries.

According to Colecchia-Schreyer (2001) findings, over the past twenty years, ICT contributed between 0,2 and 0,4 percentage point per year to economic growth, depending on the country. During the second half of the 1990s, the range increased, going from 0,35 to 0,9 percentage point (table 9). One of the most interesting results is that the United States has not been alone in benefiting from the positive effects of ICT capital investment on economic growth, nor was the United States the sole country to experience an acceleration of these effects. For instance, like in the United States, ICT contribution doubled in Finland. Yet, differences in the size of contributions remain. The United States witnessed the largest contribution (0,9) and France the lowest (0,35). One of the conclusions of the European Commission (2000) study is that the European Union suffers from a lag of "only" three to five years in the diffusion of ICT compared to the United States. Indeed, the ICT contribution to

output growth from 1995-1999 (0,4 percentage point out of a 2 % growth rate[9]) was slightly higher than the one observed in the United States from 1992-1994. Within the European Union, the results are very diversified, but once more, Ireland, Finland and the Netherlands are among the leading countries. Ireland and Finland recorded strong increase of the ICT contribution. Finland and the Netherlands recorded ICT contributions higher than the EU average over 1995-1999. Ireland is the sole country to reach a higher contribution (1,6) than the United States (as computed by national studies). But the sensitivity of such results to the underlying computation hypothesis prevents us from considering it as definitive. For instance, Daveri (2001) calculations do not confirm it and even show a higher ICT contribution for the Netherlands (0,7) than for Ireland (0,6).

Table 9: ICT contribution to output growth: summary of different growth accounting results[1]

Percentage points

	United States		France		Finland		Ireland	Netherlands
National studies								
	Oliner-Sichel (2000)	1.1 out of 4.8	Cette *et al.* (2001)	0.4 out of 2.2	Jalava-Pohjola (2001)	0.7 out of 6.0		
	Jorgenson *et al.* (2001)	0.9 out of 4.6	Crépon-Heckel (2000)	0.3 out of 2.6	Niininen (2001)	0.4 out of 2.4		
	Jorgenson (2001)	1.2 out of 4.1	INSEE[2] (2000)	0.3 out of 1.7				
			INSEE[3] (2000)	0.1 out of 2.9				
International comparative studies								
Schreyer (2000)	0.4 out of 3.0		0.2 out of 0.9					
European Commission (2000)[4]			0.4 out of 1.9		0.5 out of 4.5		1.6 out of 7.5	0.6 out of 2.9
Schreyer-Colecchia (2001)	0.9 out of 4.4		0.35 out of 2.8		0.6 out of 5.6			
Daveri (2001)	0.9 out of 3.3		0.4 out of 1.6		0.5 out of 2.1		0.6 out of 6.9	0.7 out of 2.8

1. Figures are not directly comparable because of some differences in methodologies, periods and coverage (except of course within an international comparative study). For more details, see Appendix B.

2. The contribution is based on individual firms data.

3. The contribution is based on national accounts data (and over a longer time period).

4. Figures correspond to the intermediate estimate (scenario 2). It assumes an ICT price decline in the EU15 equal to half of that in the United States and an elasticity of substitution between ICT capital and other factors of production of minus 1,5.

9. These results are similar to those of the ECB (2001) study, which also found a contribution of 0,4 percentage point out of a 1,9 % growth rate over 1996-1999. But due to data limitations, the ECB study only covers France, Germany, Italy and the Netherlands, which together account for around 77 % of Euro area nominal gross value added.

In general, cross-country differences in ICT growth contributions are a close counterpart of differences in ICT investment and ICT accumulation[10]. At least for Ireland, though, rates of return do make a difference (Daveri, 2001). Comparing Finland and Ireland more closely conveys the importance of rate of returns. In 2000, Finland invested roughly the same fraction of GDP in ICT capital goods as Ireland (table 5). It also started with a similarly poor ICT capital endowment in the early nineties. But Finland obtained a smaller contribution from ICT than Ireland. This has to do with its smaller real net rate of return (4,4 % against 5,9 % in Ireland), and also with its much lower growth rates of ICT capital stocks (see table AC in Appendix C for more figures).

Contributions to Productivity Growth: the "New Economy" Criterion

Even though an acceleration of GDP growth might be a first sign of positive macroeconomic spillovers of the diffusion of ICT, only an acceleration in labour productivity growth may generate a sustainable higher growth path derived from ICT. This is the basis of the "new economy" concept. Unlike in the United States, and to a lesser extent in France, there has been no acceleration in the growth rate of labour productivity between the early 1990s and the late nineties in Finland, nor in the Netherlands (table 10)[11]. Labour productivity growth is substantially faster in the ICT-producing sector and also in the ICT-using sector than in the whole economy (but in France). The productivity acceleration in the ICT-producing manufacturing industries was especially strong in the United States, and to a lesser extent in Finland and France too. The Netherlands appears in a bad shape compared to the other countries: deceleration of labour productivity in ICT-producing manufacturing; no acceleration of labour productivity in ICT-using manufacturing industries (like France); much lower labour productivity gains in the ICT-using services industries.

10. The numerical values of growth contributions are the combined outcome of three elements, *i. e.* rates of accumulation, rates of return on investment and capital-output ratios. See Appendix D for a brief description of the growth accounting framework.

11. One must keep in mind the severe recession of the early 1990s faced by Finland in line with the loss of foreign demand from the former USSR. Real GDP declined by 10,4 % between 1990 and 1993. Since 1994, GDP grew at the average annual rate of 4,7 %, which is substantially higher than the pre-recession rate of 3,3 %, but at the same time, labour productivity growth rate declined from a pre-recession pace of 3,1 % to a post-

Table 10: Labour productivity growth

Percent

	ICT-producing		ICT-producing manuf.		ICT-producing services		**ICT-using**		ICT-using manuf.		ICT-using services		**productivity growth**	
	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999
Finland	7.8	13.7	10.9	17.6	4.7	8.3	0.5	4.9	4.0	6.0	– 0.4	4.5	3.4	2.8
France	4.1	8.5	8.6	16.2	2.4	5.4	0.9	0.7	4.7	4.1	0.0	– 0.1	1.1	1.3
Netherlands	4.0	4.4	7.3	2.4	1.8	4.4	1.3	1.8	4.7	4.0	0.5	1.5	1.3	0.9
United States	4.8	7.2	10.0	16.8	2.1	1.5	1.3	4.4	1.6	4.7	1.4	4.5	1.2	2.1

Detail may not sum to totals due to rounding.

Source: van Ark (2001).

Table 11 shows that the combined contribution to labour productivity growth of ICT-production and ICT-use is the same in Finland and the United States from 1996-1999 (around 2 percentage points). However, in Finland it was largely accounted for by ICT-production (despite its small size), whereas in the United States, ICT-use contributed to the largest extent. This result also holds when one considers the contributions to the change in labour productivity growth. In the United States, the labour productivity acceleration arises more from the use of ICT than from the production, while in France, it fully arises from ICT production. Though facing a deceleration of labour productivity, Finland and the Netherlands, like the United States and France, benefited from an increase of the ICT contribution between the first and the second half of the nineties. In Finland, this increase is stronger for ICT-producing industries than for ICT-using industries, while in the Netherlands, the increase is roughly the same for the two sector. In fact, the labour productivity deceleration in those countries is due to the under performance of the non-ICT sector, which offset the productivity-enhancing impact of ICT. In this sense, the "new economy" is yet to demonstrate its strength in Finland and the Netherlands. By contrast, France may be more "on the way" because the positive contribution of the ICT sector to the acceleration of labour productivity growth has been only marginally offset by the negative contribution of the non-ICT sector.

recession pace of 2,5 %. It is also worth remembering that both during the eighties and the first half of the nineties, labour productivity growth in the EU was, on average, faster than in the United States.

