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SIN DISCUSSION PAPER SERIES

MEASURING THE ECONOMIC IMPORTANCE OF ICT*

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Measuring the economic importance of ICT

INTRODUCTION

In the literal sense, ICT, the Information and Communication Technologies, include the postal system, the telephone, the computer, the television, and so forth. In this paper, the term is used in the more restricted sense that refers to a specific bunch of technologies (the Internet Protocol, written ten years ago to use non-proprietary protocols in networks established through an open standard setting process; a standard coding system, the World Wide Web, for representing data; browsers for standard interface between sites; as well as hardware technologies like optical fibres and semi-conductors) allowing the information stored on a computer to be accessed quickly and efficiently from anywhere in the world. Thanks to that breakthrough, computers – supported by other devices – have begun to communicate and even interact directly over a variety of networks such as the Internet or Electronic Data Interchange (EDI).

This new networking possibility is already quite useful in the conduct of many affairs, and it seems to open the door to a not too distant world populated by intelligent computers that will take over most of human chores. The achievement and, mostly, the perspective have given ICT an enormous importance in the eyes of the public and of decision makers.

A socially important fact deserves to be studied carefully. For that purpose, some measurement is desirable. This paper is about the present status of the measurement of ICT. The domain of application of ICT is immense. This paper is interested only to that portion of the domain that presents a clear and immediate interest to UNIDO. Roughly speaking, the scope of this paper will therefore be ICT in so far as it is related to the developmental impact of the manufacturing sector.

ICT is a novel domain. Those who first attempted to charter this domain were consulting firms. Their exploratory efforts, relayed by the media, gave the public the first hints of the economic importance of ICT. But the validity of the estimations obtained from these sources proved very difficult to assess. The objective was more to announce the future than to study the present and the methods were kept confidential. What exactly was measured and how it was measured, remained unanswered questions. Accordingly, it was not possible to assess the confidence deserved by the estimations. The recent collapse of the expectations based on these figures did not do any good to reinforce whatever trust had been placed in these figures.

Official Statisticians had entered the ICT measurement arena more or less at the same time as consultants but, with their purpose to bring about reliable and transparent data, the former placed more emphasis on methodology and therefore took more time to release results. Recently, the methodological work began to bear fruits. Under the pressure of public decision makers, mostly those of OECD countries, a certain number of surveys were taken and the first official figures are becoming available.

Mostly, this paper reports on the first findings of Official Statisticians. From there it also goes a little further to present some views on the economic importance of ICT based on the newly released figures.

Section 1. ADDRESSING THE MEASUREMENT OF ICT

The first step in taking a measurement is to define where the thing to be measured starts and where it ends. ICT being a general-purpose technology, it would be hopeless to approach it as a compact "thing" with only one head and one tail. Recognising this, official statisticians had to carve ICT into several facets amenable to statistical enquiries.

In what follows, two facets will be considered successively. First, there is the supply side, i.e. the side of the economy where the goods and services identified as ICT are produced.

Second, there is the use side of ICT, i.e. the applications to which ICT are put. Applications as such may be difficult to track but, at least, they can be characterised in terms of the entities making use of ICT: Households, governments, and businesses.

1.1. The supply side

An obvious approach to measure ICT is to collect statistics on the sectors of activity where ICT products are elaborated. To identify these sectors, an activity-based definition is needed. After several years of discussions between the OECD, EUROSTAT and the VOORBURG GROUP (a group of national statistical offices acting as a task force sponsored by the United Nations), a definition was officially approved. It reads as follows:
"For manufacturing industries, the products of an industry candidate to be chosen as an ICT industry must: Be intended to fulfil the function of information processing and communication, including transmission and display; or use electronic processing to detect, measure and/or record physical phenomena, or to control a physical process. For service industries, the products of a candidate industry must: Be intended to enable the function of information processing and communication by electronic means [OECD, forthcoming]."

In terms of the International Standard Industry Classifications (ISIC Rev.3) this definition includes:

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
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

Services – good related

5150 Wholesale of machinery, equipment and supplies
7123 Renting of office machinery and equipment (including computers)

Services – intangible

6420 Telecommunications
7200 Computer and related activities

Based on this definition, the statistical offices of OECD countries have collected data for the year 1997 taken as common reference. Among the most interesting results are:

For the whole OECD minus Greece, Luxembourg, Mexico, Poland and Spain, employment in ICT is estimated to have been 12.8 million persons (35% thereof in the USA, 16% in Japan, 9% in the UK, 8% in Germany, 3.5% in South Korea).

- Value added for OECD minus Greece, Luxembourg, Mexico, Poland, Spain, Denmark, Iceland, Ireland, New Zealand, Switzerland and Turkey, is estimated to have been 1,191 billion $ (of which 49% in the USA, 13% in Japan, 7 to 8% in Germany and in the UK, 5% in South Korea).
- Korea and the USA had by far the highest ratios of value added to employment (135,000 and 129,000$ respectively).
- The statistics of value added in the ICT sector related to value added in the whole business sector show that: Korea had the highest proportion with 10.7%; Sweden, Hungary, the USA, the UK, and Finland all had ratios of 8-9%; the OECD average is just over 7% and the EU average is just over 6%.
- ICT is supplied by three broad sectors, namely, the telecommunications, manufacturing and services. In Korea, manufacturing represents 70% of the three sectors; in Japan, 60%; in the USA, 30%.

