SECTORAL DETERMINANTS AND DYNAMICS OF ICT INVESTMENT IN ITALY

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Abstract

Many measures of the impact of Information and Comunication Technology (ICT) on growth have been provided for the United States; much fewer analyses have been proposed for European countries, due also to scarcity of disaggregated data. In this paper we make use of very detailed sectoral data for Italy to study both the aggregate evolution and the sectoral diffusion of ICT investment expenditure during the 1990s.

In the aggregate we find that the 1992 recession strongly halted ICT investment, and only in 1999 the Italian economy recovered the same rate of ICT capital formation. Second, mixed evidence on diffusion is shown by the sectoral expenditure on ICT capital goods: although the ICT fraction of total investment has increased in all the relevant macro-sectors (industry, commerce and advances services), the number of total sectors investing in ICT has not risen between 1992 and 2000. Finally, an econometric analysis of sectoral ICT determination shows that, besides capital intensity and interest rates, R&D expenditure is a strong predictor of ICT investment expenditure. Hence, since R&D-intensive sectors are usually associated with the highest growth potential, ICT expenditure by those sectors may trigger a virtuous growth dynamics.

1. **Introduction**

The revolutionary use of Information and Communication Technologies (ICTs), started in the USA, has by now spread in most European countries. However, while the macroeconomic benefits of the ICT revolution are already apparent in North America, they are still hardly quantifiable in several European countries, including Italy.

As it has been widely shown by now, ICTs enhance labour productivity through both capital deepening and total factor productivity (TFP) growth. Indeed, on the one hand, the rapid decline in the prices of high-tech goods has stimulated ICT investment, thus resulting in significant capital deepening (ICT-related capital deepening). On the other hand, the technological advancement in ICT raises the TFP growth in the innovating sector. Both phenomena lead to an acceleration in overall productivity growth. Therefore, both the level and the (sectoral) diffusion of ICT expenditure in the whole economy represent a key starting point to obtain a measure of the ICT capital stock and of its impact on total growth.

In this paper, we focus on some features of the aggregate and sectoral Italian experience with ICT investment. After a short review of the literature on the so-called "ICT revolution" in Section 2, we describe the main characteristics of the *aggregate* expenditure on ICT investment goods in Italy over the last decade (Section 3); in particular, we propose a measure of real ICT investment flows by means of an "appropriate" price index. We find that ICT expenditure was relatively high in 1992, dropped in 1993, but has been rising since then. Hence, the 1992 downturn exerted a strong negative impact on Italian ICT investment. In Section 4 we turn to the issue of ICT diffusion across economic sectors by using *sectoral* data on ICT expenditure: if one believes that ICT investment is more productive when spread across the whole economy, more diffusion may result in a stronger effect of ICT on growth. Results are ambiguous since we find an increase in the spreading of ICT expenditure at the macro-sectoral level, but also evidence of lower diffusion when the economy is disaggregated in 101 sectors (except for computer software). Finally, we perform an econometric study of the determinants of ICT investment and find that capital intensity, the financial cost of investing (proxied by sectoral interest rates), but also sectoral R&D expenditure is a significant predictor of ICT expenditure. Hence, a heuristic encouraging result is that ICT demand is higher in the sectors where the potential for productivity growth is higher. Some conclusions are drawn in Section 6.

2. ICT and Growth in the US and in Europe: a Short Review

2a. An overview of the US debate on ICT and growth

Since the mid-1990s, that is almost a decade after the start of the "endogenous growth" debate, the so-called "New economy" and its relations with growth have moved to the centre of the stage. More and more researchers have started to study the conceptual links between the introduction of ICT and economic growth, and evaluate their quantitative effects on national accounts.

One reason for this widespread interest was the mounting attention to the "Computer productivity paradox", i.e. why productivity growth in the US had not been so strong in the 1980s and early 1990s despite the spread of ICT in the economy (Triplett, 1999).