Table 11: Contributions to labour productivity growth

Percentage points (except for productivity growth in percent)

	ICT-producing		ICT-producing manuf.		ICT-producing services		**ICT-using**		ICT-using manuf.		ICT-using services		**productivity growth**	
	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999	1990-1995	1996-1999
Finland	0.6	1.4	0.4	1.0	0.2	0.4	0.1	0.6	0.1	0.1	– 0.1	0.5	3.4	2.8
France	0.2	0.4	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	1.1	1.3
Netherlands	0.1	0.5	0.01	0.00	0.1	0.5	0.3	0.6	0.1	0.02	0.2	0.6	1.3	0.9
United States	0.3	0.7	0.2	0.4	0.1	0.2	0.3	1.4	-0.01	0.1	0.3	1.3	1.2	2.1

Detail may not sum to totals due to rounding.

Source: van Ark (2001).

Though differences of methodology between such basic accounting framework and the growth accounting framework, all figures provide evidence about the high level of the ICT contribution to labour productivity growth and acceleration in each country of our sample. The growth accounting framework presents one more advantage: it allows to compute the contribution of capital deepening and multifactor productivity (MFP) growth to the change in labour productivity growth. Compared to the deceleration of labour productivity growth in the whole euro area and its origin, the cases of Finland, France and the Netherlands appear relatively less problematic (table 12). The contribution of MFP to the change in the average growth rate of labour productivity is surprisingly high in Finland, France and the Netherlands, and surprisingly negative in the euro area. Even if comparison of MFP growth rates must be made with great caution, the different figures are compelling. France and the United States exhibit a high contribution to MFP acceleration of both the ICT and the other sectors. But evidence is still mixed to attribute this high contribution in the other sectors directly to their intensive use of ICT.

Table 12: Sources of the change in labour productivity growth rate between the first and the second half of the nineties

Percentage points

	Finland	United States	United States[3]	Euro area	France	Netherlands
Change in the average growth rate of labour productivity in 1995-1999 over 1990-1995	– 0.4	1.0	0.9	– 1.1	– 0.5[1]	0.3[2]
Contributions from:						
Capital deepening	– 2.1	0.5	0.7	– 0.3	– 1.2	– 0 .3
ICT capital	0.0	0.5	0.6	0.1	0.1	0.1
Other capital	– 2.1	0.0	0.1	– 0.4	– 1.3	– 0.4
Labour quality	0.0	– 0.1	– 0.1	n. a.	– 0.4	n. a.
Multifactor productivity	1.8	0.7	0.3	– 0.8	1.0	0.7
ICT sector	n. a.	0.3	0.3	n. a.	0.5	n. a.
Other sectors	n. a.	0.4	0.0	n. a.	0.5	n. a.

1. Change of output per head in 1995-2000 over 1990-1995.

2. Change in 1996-2000 over 1991-1995. The inclusion of the year 2000 seems to explain the acceleration of labour productivity, though it decelerates between 1990-1995 and 1996-1999 according to van Ark (2001) figures.

3. Change in 1996-2001 over 1991-1995. This column presents the most recent data for the United States.

Detail may not sum to totals due to rounding.

Sources: Jalava-Pohjola (2001) for Finland, table 8; for the United States, Oliner and Sichel (2000), table 5, and (2002), table 1; ECB (2001) for the euro area, table 6; van der Wiel (2001) for the Netherlands, table 4. 2; Cette *et al.* (2001) for France, table 1-B.

The ICT contribution to MFP growth is a controversial issue. MFP is a doubtful concept. The increase in MFP growth could be little more than the result of rapid technological progress in the production of computers, semi-conductors and related products. Some empirical studies at least provide some evidence of this contribution[12]. On the other hand, ICT, like previous "general purpose technologies", may help other sectors of the economy become more efficient and innovative, and boost MFP growth in other countries, albeit in a different context than the United States. In this sense, the figures for France are encouraging, and confirm the idea that France may be more on the way toward the "new economy" than its European partners. Finally, it does not deserve its "stragglers" label.

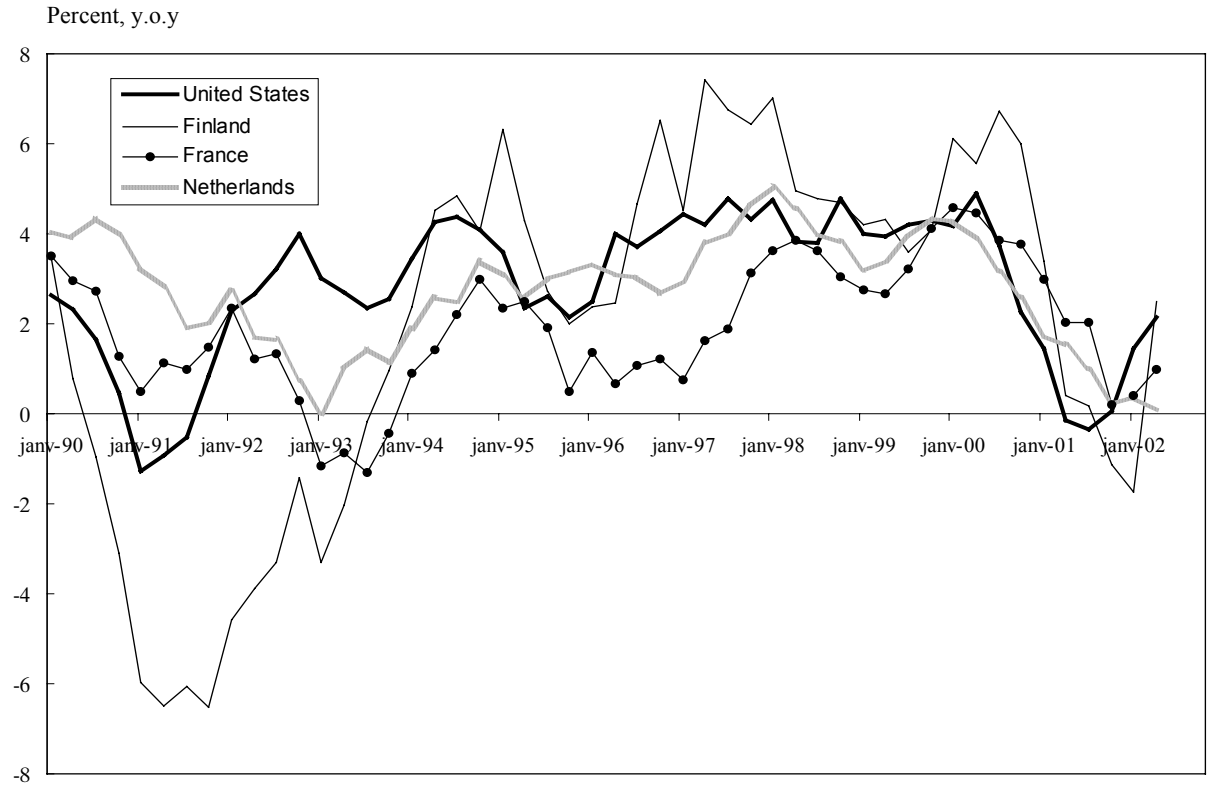
A Macroeconomic Approach of the ICT Bust in Five OECD Countries

Since the middle of 2000, the slowdown of economic activity has been quite important (graph 3). The United States has been officially in recession since March 2001 (even if GDP growth has been negative only in the third quarter of 2001). GDP growth of Ireland and

12. See for instance, Oliner-Sichel (2000 and 2002), Jorgenson *et al.* (2001), Cette *et al.* (2001), Pilat and Lee (2001), European Commission (2000).

Finland has been reduced by about 5 percentage points between 2000 and 2001, a steeper slowdown than for the United States. French GDP growth has also noticeably slowed, in fact in the same extent than the United States. The slowdown of Dutch growth has been less pronounced than in the other countries, but still contrasts with previous years of high regular growth (just like the United States). The ICT bust is of course not the sole explanation for these evolutions. But it played a role through three main channels. The first one is the abrupt slowdown of foreign trade, initiated by the fall of demand for ICT products and the American recession. The second one is that the ICT sector of each country has been strongly hit, regardless of the type of specialisation. The third channel is the fall of market capitalisation since the Internet bubble burst, shared by all countries[13]. This fall is likely to affect their economy through negative wealth effects, diminishing value of stock options, higher access costs to capital markets.

Graph 3: GDP growth in ICT leading countries



Sources: BEA, Eurostat.