- R&D in the ICT sector is estimated to have been 116 billion$ in 1997 (of which 52% in the USA, 22% in Japan, 5% in Germany, 5% in Korea, 4% in France).
- The share of R&D by the ICT sector in total business R&D was just over 51% in Finland; the mean value for OECD Member countries was just under 35%, the value of the EU being significantly lower with less than 24%.
- R&D in the ICT sector is mainly carried out in the manufacturing part of ICT. Korea, Finland, Japan and Italy reported proportions close to 90%.
- For most countries, the ICT sector is a lot more prone to undertaking R&D than other industries, often by a factor of about five.
- One country, Japan, had a huge trade surplus in ICT products (54 billion $), Korea had a surplus of 14 billion$, Finland 4 billion$, Ireland, Mexico and Sweden had 3 billion$ each.
- Countries with large trade deficits included: The USA (36 billion $), Canada (12 billion $), Germany (11 billion $), Italy (10 billion $), and Australia (7 billion $).
- ICT trade has become relatively important in a good third of the OECD countries. In Ireland, the combined imports and exports of ICT goods and services amount to 30% of total trade. In Hungary, Korea, Mexico and Japan, ICT trade makes up nearly 20% of total trade. In Finland, Netherlands, USA, UK and Sweden it amounts to between 10 and 20%.

To gain an overall impression about the importance of ICT in the supply side of Member countries economies, the above data items (employment, value added, R&D and trade) have been scored across countries. Given each data item an equal weight, countries were then ranked according to their combined scores. Three categories of countries were created: High, Medium and Low ICT intensity.

High intensity countries included: Finland, Hungary, Ireland, Korea, Sweden, UK, and USA.

Low intensity countries included: Australia, Belgium, Czech Republic, Germany, New Zealand, Poland, Portugal, Spain, and Turkey.

A new publication, “Measuring the Information Economy”, will be issued later this year by OECD with an update of the above indicators plus additional ones. A module of the “Science, Technology and Industry Scoreboard of Indicators”, to be issued in September 2001, also by OECD, will be dedicated to indicators for the information economy [OECD, 2001].

UNIDO applied the OECD definition to measure the importance of ICT manufacturing branches in total manufacturing not only in OECD countries but also in developing countries. Here are the main findings:

- Singapore is outstanding in terms of manufacturing specialisation in ICT industries. Almost 46% of total manufacturing performed in Singapore comes from the ICT branches, mostly from the Manufacture of office, accounting

and computing machinery (24%) and from Electronic valves and tubes and Other electronic components (16%). Such a strong specialisation is unseen anywhere else, not even in the OECD, where the most specialized countries are Korea, Finland, Ireland (16%) and Japan (14%).

- Asia is the region where developing countries with a certain specialisation in ICT are most easily found. Thailand follows Singapore and Korea with 8%, achieved in the same branches as Singapore plus in Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods. In India, Indonesia, Vietnam ICT manufacturing contributes a little more than 5% to total manufacturing. Bangladesh is in the same league but in that country ICT are less disseminated: The only important ICT is the branch Insulated wire and cable. Data for China and Malaysia, both countries presumably with ICT of some importance, are not available.
- Latin America's manufacturing owes very little to ICT branches. Only in Brazil, with 4%, and Mexico, with 2%, have these branches begun to make some inroad into the structure of manufacturing.
- In Africa, ICT are present in only few countries. In Egypt and South Africa, statistics show that ICT manufacturing is about 2% of total manufacturing, with half of it accounted by the branch Insulated wire and cable.

1.2. The use side

Official statistics approach the use side from the angle of the entities that make use of ICT [Statistics Bureau and Statistics Center, 2001]. Three entities are identified: The households, the governments the businesses.

1.2.1. ICT use by households

Australia, the Nordic countries and Canada are working to come up with the design of a model survey on ICT use in households. The work is to result in a final draft in 2002.

Meanwhile, several countries have already undertaken to collect data both by adding questions on ICT to ongoing surveys or censuses and by conducting dedicated ICT surveys. Questions are about possession of ICT facilities and the use of PC/Internet by households or individuals; purchases of telecommunications facilities such as PC or mobile phones and the expenditures for their use such as telecommunications charges; place, time, purpose of the use of PCs and Internet by households or individuals. The results are robust:

a) The use of ICT spreads like prairie fire

In Korea, computer ownership by households rose from 29% in 1997 to 46% in 1999. Computer literacy rate among people aged 6 years and over soared from 40% in 1997 to 52% in 2000. The hours spent on computer per week increased from 6 in 1997 to 17 in 2000.

In Japan, in 2000, 75% of households possessed some ICT facility (mobile phone, word processor, fax, car navigation) and more than 50% had a Pc. ITC expenditure per household was on average 3.7% of total expenditures. Internet users of over 15 years increased from 12 million in 1997 to 47 million in 2000, thus attaining a penetration rate of 37%.

In Canada, in 2000, 53% of individuals aged 15 or more used Internet.

In Australia, in 2000, 53% of households had home computer access and 33% had home Internet access against, respectively, 48 and 22% in 1998.

b) The digital divide passes mostly across age and income lines

In Japan, 70% of the 15 to 19 years old and 79% of the 20-29 use Internet, but only 34% of the 50-59 and 15% of the 60-69.

In Canada, people that used ICT were more likely to have a higher income, had more education, and were younger than those that did not. In 1999, the top quartile of households was slightly less than four times more likely to have an Internet connection than a household in the bottom income.