The paradox was due to many factors. First, there was (and possibly is) a measurement problem involved in the *definition* of the ICT sector itself, and then in the economic evaluation of the components of this sector (the ICT goods). The problem is now apparently solved as the OECD provides an official definition of ICT, and the ICT goods and services are evaluated taking into account their inner quality (in the US, with the tool of hedonic pricing; see OECD, 2001, for an assessment of methodological issues). Another problem was implicit in the definition of *productivity* itself and in the productivity dynamics assumed by new-economy theorists. The distinction between the production and use of ICT is central in this case. According to a simple two-sector neoclassical framework, if we are to measure the growth contribution of technical progress in the sectors *producing ICT*, we have to compute *total factor productivity (TFP)* in the ICT-producing industries, as in this case technical progress is associated with an outward shift of the production function. If, on the other hand, we are to measure the impact of *ICT utilization* on the productivity of whole economy, we have to calculate the variation in *average labour productivity (ALP)* associated with the economy-wide rise in ICT investment (see Stiroh, 2001). This distinction is fundamental, because the overall impact of ICT on per capita output crucially depends on which is the main channel of productivity improvement, and on the relative weight of the ICT sector vis-à-vis the rest of the economy. It is clear that the contribution of technical progress is the smaller, the lower the relative weight of the ICT-producing sector; on the other hand, in order for the effects of the ICT investment channel to become visible, more time is required for the new capital goods to fully generate a strong and permanent effect on labour productivity.

A final question is whether productivity spillovers are associated with the ICT. In this case too, we can have spillovers due to the diffusion of technical progress from the *ICT-producing* sectors outside (but how relevant is this likely to be?), or productivity spillovers due to the *use of ICT* in the rest of the economy (network externalities; technical complementarities with other innovations generating in other sectors, such as the aircraft industry). In both cases, one has to distinguish between a neoclassical, constant-returns-to-scale paradigm, and an alternative increasing-returns-to-scale paradigm: no spillovers are admitted in the first one, but they are allowed in the second one. In general, empirical analysis is needed to discriminate across these models.

Empirical studies on the contribution of ICT to growth have flourished in the US in recent years. They have been mainly inspired by the growth-accounting methodology, and they have provided slightly different answers to the above questions (also because of differences in the measurement approach). In the years of the so-called "Computer productivity paradox" (broadly speaking, the 1980s and the first half of the 1990s), the contribution of ICT services to growth was sluggish. According to the estimates obtained in growth-accounting studies, the contribution of ICT capital goods to the annual growth rate was of 0.35 percentage point in the period 1973-90, and of 0.40 percentage point in 1990-95 (Jorgenson and Stiroh, 2000). This is not a negligible contribution, but is possibly less than expected if one considers that investment in ICT amounted already to 15 percent of non-residential gross fixed capital formation of the US business sector in 1980, to rise to 22.5 percent in 1990 (OECD, 2001). Moreover, Moore's Law of the doubling of the power of computer chips every eighteen months would have pointed out to a stronger impact of ICT investment on growth.

As mentioned above, the paradox faded away in the second half of the 1990s, when the contribution of ICT to aggregate growth was estimated as substantially higher. Jorgenson and Stiroh (2000) report that the contribution of computer hardware alone moved from 0.19 percentage point per year in 1990-95 to 0.46 percentage point in 1995-98; adding computer software and communication equipment, the global contribution of ICT to growth is of 0.75 percentage point in the second period. Slightly different figures are found by Oliner and Sichel (2000), who estimate a contribution of computer hardware of 0.25 percentage point per year in 1990-95, and of 0.63 in 1995-99. Both studies agree that ICT capital accumulation has played an important role in the resurgence of US productivity growth in the late 1990s. The reason why ICT investment was so late in materialising in aggregate accounting data, is that the dimension of the ICT producing sector, on the one hand, and of the stock of ICT capital goods in the whole economy, on the other hand, was still small at the beginning of the 1990s. This means that, although technical progress and TFP growth were strong *in the ICT sector*, only after a sustained boom in ICT investment during the 1980s and 1990s there were enough information technology inputs in the whole economy to have a significant effect on economy-wide productivity growth. This is not to deny the key role of technical progress in this neo-classical interpretation of the US productivity puzzle: quite the opposite, indeed, as the impressive decline in the relative prices of these high-tech industries, due to innovation and TFP growth, prompted massive investment in ICT in other sectors. In turn, this ICT investment may act either as a substitute or a supplement to other kinds of capital expenditure: however, in both cases one is likely to expect a positive contribution to growth through the ALP channel, either because ICT investment replaces more traditional, and less productive capital goods; or through a capital deepening mechanism of higher capital-labour ratios.