13. The Europe NASDAQ composite index (EASDAQ) and the FTSE Eurotop 300 Telecommunications index both peaked in March 2000, simultaneously with the American indices.

The United States will serve as a reference to describe the timing and the nature of the reversal because of the availability on a quarterly basis of disaggregated investment data, and on a monthly basis of various ICT indicators. The same set of data does not exist for the other countries, but similar data can nevertheless be mobilised.

At the Beginning, the United States

The present recession is compared to the previous six slowdowns (defined here on a growth cycle basis rather than on a NBER-business cycle basis[14]) in order to gauge the degree of resilience of the economy. The contribution of fixed private nonresidential investment has been strongly negative (– 1,0 percentage point compared to an average contribution over the previous recessions of – 0,4). But thanks to symmetrically strong positive contributions of private consumption and residential investment, the current slowdown has remained relatively mild until the first quarter of 2002. The negative contribution of fixed private nonresidential investment essentially comes from the negative contribution of ICT investment, and more specifically from "other ICT investment" (communication equipment; instruments; photocopy and related equipment; office, computing and accounting machinery) (table 13).

Table 13: Contributions of fixed private nonresidential investment to GDP growth in the current and previous six slowdowns

Percentage point per quarter (annual rates)

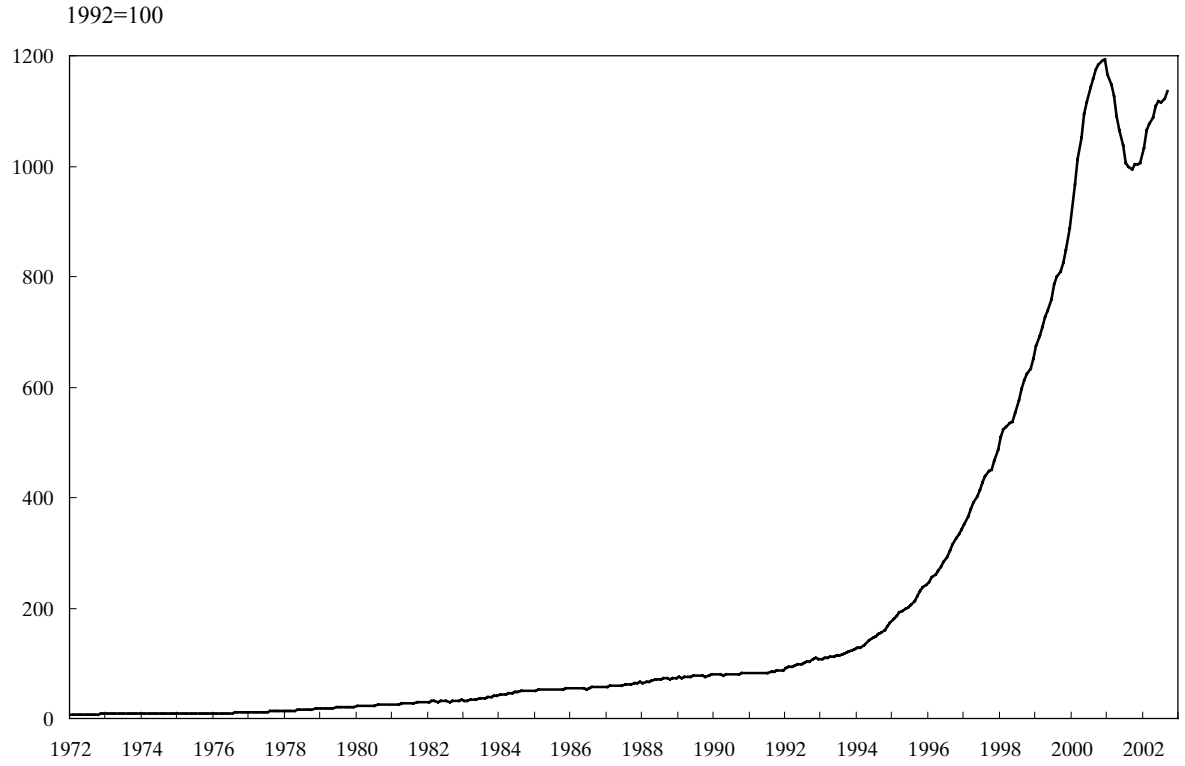
	1959:1 – 2001:4	mean of previous six recessions	2000:4 – 2001:4
Labour productivity growth	0,6	– 0,1	0,5
GDP	3,4	– 1,3	0,3
Fixed private non residential investment	0,6	– 0,4	– 1,0
Structures	0,1	0,0	– 0,3
Equipment and software	0,5	– 0,3	– 0,8
ICT	0,3	0,2	– 0,4
Computers and peripherals	0,1	0,1	0,0
Software	0,1	0,1	0,0
Other	0,1	0,1	– 0,3
Industrial equipment	0,1	– 0,1	– 0,2
Transportation equipment	0,1	– 0,3	– 0,2
Other	0,0	– 0,1	– 0,1

Source: BEA.

14. On the basis of Koenig *et al.* (2002) criteria, cyclical growth slowdowns began in 1960:1, 1969:2, 1973:4, 1979:2, 1981:3, 1990:1 and 2000:4. Only the first four quarters of each slowdown are considered here.

But as mentionned by Koenig *et al.* (2002), "that the ICT sector was unusually hard hit during the recent economic slowdown does not necessarily mean that the ICT collapse caused the slowdown". The ICT collapse was preceded by a decline in manufacturing output which was, in turn, preceded by a sharp slowing of growth in retail sales and a build-up in inventories. In fact, the industrial production downturn was initiated by the drop of transportation equipment production. This sector reached its peak in January 2000, whereas industrial production reached its peak five months later, and ICT production at the end of the year. This timing also appears in the investment data. Risks and growth prospects in the ICT sector were abruptly reassessed when financial markets became aware of their "irrational exuberance", of their unrealistic profits forecasts and of the end of the investment boom related to Y2K. The Internet bubble then busted (the NASDAQ and the S&P500 indexes reached their peak in March 2000), and this contributed to spreading weakness throughout the economy. The enthusiasm for ICT suddenly collapsed, revealing excess capacities and worsening profits. Nominal orders for ICT equipment dropped in the middle of 2000 and ICT production reached its peak in December, sparking layoffs early in 2001. From the peak (June 2000) to the trough (September 2001), nominal orders fell by 43 %, reversing the gains of the prior 6 years. From its peak (December 2000) to its trough (September 2001), ICT production fell by 17 %. Capacity utilisation fell from a May 2000 high of 88,8 % to a historic low of 60,6 % in December 2001. In one year, ICT industries reversed the net job gains of the prior 6 years. For the year 2001, ICT manufacturers reduced their ranks by 213 000 jobs, directly accounting for 16,2 % of manufacturing's job losses (graphs 4 to 7).