In Australia, in 2000, 24% of households with less than 25,000$ income had home computer access while those with between 75,000 and 100,000$ had access in 85% of the cases.

1.2.2. ICT use by governments

Few results are available at this stage on government use of ICT. There are data on the technologies available in the government departments, but there are not many data on the electronic services offered by the governments and on the uses of these services by the public.

In Australia, it was found that, by mid-1998, 89% of the federal departments had a web site, that 12% received and 33% placed orders via Internet.

The Survey of Electronic Commerce and technology of Canada, however, came up with data suggesting that in Canada the government plays a lead role in Internet use. By 2000, 96% of the federal and provincial government departments had a web site and these web sites were reported to be more likely than their private sector counterparts to offer interactivity with the public, digital products, and on-line payments.

1.2.3. ICT use by businesses

Official statistics offer two perspectives on ITC uses by businesses. The first one is on the diffusion of ICT use; the second is on the kind of applications in which ICT are used.

1.2.3.1. The diffusion of ICT use

The OECD is approaching the question of ICT use by businesses by means of a prototype survey comprised of five modules: 1) the use of ICT in general, 2) the use of the Internet, 3) Internet commerce, 4) commerce by other computer mediated networks and 5) barriers to the use of the Internet.

The preliminary results obtained with this survey indicate that in OECD countries business use of ICT is fairly generalized. By 2000, between 70 and 90%, depending on the countries considered, of businesses with ten or more employees had access to Internet (the reader should be aware that statisticians make a difference between enterprises and their establishments; in Japan, in 1999, the Internet had penetrated in 89% of the enterprises but only in 32% of the establishments).

The pervasive diffusion of ICT in businesses is not surprising considering that ICT use by businesses is not a novelty. It had been going on quite a while before the entry of Internet, in the form of EDI mediated by value-added networks (VAN) operating over leased telephone lines. What is new is: The conversion of EDI from a set communication system based on dedicated leased lines to a flexible system based on the Internet infrastructure and employing Internet protocols to allow the enlargement of networks from selected established partners to a much wider range of firms that do not necessarily know each other); the establishment of intranets (networks that rely on the IP protocol but are confined to the firm itself); the deployment of intranets to extranets comprised of selected business partners.

While largely diffused, the penetration of ICT still shows signs of a digital divide between the two tails of the size distribution of businesses. In Canada, 96% of enterprises with 500 or more employees were connected to the Internet against 65% of enterprises with 1-19 employees. Larger businesses were also more likely to use ICT in inter-enterprise communication. While, on average, 44% of enterprises had an extranet and 68% EDI, only 3% of 1-19 enterprises had an extranet and 8% used EDI. In Australia, by June 2000, of the businesses with 1-4 persons engaged, 50% had access to Internet, 9% had a web site, 38% were Internet business active and 5% were Internet commerce active; of the businesses with 100 or more persons engaged, the corresponding percentages were: 95%, 68%, 93%, and 14%. In the UK 92% of the businesses used computers (when weighted by employment this figure rises to 98%); 63% had web access, with access increasing with size; 61% of businesses had a web size and a further 19% were planning to do so within a year.

Across OECD, the penetration rates were markedly lower in Retail trade and Transport, but other sectors, like Manufacturing or Wholesale trade, are getting close to saturation levels.

1.2.3.2. Kind of ICT use

Reliance on networked computers is what defines E-business. But, a gamut of business functions may be conducted through computer-mediated networks. Accordingly, E-business could be desegregated in various kinds. There could be, for instance, E-manufacturing (how the manufacturing of products is supported by computer networks), E-management (how business is conducted), and E-commerce (selling goods and services online). Innovation, too, is supported by ICT and could be identified as a particular process. Surveys have indicated that innovative firms use ICT as facilitating technologies to gather, process, and use knowledge about themselves and their environment, past and present, in order to take decisions about their future.

In practice, however, it is often difficult to clearly differentiate the ICT business applications, and the limits that separate them tend to fluctuate. Furthermore, more and more plants use Fully Integrated Enterprise Resource Planning (FIERP) integrating many processes into a single system of ICT applications. Accordingly, data collection tends to perhaps make a difference only between two broad categories of applications: In-plant processes (roughly, E-manufacturing plus E-business), on the one hand, and, on the other, E-commerce.

1.2.3.2.1. In-plant processes

Supporting manufacturing operations with the help of computer is an important aspect of modern manufacturing technology but is not included in the narrow understanding of ICT, which is concerned with both processing and communication of data, as mentioned in the introduction of this paper. It remains that the practice of computer-assisted-manufacturing created a fertile environment for the diffusion of ICT in manufacturing firms, a fact that explains the rapid diffusion of ICT in the manufacturing sector.

The E-manufacturing that is part of E-business in the narrow sense comprises the networking of computers in support of production-focused processes. The two major business functions involved are, on the one hand, to link the firm to its suppliers and clients, and, on the other, to monitor the production process. The main process concerned procurement, ordering, tracking product delivery, automatic stock adjustment, and statistical process control.

In-plant processes that are part of E-business but not of E-manufacturing include the engagement of computer networks in business processes focused on internal management such as accounting services, human resource development, recruiting, videoconferencing, training, information sharing.