Graph 4: ICT production

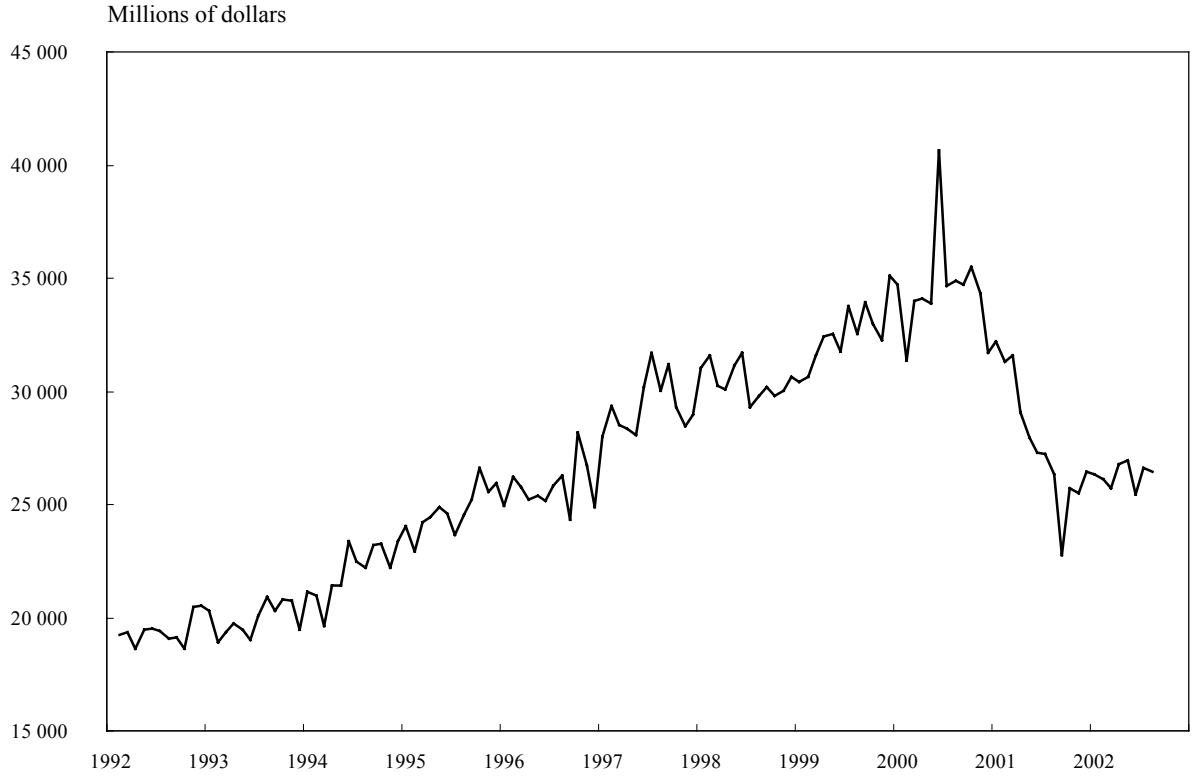


Source: Federal Reserve.

Graph 5: ICT capacity utilisation rate

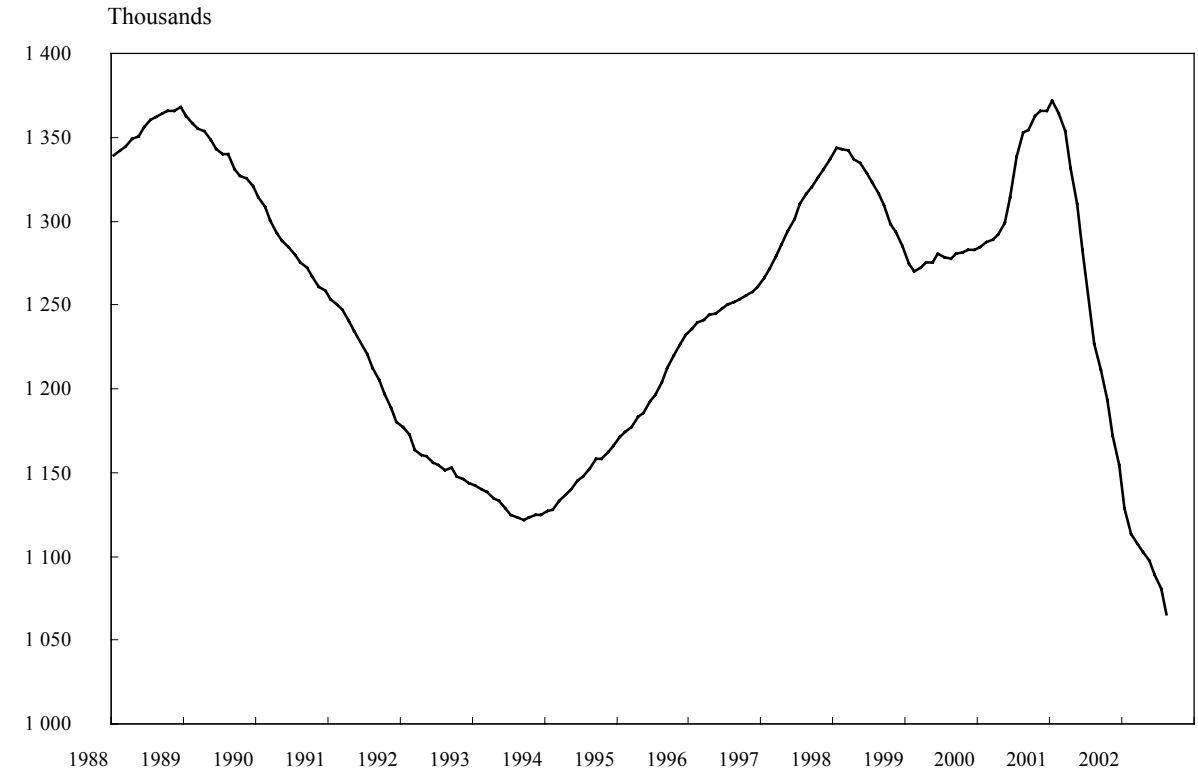
Source: Federal Reserve.

Graph 6: ICT orders



Source: US Census Bureau.

Graph 7: ICT manufacturing employment*



*ICT manufacturing employement includes computer and office equipment (SIC 357), communications equipment (SIC 366) and electronic component and accessories (SIC 367).
Source: US Bureau of Labour Statistics.

While the mark-up was already declining since the beginning of 1997, the higher access cost to capital markets followed by an abrupt squeezing of bank loans eventually led to the decline of the investment rate by the middle of 2000. The falloff in ICT investment growth during 2001 was dramatic: from an average growth rate per quarter of 5 % during the boom period, ICT investment decreased by 3 % per quarter during the bust period (table 14)[15]. The average growth rate of computers (and peripherals) investment was the highest of the different types of investment, but its fall remains less important than the communication equipment investment growth rate drop. Excess capacities had clearly been built in this sector.

Table 14: Average growth rate of different types of investment during the 1991-2001 cycle

Percent by quarter

Type of investment / Periods	whole cycle	beginning	boom	maturing	bust
Fixed private non residential investment	1.4	1.3	2.5	0.0	– 2.4
Structures	0.2	– 0.7	1.3	1.9	– 2.7
Equipment and software	1.9	2.1	2.9	– 0.6	– 2.3
ICT	3.1	2.9	4.6	0.7	– 2.7
Computers	6.8	6.2	9.2	0.9	– 0.9
Software	3.0	3.0	4.1	0.4	– 0.7
Other	1.3	1.4	2.6	1.1	– 5.8
Communication equipment	1.9	1.7	4.2	0.6	– 9.0
Industrial equipment	0.9	1.3	1.2	1.3	– 3.0
Transportation equipment	1.4	2.7	1.9	– 5.2	– 1.1
Other	0.8	0.6	1.6	– 0.6	– 1.5

Beginning: 1991:1 – 1994:4
Boom: 1995:1 – 2000:2
Maturing: 2000:3 – 2000:4
Bust: 2001:1 – 2001:4. The bust period ends in the fourth quarter of 2001, because ICT investment increased in the first quarter of 2002 (final estimate).
Source: BEA.

The fall off of ICT investment was accompanied by a sharp drop of exports and imports of computers, peripherals and parts[16] as world demand for computer components, ICT equipment and software declined. After an average quarterly growth rate of 5 % during the beginning and boom periods, exports have been declining since the fourth quarter of 2000. And the average quarterly rate of decline was a little more than 6 % during the bust period. As

15. The annual NIPA revision of July 2002 makes less relevant this splitting into four periods: the maturing period is no more really different from the bust period.
16. The only type of ICT products available in NIPA foreign trade data.

for imports, they increased at an even more rapid rate (around 7 %), before also contracting. The decline has also started in the fourth quarter of 2000, but it was shorter and milder. Indeed, imports of computers have been increasing again since the fourth quarter of 2001, and the cumulative decline reached 17 % (between the fourth quarter of 2000 and the third quarter of 2001), while in the case of exports, the cumulative decline reached 28 % (between the fourth quarter of 2000 and the first quarter of 2002).