In the USA, by 2000, 52% of the plants in the manufacturing sector had at least one computer network in place. Networks were slightly more present in non-durables than in durables sectors (54 versus 51%). The lowest percentages were in Apparel (27%) and in Furniture (35%). The highest were in Chemicals and Electrical equipment (both 71%). Only 8% of plants had FIERP software in operation. Here the three highest percentages are: Electrical equipment (18%), Transportation equipment (17%), and Chemicals (16%). One third of the manufacturing plants accepted orders on-line through Internet and 53% through an EDI network (but these orders represented respectively 5% and 67% of e-shipments).

Statistics Canada has a relatively long tradition of surveying the use of advanced manufacturing technologies (AMT). In the 90s these surveys showed the diffusion of E-manufacturing in the Canadian firms. These surveys revealed interesting aspects of the diffusion of the technology. Canadian plants made use of AMT before foreign-controlled plants. Canadian firms adopted technologies developed domestically faster than technologies from foreign countries. Newer plants adopted newer technologies sooner than older plants.

Among the various technologies of E-manufacturing, two seem to have diffused more widely. There was more use of local area networks (LAN) in the plant to support the statistical process control that is used in quality management. There was also more use of wide area networks (WAN) or inter-company computer networks (ICN) linking the plant to suppliers and clients to support the dissemination of "just-in-time" stock management.

1.2.3.2.2. E-commerce

Much more information has been amassed on E-commerce than on other aspects of E- business. Yet, the measurement of this domain is almost as much in infancy as the rest of E-business. Official statisticians are still hesitating between two definitions of the scope of this domain. On the one hand there is the OECD definition, on the other, the U.S. Bureau of the Census definition [Mesenbourg, unpublished].

From the OECD point of view, E-commerce is determined by the use of electronic networks to place an order through Internet. Following the definition of the U.S. Bureau of the Census, E-commerce occurs when a transaction involving the transfer of ownership or rights to use goods or services is completed over any kind of computer-mediated network, thus including, for instance, EDI. The OECD definition is larger than the second one in that it considers as E-commerce the simple placement of an order instead of the completion of a transaction. But, the definition of the U.S. Bureau of the Census is wider when it admits that E-commerce can take place on any kind of networks, unlike OECD that admits only Internet as the vector of E-commerce.

Notwithstanding the definitional and measurement issues, which are many, a certain number of results are becoming available. In the UK, by January 2001, a survey of 6,000 businesses revealed that Internet sales represented 2% of total sales, while sales via all electronic networks, including EDI, totalled 5.8% of sales. Computer-mediated networks were used by 16% of the firms for sales. For purchases, one third of the firms used computer networks.

The British Business E-commerce Inquiry also sheds light on the reason why firms adopt E-commerce. The most common perceived benefit of selling over the Internet was the potential to reach more customers. One in five respondents considered that a potential benefit was lower purchase cost, and one in four saw speed as a benefit.

In Korea, the monthly Cyber Shopping Mall Survey indicates that B2C sales represented 1.6% of total retail sales in the first quarter of 2001. That Survey also indicates that the proportion is growing quickly. It was 0.9% in the second quarter of 2000, 1.1% in the third quarter, and 1.5 in the fourth quarter. B2B commerce was much more important than B2C (90% to 10%) in total e-commerce. B2B commerce is done via Internet to an extent of 63% of all B2B purchases. B2B purchases represent 4.1% of all transactions of Korean firms and the manufacturing sector accounted for 81% of all the B2B transactions.

B2B is not only larger than B2C, but it grows faster. In Japan, for instance, between 1999 and 2000, B2B increased 2.6 fold whereas B2C increased by 78%. B2B does not spread uniformly across the economic activities, it first passes through manufacturing branches. Manufacturing is probably the sector of activity where the division of labour is most exploited. In a sector which consists to a large extent in transforming manufactures purchased from manufacturers into manufactures that will be sold to other manufacturers, B2B finds a natural scope for expansion. In Japan, in 1999, 79.3% of B2B took place in the Automobile branch (the pioneer of ICT applications), 17.7% in the Electrical machinery branch and 1.8% in other manufacturing. In 2000, the distribution had largely changed due to the surge of B2B in follower manufacturing branches. The Automobile branch's relative importance went down to 43.3%, while Electrical machinery expanded to 33.6% and Other manufacturing to 16.9%.

In Canada, in 2000, sales over the Internet accounted for 0.4% of total operating revenue by the Canadian private sector. Albeit modest, this share is on the increase from 0.2% in 1999. The Canadian Survey of Electronic Commerce and Technology not only documents the amount of sales over the Internet, it also explains why this type of commerce still remains a rare occurrence and still amounts to a very small amount. Three barriers are cited more frequently by firms that do not buy or sell on the Internet: These firms consider that their goods do not lend themselves to Internet transactions; they have a preference for the face-to-face allowed by brick-and-mortar formula; they have security concerns.

One more very interesting result of the Canadian survey is that, between 1999 and 2000, for every 2 firms that entered E-commerce, 5 have exited. It is an interesting feature because it goes against the widely held belief that E-commerce is becoming more pervasive and favours more competitive market structures. Indeed, between 1999 and 2000, the value of sales over the Internet by the private sector rose by 73%. However, at the same time, the proportion of businesses selling on-line declined from 10 to 6%. Taken together, these facts mean that E-commerce became more concentrated into fewer larger businesses.