The Experience of Other Countries: some common features

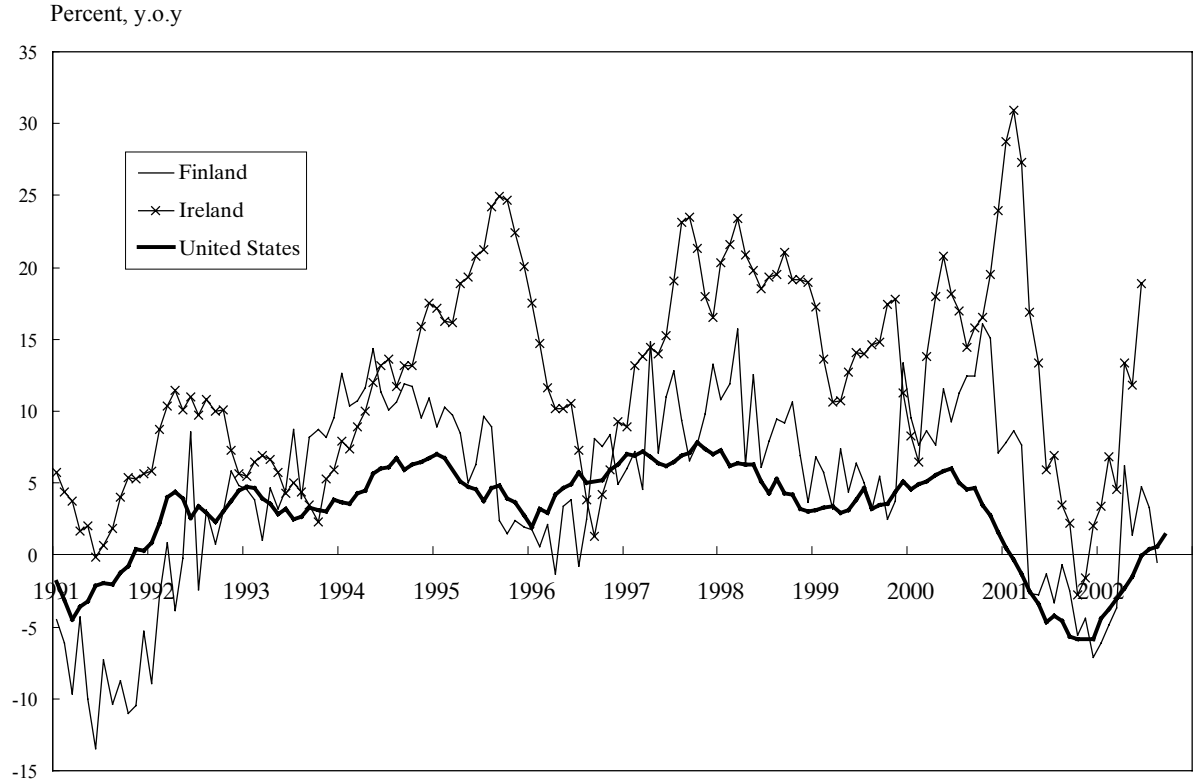
If one considers only the mild American slowdown, it gives the impression that, though the ICT downturn was severe, the ICT stabilising influence has been indirect. ICT products and applications have increased the resilience of non-ICT producing sectors of the economy, in particular thanks to strong and sustained labour productivity gains. In this sense, the high ICT contribution to growth and labour productivity growth in this country may have helped creating a relative immunity toward business cycles fluctuations. In the other countries of our sample, the transformation of their economy towards a knowledge-based economy should also make them less prone to cyclical fluctuations. It is indeed easier for a highly educated labour force to adapt to changes in demand. However, and broadly speaking, Finland, France, Ireland and the Netherlands have been at least as much affected by the ICT reversal than the United States, both in terms of GDP growth, industrial production growth and labour productivity growth.

The European countries suffer from the importance taken by the ICT sector without benefiting from the stabilising advantages of this importance. The ICT's productivity enhancing impact was offset by inefficiencies in the non-ICT sector and by a continued improvement in creating employment. This is evident in figures till 2000 but also in figures for 2001. By contrast to the United States, labour productivity growth in the four European countries of our sample significantly slowed in 2001, and even declined in Finland and the Netherlands. According to McGuckin and Stiroh (2002) figures, labour productivity growth in the United States was still a "high" 1,8 %, after an average rate of growth of 2 % between 1995 and 2000. Labour productivity growth in Finland slipped to a –0,9 % rate of growth in 2001 after an average annual rate of 3,2 % between 1995 and 2000. The slowdown is less important in the other countries, but even so significant. In the Netherlands, labour productivity growth was also negative (–0,3 %) but slipped from a less dynamic rhythm of growth from 1995-2000 (1,1 %). In France, labour productivity increased by a mere 0,1 % in

2001 after an average annual rate of growth of 1,1 %. In Ireland, the pace of labour productivity growth is still higher than in the other countries (3,5 %) but it has lost two percentage points compared to 1995-2000.

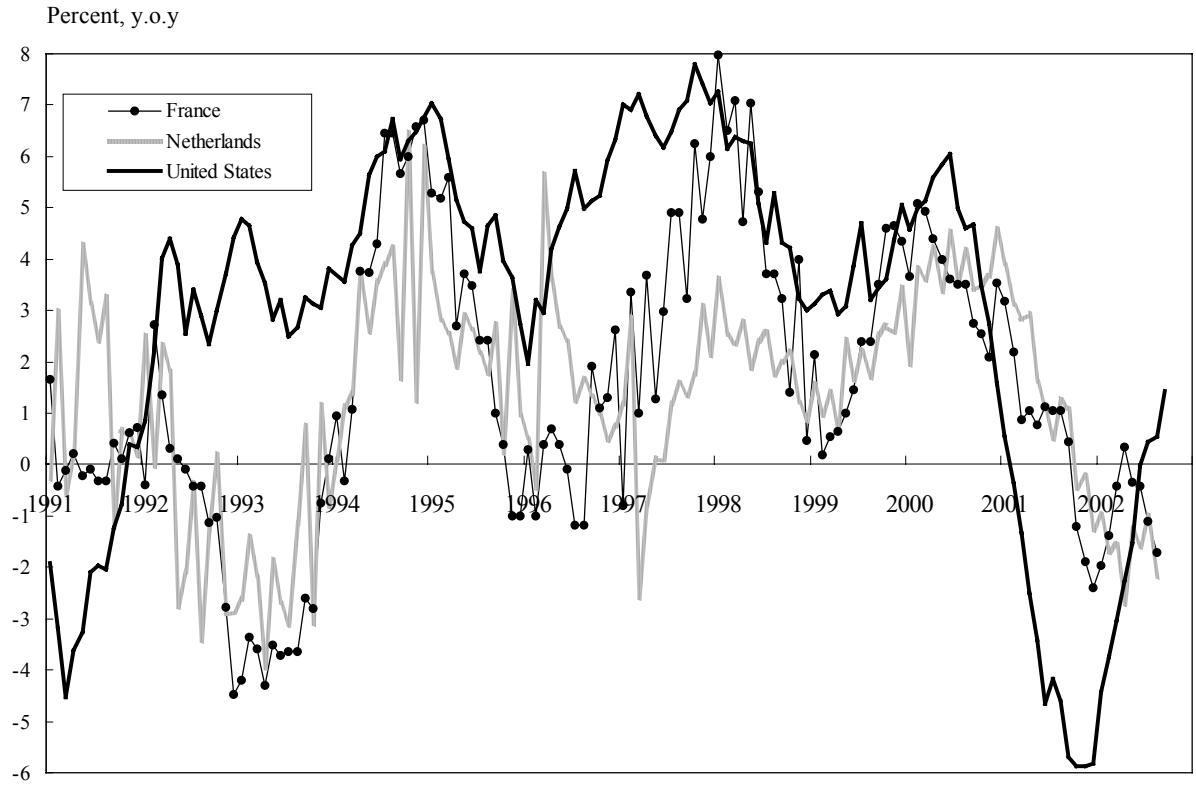
The GDP and industrial production slowdown has been more important in Ireland and Finland than in the Netherlands and in France. The falloff of Irish and Finnish industrial production is more or less similar to the American one in terms of decline at the trough (graph 8). But it is in fact much more abrupt because the pace of growth was faster before the bust. By contrast, the decline of industrial production in France and the Netherlands is half the decline in the United States (graph 9).

Graph 8: Industrial production in Finland, Ireland and the United States



Sources: Federal Reserve, Eurostat.

Graph 9: Industrial production in France, the Netherlands and the United States



Sources: Federal Reserve, Eurostat.

The more closely related GDP components to the reversal of the ICT sector are fixed private nonresidential investment, exports and imports. The contribution of nonresidential investment to the growth slowdown between 2000 and 2001 is unambiguously negative (table 15). The contribution of foreign trade is less clear because of a strong adjustment of both exports and imports. For instance, in France, the United States and to a lesser extent in the Netherlands, the imports slowdown was more important than the exports slowdown, and this helped support growth in 2001. By contrast, foreign trade contributed to the growth slowdown in Finland and Ireland. Changes in private inventories also played a very important role. As far as ICT allow to better anticipate demand fluctuations, such a strong adjustment of private inventories is also a consequence of the ICT reversal. Without the Internet bubble burst and the rapid fallout of demand for ICT products, private inventories would have not so much decreased.

Table 15: Contributions of main components to GDP growth in 2000 and 2001

Percentage points (except GDP growth in percent)

	Finland	Ireland	Netherlands	France	United States
2000					
GDP growth	6.1	11.5	3.5	4.1	3.8
Private consumption	1.3	5.0	1.9	1.6	2.9
Fixed private investment	0.7	1.6	0.6	1.3	1.0
non residential	n.a.	n.a.	0,7	1.1	1.0
residential	n.a.	n.a.	0,0	0.2	0.05
Change in private inventories	0.6	0.5	– 0.2	0.4	0.1
Exports of goods and services	8.6	17.5	6.1	3.6	1.0
Imports of goods and services	– 5.1	– 13.9	– 5.5	– 3.7	– 1.8
Government expenditures and gross investment	0.0	0.8	0.6	1.0	0.5
2001					
GDP growth	0.7	5.9	1.1	1.8	0.3
Private consumption	0.5	2.7	0.6	1.5	1.7
Fixed private investment	0.7	0.3	– 0.3	0.3	– 0.7
non residential	n.a.	n.a.	– 0.3	0.4	– 0.7
residential	n.a.	n.a.	0,0	0.0	0.0
Change in private inventories	0.1	– 0.9	– 0.1	– 1.0	– 1.2
Exports of goods and services	– 1.1	8.5	0.6	0.4	– 0.6
Imports of goods and services	0.0	– 5.6	– 0.5	– 0.2	0.4
Government expenditures and gross investment	0.4	0.9	0.9	0.7	0.65

Changes in private inventories figures for Ireland do not correspond to national accounts figures because of inconsistency problems: they are computed as a residual.

Detail may not sum to totals due to rounding.

Sources: BEA, INSEE, Eurostat, OFCE.

The Experience of Other Countries: some national features

The decline in GDP growth is not perfectly synchronised (graph 3). GDP growth started stagnating in the Netherlands in the fourth quarter of 1999. In France, the decline began in the first quarter of 2000. In the United States, it began in the second quarter of 2000 and in Finland in the third quarter. Though the reversal of the ICT sector has been rather synchronised all over the world, this time-lag suggests two things. On the one hand, this downturn affected each economy depending on the type of its ICT specialisation. In Finland, the ICT-producing sector has a disproportionate importance compared to the other ICT sectors. The Irish economy is highly exposed to trade fluctuations due to its high degree of

openness (more than 90 %[17]), this high degree being itself closely related to the ICT share in the Irish economy. The Netherlands witnesses a high contribution of ICT-using services industries, services being less prone to cyclical fluctuations. France is characterised by its "in-between" status and an ICT sector less oriented towards foreign markets, which may help smooth the impact of the ICT reversal on the economy. On the other hand, the ICT downturn cannot solely explain the slowdown of economic activity. Domestic causes are also engaged, especially in the case of France and the Netherlands.

Even taking into account the growth slowdown, Ireland's GDP grew faster than any other OECD country in 2001. But studies about Irish economic development now focus on the durability of this performance and a possible hard landing of the Irish economy due to the downturn of the ICT sector. Irish exports particularly suffered from this downturn and from the withdrawal of American FDI generated by the American economy slowdown. Irish firms were also particularly affected by the spillover effect of the retrenchment of multinational companies. Some 4,000 jobs were lost in the foreign-owned ICT sector in 2001, some 6 % of the labour force of the ICT sector. Such job losses raise questions about the country's vulnerability: they are not symptomatic of a deterioration in Ireland's competitiveness, but are rather the sign that the Irish ICT sector relies largely (too much) on the health of foreign companies.

With a GDP growth of 0,7 % in 2001, Finland witnessed the lowest rate of growth since the recession of the early nineties. This poor performance relies on the fact that growth in the two dominant sectors of Finnish economy faltered at the same time. Though the emergence of the ICT cluster as an outsider of the wood and paper industry, the Finnish economy remains highly specialised, and the impact on the economy of a reversal is unequivocal. The production of the wood and paper industry fell by 7 % in 2001, after an average annual growth of 7 % between 1997 and 2000, because of the world economic slowdown. After a growth rate close to 30 % per year on average from 1997-2000, the production of the electrical industry exhibited a "ridiculous" 2 % growth rate in 2001. Exports of ICT products (as defined in section 1.2) declined by 15 % in 2001 (in nominal terms, constant prices figures being not available). One illustration of the globalised nature of ICT production process is that Finnish imports of ICT products also fell by 11 %. Similar rhythms of decline affected

17. The same figure for the Netherlands is 65 %, Finland 42 %, France 28 %, the euro zone 37 %, and the United States 13 %.

American exports and imports of ICT products, with growth rates of respectively –17 and –18 %.

Small open economy get buffeted by exogenous shocks. It is certainly not good news that Ireland and Finland's strongest growth sector weakens. The slowdown of economic activity helped temper the threat of overheating and the labour supply shortages (this also helped the Dutch economy). But these countries still face challenges at the dawn of the 21st century. As for Finland, despite continuous efforts to increase the amount of educated staff, the shortage of experts remains the biggest challenge to the Finnish ICT cluster. The main dangers for Ireland's specialisation in new technologies consist in a loss of competitiveness due to prices and wages pressures. Besides, the Irish economy faces the threat of competition from Eastern Europe diverting FDI in the longer run. In order to do well in the face of increased international competition and to protect its industry from the slowdown of other economies that invest in Ireland, industrial policy must be oriented towards an autonomous development of the ICT sector. Greater domestic investment in high technology sectors is indeed required to boost productivity in the long run. This could be made by promoting domestic investment in this sector, helping the diffusion of technological innovation brought by foreign-owned firms, supporting R&D and encouraging greater collaboration between industry and universities. Finnish industrial policy should be considered as a reference in this area.

The Dutch economy also experienced a sharp downturn in 2001 with a growth rate of 1,1 %, after an annual average growth of 3,7 % during 1996-2000. For the first time since 1988, Dutch GDP expanded less than euro zone GDP. The slowdown was largely due to low export growth, but there are also specific structural reasons that can explain the abruptness of the downturn. For instance, faster unit labour costs growth in Dutch manufacturing industry provoked a loss of competitiveness within the euro zone. A specific ICT effect may have amplified the downturn. The manufacturing downturn was roughest in the electronics industry because of the diminishing demand for computers and mobile phones that led to shrinking production of chips and chip machinery. Production of business services, and more precisely computer services firms due to cuts in ICT budgets, also declined sharply in 2001. This feature contrasts with the boom of this sector in previous years.