The USA is the base of perhaps 80% of E-commerce taking place in the whole world. In this country, by 2000, E-commerce was about 1% of total retail sales. Like in other countries, the miniscule proportion is on a rapid increase, except in 2001 where a recession is observed [United States Department of Commerce, 2001]. The share was 0.63% in the 4th quarter of 1999, 0.77% in the 1st quarter of 2000, 0.77% in the second quarter, 0.89% in the third quarter, 1.09% in the fourth quarter of 2000, 1.04% in the first quarter of 2001 and 0.90% in the second quarter of 2001.

Manufacturing was in 1999 by far the first sector in terms of proportion of E-commerce over total value of shipments with 12% (485 billion $). Merchant Wholesalers were second with 5.3%. A group of Selected Service Industries recorded 0.6% and Retail Trade had E-commerce of 0.5% of total retail sales. From the total manufacturing E-commerce, Transportation Equipment took the lion's share of 29%. Computers and Electronics had 10%. Chemicals had 9%. Machinery had 8%. Food products had 8%. The manufacturing groups that had the more intense use of E-commerce in relation of their own shipments were: Transport Equipment 21%, Electrical Equipment, Appliances and Components 20%, Leather and Allied Products 18%, Apparel 18%, Textile Products Mills 15%, Machinery, 14%, Plastics and Rubber Products 13%.

In sum, E-commerce is still a minuscule fraction of total sales but it is a fast-growing fraction (although a set back is recorded in 2001). About 90% of E-commerce is B2B and 10% B2C and the former seems to grow faster than the latter. Firms use most frequently the Internet but the bulk of the transactions are done through EDI. Manufacturing is by far the largest user of E-commerce. The spread of E-commerce may be leading to a concentration of firms.

Section 2. ASSESSING THE IMPACT OF ICT

The figures assembled by official statisticians already authorize attempts at measuring the economic impact of ICT. There are two levels at which this impact can be considered: The macro and the micro levels.

2.1. Impact at the macro level

The second half of the nineties in the USA saw the coincidental blossoming of ICT (browsers were invented in 1993) and of a long period of expansion marked by record employment, high growth and low inflation. During the four previous decades, business cycles would provide instances of growth phases leading fairly quickly to inflationist tensions and even of stagnation combined with inflation, but record employment combined with growth and price stability was rather unusual. An unusual phenomenon seemed to require an unusual cause and many postulated that this cause was the advent of ICT.

The diffusion of ICT was supposed to be the cause of an acceleration of productivity and this acceleration of productivity was in turn supposed to explain that high growth and high employment could be sustained without inflation over a much longer period than predicted by the famous "Philips curve". Obviously, if corroborated, these assumptions would give weight to the notion of ICT fathering a "new economy" capable of a durable improvement in growth prospects.

Not surprisingly then, the question of the economic impact of ICT became the centre of a hot debate. Unfortunately, a single phase of productivity resurgence in a single country is too scanty an empirical base for economists to reach solid conclusions in this debate. Yet, a certain number of facts established in the course of the debate have begun to clarify our understanding of the relationship between ICT and productivity.

Two main methods are in use to calculate the impact of ICT at the macro level. The first method takes the perspective of ICT industries and their contribution to growth. The basic idea is that if productivity is relatively high in producing and using ICT industries, then rapid growth in these industries relative to the rest of the economy contributes to macroeconomic productivity gains.

A study by van Ark [van Ark, 2001], estimates the shares of ICT-producing and ICT-using industries in the GDP and in employment of eleven OECD countries (those that have comparable figures) in 1990 and 1998. In 1990, the share of these industries in GDP was highest in Japan (28%) and lowest in Finland (20.9%). The share of employment was highest in USA (26.8%) and lowest in Finland (16.5%).

In 1998, the share in GDP had increased in all the countries except Germany and Japan. The highest value was now in the Netherlands (29.1%) and the lowest in Denmark (23.4%). In that same year the share in employment had increased in all countries except in Denmark and Germany. The highest value was in USA (27.9%) and the lowest in Denmark (17.7%).

The contribution of ICT to the growth of labour productivity was then computed by weighting the annual change in each sector's labour productivity at the employment share of that sector in the previous year.

The interesting sub-period is 1995-1999, when the technological progress in semiconductors and other ingredients of ICT delivers its fruits. The total growth of labour productivity over the period 1995-1999 was not very impressive. The two best results were found in Finland (2.7%) and in USA (2.6%). The two lowest were in Denmark (0.9%) and in Italy (0.6%).

The largest contributions of ICT using and producing sectors to the growth of labour productivity were in Finland (2.0%) and in USA (1.6%). The smallest contributions were in Canada (0.4%) and in Italy (0.5%).

Thus, albeit the ICT sectors never reach 30% of all the economy, they contribute between 40%, in Canada, and 122%, in the Netherlands (where the non-ICT sectors lost productivity), to the labour productivity gains made in the whole economy.

In sum, van Ark's findings tell us that it is the relatively good performance of the ICT sectors that saves the OECD labour productivity of the second half of the nineties from an utterly mediocre performance.

The second method assesses the impact of ICT by treating them as capital inputs in a growth accounting framework. A growth accounting framework would state that overall output results from the respective contribution of factors of production like capital, labour, environment, material inputs, or service inputs and that the share-weighted growth of outputs is the sum of the share-weighted growth of inputs and growth in total factor productivity.

In this framework the contribution of ICT to overall output growth can be measured by the rate of change of ICT investment, weighted by its share in total income. Data on ICT specific investment and on the ICT capital stocks are of course vital ingredients in the application of the method.