The French case is less clear cut than its European partners, both in terms of slowdown of activity and in terms of the ICT bust. French GDP growth remained among the highest

whithin the euro zone in 2001 mainly thanks to a dynamic private consumption[18]. Industrial production in the ICT sector did not fall as much as in the United States and Finland[19]. Some ICT industries (electrical and electronic components and phone equipment) even exhibited positive growth rates in 2001. And the decline of production in the PCs or electrical and electronic equipments industries remained mild. The picture is a bit different since the beginning of 2002 with a more pronounced decline of production in the electrical and electronic components industry and a slow recovery of production in the electrical and electronic equipments industry. These evolutions are a bit puzzling in the sense that they do not stick well to the general idea of a strongly hit ICT sector. The data may be not as relevant as in the other countries because of the "in-between" status of France. Investment data derived from the annual national accounts give a more reliable and more comparable information. Investment growth in computers faltered to 9 %, after an average annual growth rate of 37,5 % during the second half of the nineties. The slowdown is less important for software, but nevertheless significant: software investment increased by 6 % in 2001, after an average annual growth rate of 15 %. By contrast, investment growth in communications equipment only moderately slowed to 10 %, remaining close to its average pace of growth. Compared to similar figures for the United States, these data confirm the French lag in the diffusion of ICT: the investment boom has been more recent in France and did not lead to the same excess capacities. The consecutive adjustment needed not to be as severe as in the United States, and ICT investment contributed positively to growth in 2001 (for 0,2 percentage point).

Concluding Remarks: "This Is Not the End"

All the figures presented in the first two parts of this work are not yet available for the year 2001. That is why our approach remained based on national accounts, industrial production and various national data. Nevertheless, the latest WITSA data provide a first glance of the evolution of ICT investment in 2001 on a comparable basis (table 16). What is striking is the resilience of telecommunications investment (already evident in French data), except in the United States. Knowing the problems of telecom companies and excess capacities, 2002 will surely be a year of negative growth rates for this ICT component, just like 2001 has been for IT hardware. The impact of the ICT bust will clearly not be limited to 2001.

18. See Chagny *et al.* (2001) for more details on this subject.
19. Data are not directly comparable from one country to another, but still give an idea of the changes.

Table 16: Annual average growth rate of nominal and real ICT investment in 2001*

Percent

	Finland	France	Ireland	Netherlands	United States
Current prices figures					
Total ICT	6.6	7.6	3.4	6.6	– 10.1
IT hardware	– 1.6	– 1.8	– 6.1	– 4.2	– 19.8
Software	11.8	11.5	10.5	9.3	3.2
Telecommunications	5.6	8.1	4.7	10.1	– 21.9
Constant prices figures					
Total ICT	16.1	16.3	9.3	11.6	– 3.8
IT hardware	22.6	23.2	13.3	16.3	– 0.7
Software	10.8	11.2	6.1	5.6	2.3
Telecommunications	8.7	12.1	4.4	13.3	– 19.6

*Figures are based on WITSA data for European countries and NIPA data for the United States. Because of the method used to derive investment data from spending data, and contrary to WITSA data, total ICT only include the IT hardware, software and telecommunications equipment components. WITSA ICT definition is a bit broader: it also includes IT services, internal ICT and other office equipment. Constant prices figures are computed based on the assumption that the difference between price changes for ICT goods and GDP in the United States is the same across countries.

Sources: WITSA (2002), OFCE.

This final positive note is not free: though the severity of the ICT downturn, the "new economy" is not yet dead. We see three reasons for this: the resilience (up to now) of the American economy, the still bright outlook for the global ICT market and the fact that the diffusion process of ICT has just begun.

First of all, the more recent figures for ICT investment are encouraging and suggest a near end of the adjustment. Besides, numerous ICT business cycle indicators have already been reversing their plunge since the end of 2001, except ICT employment[20]. At last, another important evidence towards the resilience of the American "new economy" is the sustained dynamism of labour productivity gains since the beginning of the recession. Labour productivity gains in the nonfarm business sector have indeed slowed a bit but much less than during prior recessions. For instance, within the year following the business cycle peak, labour productivity increased by 0,2 % per quarter during the 1990 – 1991 recession, but decreased by 0,1 % per quarter during the 1981 recession. Today, labour productivity gains rest at a +0,5 % rate of growth per quarter (they are even higher if the first quarter of 2002 is taken into account, reaching 0,7 %). Data through 2001 continue to show that the use and production of ICT have made large contributions to the acceleration of labour productivity since 1995. In particular, according to Oliner and Sichel (2002), for the year 2001, ICT capital

deepening contribution to labour productivity growth mounts to 1,08 percentage point out of a labour productivity growth rate of 1,8 %. The authors make two other prospective computations. The first forecasts the ICT contribution in 2002, ranging from 0,49 to 0,73 percentage point (depending on the growth of real investment), lower than during the second half of the nineties but still higher than most similar figures for European countries. The second forecast identifies a plausible range for productivity growth over the long term with the help of a steady-state analysis. With a conservative hypothesis, this steady-state growth of labour productivity is a touch below 2 % per year, compatible with a 3 % potential growth.

The period 2000-2002 may be considered among the most challenging ever faced by the ICT industry[21]. Many firms entering the period with smashing IPOs and huge aftermarket gains left the field completely disillusioned, because of overvalued markets, unrealistic customer expectations, unrealisable analyst demand for financial growth, salary escalation. After an initial infusion of investor cash and media interest, these firms found their propositions difficult to defend, customer service difficult to provide, margins difficult to maintain, growth rates difficult to sustain, competition difficult to avoid, and above all their next round of equity financing difficult to attract. The bubble busted for many companies, workers, and shareholders, particularly in the dot. com and telecom sectors. Meanwhile, traditional retailers may have started slowly in the online space but found one advantage: business experience. They discovered that e-business could be a useful adjunct to but not a replacement for traditional "brick and mortars" stores and first-person customer experiences.

While this change in corporate spending had left plenty of ICT equipment sitting in inventory (in part already corrected) and many software developers on the bench, the shift has not spelled disaster for the whole ICT sector. Companies may be more interested in productivity than new business development, but ICT are often part of the productivity solution. Many ICT companies with sound fundamentals and a strong value proposition met or exceeded analyst expectations and now seem to be well positioned for future growth. For instance, after a period during which business men only wanted web sites for advertising, they now want smart web sites, through which they can collaborate with their partners. Such web sites propose a true value added, and can boost e-commerce (B2B and B2C) and productivity. The WITSA report makes clear the global ICT market remains open for business, considering

20. The heavy employment drain has been going on since the beginning of 2002, culminating at job losses of 250,000 in March 2002 over the previous year.

21.These remarks are based on the latest WITSA report (Digital Planet, 2002).

a few statistics. The developed world may be suffering from no to slow ICT spending growth rates, but the developing world continues to advance. The software sector growth rate also continues to outpace the other ICT sectors (that is hardware and telecommunications). The online community continues to grow. E-business is far from dead. The terrorist attacks of September 11 have brought new urgency to harden information systems.

As underlined by Colecchia-Schreyer (2001), "ICT diffusion plays a key role and depends on the right framework conditions, not necessarily on the existence of an ICT producing sector". Such a conclusion is in line with the push towards more deregulation of goods and labour markets. What is a bit less usual compared to prior studies is the idea that being an ICT-producing country is neither a necessary nor a sufficient condition to benefit from the diffusion of ICT. This is demonstrated by the example of Australia in Colecchia-Schreyer's work but also by the example of the Netherlands. Both countries have small ICT-producing sector but large ICT-using ones and have exhibited above average growth rates and above average growth contributions from ICT equipment. The idea is gaining momentum but it was not so clear only one year ago, mainly because of the lack of statistical material. The use of ICT, not its production, is then the likely key to growth acceleration. It implies that, even in the United States, the ICT diffusion process has just begun.

Appendix A: Definitions of the ICT sector

OECD definition (ISIC Classification System – Revision 3)

ICT manufacturing

- 3000 manufacture of office, accounting and computing machinery
- 3130 manufacture of insulated wire and cable
- 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
- 3312 manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
- 3313 manufacture of industrial process control equipment

Narrower definition of ICT manufacturing (used by Koski *et al.* to measure ICT specialisation)

- 3000 manufacture of office, accounting and computing machinery
- 3200 manufacture of radio, television and communication equipment and electronic components

Services goods related

- 5150 wholesale of machinery, equipment and supplies
- 7123 renting of office machinery and equipment (including computers)

Intangible Services

- 6420 telecommunications
- 7200 computer and related activities

McGuckin and Stiroh (2001) definition

The data set used by McGuckin and Stiroh (2001), which is part of the Conference Board / Groningen Growth and Development Center (GGDC) Productivity database, is largely constructed from the OECD STAN database, which is derived from individual countries' national accounts. The data can be freely downloaded from the Conference Board's web site www. conference-board. org. More detailed explanations of the methodology, and extensive tables, are also given in van Ark (2001). The classification system used for ICT production matches that used by the OECD and is based on the ISIC Classification System (Revision 3).

The distinction between intensive ICT users and less intensive ICT users (the non-ICT sector) has been made on the basis of two criteria: the share of ICT investment in industry output and the industry share in the ICT capital stock. For this purpose, evidence was used for two countries, i. e. , the Netherlands and the United States. About one-third of industries with the highest ICT-intensity and/or the highest shares in the ICT capital stocks are defined as ICT-using industries. As the same classification is used for all countries, ICT-using industries do not necessarily invest equally heavily in ICT across countries. It only indicates that these are the industries that are likely candidates to generate substantial output and productivity effects from ICT investment.

ICT-producing industries	*ICT-using (excluding ICT-producing) industries*
Manufacturing	
30 office, accounting and computing machinery	22 publishing
313 insulated wire and cable	24 chemicals and chemical products
32 radio, television and communication equipment	31* electrical machinery, apparatus, nec
331 medical appliances and instruments, appliances for measurement, etc.	33** medical, precision, and optical instruments
Services	
64 post and telecommunications	51 wholesale trade
72 computer and related services	65 financial intermediation
	66 insurance and pension funding
	67 activities related to financial intermediation
	71 renting of machinery and equipment
	73 research and development
	741-743 other business services

* Excluding 313, which is in ICT-producing sector
** Excluding 331, which is in ICT-producing sector

Appendix B: Some precisions about the comparability of studies

	Type of ICT capital	Covered period
Oliner-Sichel (2000)	Total ICT*	1996-1999
Oliner-Sichel (2002)	Total ICT	1996-2001
Jorgenson *et al.* (2001)	Total ICT	1995-2000
Jorgenson (2001)	Total ICT	1995-1999
Cette *et al.* (2001)	Total ICT	1995-2000
Crépon-Heckel (2000)	Computers	1987-1998
INSEE(2)	Computers	1987-1997
INSEE(3)	Computers	1967-1997
Jalava-Pohjola (2001)	Total ICT	1995-1999
Niininen (2001)	IT hardware	1983-1996
Schreyer (2000)	ICT hardware	1990-1996
Schreyer-Colecchia (2001)	Total ICT	1995-2000
European Commission (2000)	ICT hardware	1995-1999
Daveri (2001)	Total ICT	1991-1999

*When they compute sectoral contributions to MFP growth, Oliner and Sichel limit the ICT sector to the "computer and computer-related semiconductor sector". According to the authors, "the estimate of MFP growth for semiconductors covers the output that feeds into computer production and that used elsewhere in the economy. Only the first piece is relevant for measuring the MFP contribution of the computer sector, broadly defined to include the production of the embedded semiconductors. The estimate presents a contribution from this vertically-integrated computer sector. This estimate includes the MFP contribution from computer manufacturing plus 60 % of the MFP contribution from semiconductor production". If one considers the "whole" ICT sector, the contribution of this sector to MFP growth reaches 0,63 percentage point (against 0,47), and the contribution to the acceleration reaches 0,37 percentage point (against 0,26).

Appendix C: A brief description of the growth accounting framework

In a stylised neoclassical world, businesses always make optimal investment decisions and all types of capital earn the same competitive return at the margin. At the equilibrium, every business is buying the ideal amount of a specific capital good, given the price. That is the marginal rate of return of each additional investment is equalised at the cost of capital. Thanks to technological development, the capital good price can fall and it becomes profitable to realise additional investments in this capital good. But how much would income or production increase as a result ? If one assumes a world with no taxes, depreciation, market frictions or changes in relative prices, the increment to income would equal the increase in the nominal stock of the capital good ($p_2K_2 - p_1K_1$) multiplied by the competitive rate of return earned by this equipment (r_c). This expression $r_c*(p_2K_2 - p_1K_1)$ can be transformed to show the neoclassical contribution of the capital good to output growth, rather than the boost to the level of output. By switching to growth rates, the term for the increment to the capital stock ($p_2K_2 - p_1K_1$) becomes the growth rate of the capital stock denotes by $(\dot{K}_c - \dot{p}_c)$, while the term for the rate of return r_c becomes the share s_c of total income generated by the capital good. This income share is the ratio of the nominal income flow generated by the capital good to total nominal income (pY). The income flow generated by the capital good equals the nominal net stock of the capital good (p_cK_c) multiplied by the gross rate of return (that is r_c plus a depreciation term denoted by d). In summary, the growth contribution of a specific capital good is $(\dot{K}_c - \dot{p}_c)s_c = (\dot{K}_c - \dot{p}_c)\left[\frac{p_cK_c*(r_c+d)}{pY}\right]$. $(\dot{K}_c - \dot{p}_c)$ corresponds to the rate of accumulation, $(r_c + d)$ to the gross rate of return and $\frac{p_cK_c}{pY}$ to the capital-output ratio.

Because of the rapid fall of ICT prices, the expression for the gross rate of return should be amended by including a rate of capital gain (π_c), which represents the rate of price change for the capital good ($\dot{p}_c$) relative to inflation for overall output ($\dot{p}$). The rate of return of an investment must be high not only to offset the rapid depreciation of capital but also to offset the rapid decline of the relative prices. The growth contribution expression becomes: $(\dot{K}_c - \dot{p}_c)s_c = (\dot{K}_c - \dot{p}_c)\left[\frac{p_cK_c*(r_c+d-\pi_c)}{pY}\right]$. For instance, in Oliner and Sichel (2000), the gross rate of return ($R = r_c + d - \pi_c$) equals 68 % with the net real rate of return r_c = 4 %, the

depreciation term d = 30 % and the capital gain term π_c = -34 %. Daveri (2001) also provides key figures for ICT contribution to output growth (table AC).

Table AC: Key figures for ICT contribution to output growth

	Finland	France	Ireland	Netherlands	United States
Growth rate of ICT capital stock, 1991-1999, %					
Communications equipment	8.8	11.4	13.2	9.9	4.9
Hardware	23.8	24.0	28.8	32.1	31.2
Software	9.7	10.3	15.9	14.0	17.4
Gross rates of return, 1991-1999, %*					
Communications equipment	21.3	22.9	25.7	23.8	23.3
Hardware	43.5	44.5	46.6	45.6	46.4
Software	50.6	52.0	55.0	52.7	52.7
Real net rate of return, 1991-1999, %	4.4	4.0	5.9	4.4	4.6
Capital output ratios, 1999, %					
Communications equipment	5.4	5.2	8.1	6.4	7.1
Hardware	3.2	2.0	2.6	3.1	4.8
Software	2.8	2.8	1.7	4.4	6.4
Income shares, 1999, %					
Communications equipment	1.0	0.9	2.3	1.1	1.6
Hardware	1.7	1.0	1.6	1.6	2.9
Software	1.4	1.3	1.0	2.0	3.4

*Depreciation rates of 32 %, 44 % and 15 % are respectively imputed to hardware, software and communications equipment.
Source: Daveri (2001).

The advantage of the growth accounting framework is to distinguish different types of capital goods, and by the way to consider ICT goods as specific capital goods. The complete decomposition of growth contributions by input, under the assumption of constant return to scales and perfect competition, is the following: $\dot{q} = s_L(\dot{l}+\dot{q}) + s_{COM}\,\dot{k}_{COM} + s_{HW}\,\dot{k}_{HW} + s_{SW}\,\dot{k}_{SW} + s_{OTK}\,\dot{k}_{OTK} + \dot{a}$ (with COM for communication equipment, HW for hardware, SW for software, OTK for other types of capital, $\dot{l}$ the growth rate of total hours worked, $\dot{q}$ the growth rate of labour quality (sometimes distinguished), and

$\dot{a}$ the well known Solow residual). This expression supposes the availability of numerous variables, which are unfortunately scarcely available on an homogeneous basis for all countries. Many assumptions have to be made to construct such a database (in particular the capital stock data derived from the investment data). These assumptions differ from one study to another, explaining the differences of results.

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