But to measure capital stocks and capital inputs, account must be taken of the quality of the unit of investment. As technological progress is extremely fast in ICT, ignoring quality would amount to seriously underestimate the impact of investment on growth. Therefore, price indexes are needed to compare price of capital units of equal performance.

Of course, such indexes reveal a deep price decline. To give just one example of the way these deflators work: If the price of a unit of computing power was 100 in 1996, that unit would have been priced 413,000 in 1958, 11,585 in 1967, and 39 in 1999 [Triplett, unpublished].

It is basically this decline in price that explains the diffusion of ICT use in businesses. Investment in ICT boomed in the period after 1995 under the impulse of an acceleration of technological progress that saw a shortening of the semiconductor cycle from three to two years. The value of capital services to the firm depends

among other things on the price of these services. In other words, the ICT capital services became invaluable and firms have responded by substituting wherever possible ICT capital services to other forms of capital.

Jorgenson [Jorgenson, 2001] has analysed in detail the consequences of this substitution. Among other things, he shows that with the introduction of the ICT form of capital, the average productivity of the stock of capital increased.

This in turn was reflected in an increase in total factor productivity growth. Total factor productivity growth trebled to 0.75% per year between 1995 and 1999 as compared to a 0.25 rate for the period 1973-1995. Two thirds of this increase can be traced to the contribution of ICT.

Relative to the first half of the nineties, output growth increased by 1.72% of which 30% came from ITC notwithstanding the fact that the share of ITC in the capital stock was only 4.26%.

Both capital deepening –more capital per unit of labour- and TFP growth –better average quality of the stock of capital- contributed to improve the average productivity of labour. The growth of the average productivity of labour increased by 0.92%, to which capital deepening contributed 0.60 percentage points and total factor productivity acceleration another 0.51 percentage points (a negative contribution of 0.20 percentage points was due to a decrease in labour quality).

The cherry on the cake was that inflation was damped by the higher productivity growth.

Clearly, in the USA, ICT is the source of a phase, or perhaps a trend, of resurgence of the growth process. In this country the social development is so high and demography so stale that neither the numbers in the labour force nor labour quality can expand much. Hence, the post WWII growth mainly came from capital. Since the early seventies, also the contribution of capital slowed down. As a consequence, by the early nineties, growth was becoming worryingly anaemic. The advent of ICT provided a new impetus.

Whether other ICT countries, including developing ICT countries like Malaysia or Singapore, are also benefiting from this impetus is not established. In principle, one would imagine that they do, but the lack of proper price indexes and other data makes it impossible to check it for the time being. As an example of the methodological difficulty, consider that from a base 100 in 1980, the price of a unit of computing in 1992 would have become 21.30 in the USA, 157.69 in Finland and 180.52 in France. Such a tremendous dispersion is not plausible considering that prices cannot differ that much internationally. Hence, comparative studies are not feasible for the time being.

2.2 Impact at the micro level

Most interestingly, Jorgenson's results establish a link between ICT and total factor productivity growth. Rapidly falling prices make it cheaper to buy ICT capital goods causing firms and households to substitute ICT for other types of capital and for labour. With the growing share of ICT capital in the total capital stock, the quality (the capital services provided by a unit of capital stock) of the capital stock should increase. The declining prices of ICT services indicate that the ICT capital stock undergoes rapid depreciation. That capital be still accumulated notwithstanding rapid depreciation suggests that the marginal productivity of the newer vintage of ICT capital is high. Is it really so? If yes, what is so special with the ICT form of capital that it does better than other forms in contributing to output?

Standard aggregate productivity calculations can say nothing about the deeper sources of productivity. This question is better examined at the microeconomic level where firms can be observed using ICT to create value.

The point of impact of ICT on business value is to reduce the cost of processing (store, organize, retrieve, transform algorithmically, transmit) a certain category of information, the information that can be digitised (numbers, texts, images, sounds, etc.).

Needless to say, the economic potential of digital information is immense. The decline of ICT prices is a key to the further exploitation of the untouched part of that domain. However, for a firm to take advantage of the fabulous capability of ICT to process digitised information, a pre-condition is to organise itself in an information-intensive fashion.

To give information a central role, a firm needs to become capable at the same time to generate and to process much more information than it used to do. In this respect ICT is indeed of special value because the possibility to process information on a large scale, also makes it economically sensible to gather more information. The new technical capability at the processing end of information enables firms to invent processes, channels, or structures to mount an information-based organisation and at the same time reduces the cost of acquiring this information [Brynjolfsson and Hitt, 2001]. In this sense ICT is a processing technology that tends to engender systems that generate their own inputs. It is the data processing capability that justifies satellites pouring avalanches of astronomical information on modern observatories. The web enables web retailers to gather consumer data that will customise the shopping experience of their clients. Automotive assemblers were until not long ago the epitome of vertical integration, a structure thought to be the most efficient to minimise the cost of transaction with suppliers. Now, through procurements systems that penetrate deep into the very organisation of a myriad of separated suppliers, just-in-time delivery has evicted all large internal suppliers to allow a crisp specialisation on the core assembly function.

In today supermarkets, continuous shelf audits combined with supply line management make it possible to present scores of thousands of new products whereas the supermarket of 1975 would have been overwhelmed by the presentation of two thousands products. In sum, IT is special in that it tends to generate complementary innovations to form systems capable of gathering the information to be processed.

What it takes to access at the condition of ICT user is thus an investment in ICT proper and an investment in organisational change. But, the organisational change in question is not anything that one would describe as marginal adjustment, but rather a profound mutation touching patterns of organisation, channels of communications, procedures, motivation of managers and so forth. Needless to say, undergoing such a mutation is costly. The investment needed to accomplish the organisational change and establish the complementary assets may be large indeed with respect to the investment in ICT proper. Between the hardware and software, the external consultants, the staff of the enterprise, the disruptions, the total costs of the complementary processes, channels, structures and so forth may exceed those of ICT by a ratio of ten to one. Accordingly, the question of the impact of ICT should be divided in two sub-questions: The impact of the investment in direct ICT, and the impact of a large multiple of that investment in complementary assets.

The impact of investment in ICT proper is not subject to debate. Firms making computers, telecommunications equipment, or semiconductors as well as firms that directly use ICT tools in their production process (numerically controlled machine tools, robots, electronic churning of payrolls, bank statements, and so forth) are the source of relative dynamism demonstrated by the van Ark, Jorgenson, and others studies.

The impact of investment in organisational change is less clear. Approaching this question at the level of aggregate calculations, would probably lead to the conclusion that, for accounting reasons, the existence of a large derived investment in complementary assets tend to underestimate the real contribution of ICT to output and productivity growths. The expenditures on organisational changes are considered by the system of national accounts as expenses and therefore are deducted from value-added. But instead of expenses, they should rather been seen as capital formation. These are expenditures intended to durably change the production frontier of the firm. If the technological change proves successful, these expenditures will be repaid by future income flows. Hence, to the extent that these expenditures have been counted as inputs rather than as output (of which capital accumulation is part), output and productivity growths are underestimated.

A closer look, however, entails some qualification of the purely accounting view. It can be argued that expenditures on organisational change merely replace existing organisation forms by newer ones with little net impact on growth. Gordon notes that for the last fifteen years firms, those of the USA at least, do not expand the share of their GDP on computer sales [Gordon, 2000]. This fact suggests that the

expenditures on computers take advantage of the price decrease in order to substitute newer machines to older ones rather than to expand the population of computers. If this is true, i.e. if the price elasticity of the demand for computers is less than one, two basic reasons could be envisaged.

First, the marginal productivity of ICT-cum-organisational change would not be that big after all. To a certain extent these investments may be manoeuvres in a competitive game to protect or attack market shares. By altering the competitiveness, they transfer rents from certain firms to others but do not increase wealth. To a further extent these investments are actually consumption at enterprise level (the enterprise adopts the guise of an organisation-based firm but without being able to really function like one), at management level (ICT as managers status symbol), or at staff level (most of the internet-surfing is done by staff during working time).

Second, there is perhaps a global over-capacity that makes it hard to generate an adequate rate of return in the information-based mode of production. If the price of a unit of computing power decreases so fast, it is because technology makes it possible to lodge hugely increased memories and processing speeds in the successive generations of computers offered on the market. Any firm that buys a computer every few years, will pay about the same money for the new computer as, and sometimes even less than, it paid for the last computer, but it gets a much more powerful machine. However, applications for the power added to these computers require an organisational inventiveness matching the technological progress at the core of ICT. That is a tall order indeed, one that few activities can match. But some do, and foremost among activities that can make a pro-growth use of ICT are the manufacturing activities. Why is it so?

ICT is foremost a technology to process information, particularly, information that lends itself to algorithmic processes with low levels of human intervention. That kind of information does not come cheap. It proceeds from an elaboration chain that includes a good deal of fairly labour intensive links like data gathering, data assessment, data codification.

In order to recoup the huge cost of acquiring and digitising the data, firms have to invent organisational formats that give digitised information a central role in the generation of profit. Here ICT offers no recipe. It is a technology to process information, not one to turn information into profit.

In which kind of production processes can digitised information be expected to be a decisive input? What we have learned, in Section 1, about the penetration patterns of ICT in the economy, is that ICT were adopted first in the manufacturing sector and that up to now it is still there that it is used the most. In services, some activities, like wholesale trade, are following closely the trail of manufacturing. Other activities are less completely able to lend themselves to digitalisation

Why is the manufacturing sector a particularly apt information processor ? This has to do in part with the nature of manufacturing techniques. Information is either explicit (and therefore readily codified) or tacit (embedded in a context, frequently a human context). ICT-propitious techniques are those processing explicit information because it is only explicit information that can be that can be couched in formulas that can be fed to computer systems that, in turn, will apply them autonomously over and over until the problem is solved without the direct intervention of users.

Manufacturing firms are in the first ranks of firms using codified information because the essence of manufacturing is to do manufactures by means of manufactures, in other words to transform technically specified inputs into technically specified outputs. It is the specification that is of the essence. It is the technical dimension of the information that facilitates computer-ruled decision making and reduces the need for qualitative assessment of the data processed. It is intuitive, for instance, that ICT is much more useful to handle an order for a paint of x hue and luminance than for a paint of a Turcara-lake like nuance of green (von Hippel, 1994). Indeed, the whole history of manufacturing can be told as one of substitution of autonomous processes for handicraft methods. Today's industrial applications of ICT are the natural descendants of industrial robots systems that saw the light as early as the sixties precisely because manufacturing could be couched in terms of blueprints.

Another reason why ICT do marvel in manufacturing firms is that manufacturing prospers by means of a division of labour into a myriad of specialised activities that must be ordained to contribute to the final product. Here it is networking that is of the essence. In its superlative form, manufacturing is the organisation of collective intelligence by means of interactions among nodes capable of producing and treating huge flows of codified information of a technical nature. The key to such a format is offered by ICT.

Besides pro-growth effect, ICT have other kinds of advantages. In service activities for instance, it is clear that much of the organisational changes derived from ICT can add a lot of convenience for the consumers. That someone who once bought a volume of Bengali poems would be addressed regularly a list of fresh publications in a similar register was impossibly expensive in the world of pocket books a few years ago and no firm would have attempted to organize itself to provide such service. Now, such an organizational structure is imperative among large-scale booksellers because clients like this kind of service, but it is not clear at all that it fosters the total sales of books. In general, E-commerce offers the final consumers much more information and much more interface possibility than mail-order catalogue shopping ever did, yet the growth-outcome of the added convenience is not that large. The fact is that on-line transactions are no more than a format of trade that either replaces the brick- and-mortar format or inflates it into a click-and-mortar format where E-commerce is simply super-imposed to the traditional format. But a new trade format is only that: A new format, by no means

is it a system for generating new products that would require new activities, and therefore generate growth.

Of course, when the replacement of one format by another entails productivity gains or increased competition, a growth outcome can be expected. The productivity gains can be passed on to other sectors through a reduction of the distribution costs of the inputs distributed through the new format or the increased competition can cut final prices, hence enhance the real purchasing power of consumers and ultimately pull global demand.

Such effects may be important, but they are not easy to see. The macroeconomic evidence does not yet exhibit a trickling down of the productivity gains recorded in ICT proper to other sectors. True, there are some indications. For instance, the US Department of Energy reports that from 1996 to 2000, the GDP grew about 4.2% a year while electricity consumption rose by only 2.2% yearly. This may be due to organisational changes in businesses that relied more heavily on ICT. For instance, with better stock management the cost of cooling storage rooms and transport vehicles can be fairly reduced. Considering that economy-wide refrigerating and freezing costs in the business sector are much larger than the electricity costs of operating ICT equipments, it is not inconceivable that just-in-time supply might have generated most of the above improvement in electricity productivity. But this remains conjectural, no proof has yet been made that ICT was actually the reason why more goods and services were produced with relatively less electricity.

As far as the price cuts expected from enhanced competition are concerned, there is some evidence but it is fragmentary and of dubious nature (where there are indications of on-line transactions causing price decline it is not clear that this decline could be sustained if the capital owners of the E-commerce firms demanded some returns on their investments) and, anyway, it is still so minuscule (in Section 1.2.3.2.2., it transpired that B2C commerce is hardly one per cent of retail trade; a reduction of a few percentage points on a few items of B2C would not enhance much the real purchasing power of consumers) that it can hardly have any noticeable demand-pull impact on growth.

2.3 What about ICT outside OECD?

Given the available data, this review is perforce mostly about the advance and impact of ICT in developed countries. In Section 1.1., it was seen, however, that developing countries are much behind. This has nothing to do with the inability of the economic agents of these countries to use ICT or to appreciate the benefits of its use. Africa, for instance, is making rapid progress in the use of Internet and the mobile phone fed with pre-paid cards.

It has to do with the lack of opportunities to transform digitised information into profit. Such opportunities tend to arise in association with the manufacturing

sector and the developing countries that are leading in terms of industrialization are also those where ICT prospers. As far as the other countries are concerned, progress of manufacturing will be the key for a blossoming of ICT.

Of course, there is no denial that practically every developing country has already some elements of modern industry. Firms that regularly export their products, firms that are subsidiaries of multinationals, locally-owned firms with large scale production or distribution for the domestic market, all have opportunities to make use of ICT and many have already grabbed this opportunity, or intend doing it, even if, perhaps, with less intensity than in the developing world.

But, 99.5% of the firms in developing countries are outside the modern sector. They are in the informal sector, or they are in the formal sector but with less than 25 employees. They are general stores, small food outlets, transportation or business services, micro-scale manufacturers.

These firms are not complex enough to need ICT for their internal operations. As firms, they do, of course, need to communicate, to receive and emit information, to interact with the environment. Yet, their communication needs concern more information of local relevance than information from distant and alien sources. It will be information of social nature more than technical information. Therefore, it will have to be extracted from the social context in which it is embedded with the help of high doses of human assessment ("what is the implication of the last tax decree on the march of my firm?", would be a typical information need). For this kind of information needs, classical channels, based on the analogue mode, like the telephone or the fax, are more appropriated than ICT (Duncombe and Heeks, 1999).

This is not to say that ICT should not be introduced to environments at early industrial stages.

Cooperative work relations, where each worker contributes his share of intelligence to the creation of the product, obtain in a market setting where modern industry has a large place. Under the powerful impulse of the developed world, industry is going to make more and more use of collective intelligence.

As the nature of the work organisation changes, so does the ideal structure of the talents and skills of the work force. Instead of few high academic achievers hierarchically controlling firms from above, cooperative work necessitates large number of people with communicative skills and talents. With too little modern industry in place, ICT are absent from the stage, with the consequence that developing countries generate only a small part of the innate talents and skills of most of their members that could become ICT operators. In turn, without these talents and skills, ICT application opportunities will take longer to materialize.

The capacity of ICT to induce these talents and skills is to be considered as a public good underprovided by the market and, therefore, as a deserving case for a supportive intervention.

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