Notwithstanding the solution to the computer productivity paradox (the contribution of ICT to aggregate growth only becomes visible when information technology accounts for a large enough set of capital goods in the economy, or when the ICT producing sector accounts for a large part of GDP), a number of research questions are still open in the US debate. First, measurement debates are still under way, and especially the topic of if, and how, to adjust for the evolving quality of ICT goods is currently investigated. Second, ALP growth seems to remain relatively sluggish in ICT-intensive sectors such as finance, insurance and real estate services. The answers provided for this additional puzzles are that computers are still relatively new objects and that the full potential for labour productivity growth may take some more time to be exploited, or that computers are simply not so productive in some industries (Stiroh, 2001).

2b. **International comparisons of ICT and growth in the OECD area**

The academic and business debate on ICT and growth has eventually moved from a US-centred to an international dimension. In May 1999, the Economics Department of the OECD launched an ambitious two-year research project on “Sustainable growth and the New Economy”, which has provided so far a great deal of comparative studies on the nature and dynamics of innovation- and information-based growth. The starting point of comparative studies is twofold: first, there is evidence of a gap in the relevance of the ICT sector between continental Europe, on the one hand, and the US and the rest of the industrial countries, on the other hand, at the midst of the 1990s (Daveri, 2000). Second, the growth performances of continental Europe and Japan have been remarkably worse than those of the US in the 1990s, although the gap in ICT diffusion has been progressively closed during the decade (Schreyer, 2000). This evidence poses a number of intriguing research questions. In the first place, Is there still a gap in ICT adoption in Europe, or is it currently being filled? Second, what was (or, is) approximately the time-delay in ICT adoption between the US and other main industrial countries? And what is the time-delay in the contribution of ICT to growth? What are the key features of the US growth phenomenon of the 1990s, and what are the “systemic” requirements that seem essential in order for a “New Economy” to be established in OECD countries? Let us review some of the answers to these questions.

International comparisons of the role of ICT in industrial countries have shown that two, or even three, groups of national patterns can be identified. According to Schreyer (2000, Table 1), at the end of 1996 the share of capital stock accounted for by ICT goods was about 2 percent in Italy and Japan, 3 percent in West Germany and France, 5 percent in Canada and the UK and over 7 percent in the US. Even within Europe, Daveri (2000) identifies laggards (Italy, Spain and to a lesser extent Germany and France) and fast adopters (the UK, Netherlands, Sweden, Finland). However, once we have classified industrial economies according to their ICT endowments, the question becomes: Has the wedge between leaders and slow adopters been partially closed since the mid-1990s? While some authors offer a positive answer to that (see for instance Schreyer, 2000, p.5), recent evidence casts some doubts on this issue. According to the OECD (2001, Table 2), the annual rate of growth of constant price ICT investment over 1996-99, based on harmonised prices, have been 23 percent in the US, 22 percent in France but only 15 percent in Italy and Germany. Japan performed even worse, with an annual growth rate of 11 percent. Is it true that, as the national economies of continental Europe started behind, expenditure in ICT is now close to 6 percent of GDP in Western Europe with a strong catch-up effect vis-à-vis the US (Iammarino et al., 2001), the exceptional and sustained pace of economic growth in the US during the 1990s has magnified the denominator of this ratio and thus accommodated larger expenditure for ICT and larger national product.

This brings us to the second theme outlined above. The US experienced a historically unprecedented period of uninterrupted growth during the 1990s, while the pace of economic growth has been sensibly reduced in continental Europe. Of course, many factors contributed to these outcomes, including fiscal consolidation in Euroland, accommodative monetary policy in the US, structural differences in labour, product and financial markets across the Atlantic, the higher weight of R&D in the US economy relative to Europe. In Japan, economic conditions severely worsened during the 1990s, and stagnation virtually prevailed over the decade. To what extent, and why, is the ICT sector also responsible for these developments? According to Daveri (2000), the growth contribution of ICT was substantial in the UK and Netherlands, and rapidly increasing in over the 1990s in Finland, Ireland and Denmark. On the other side, ICT contributed less to growth in France, Germany, Belgium and Sweden, and only marginally in Spain and Italy. Hence, with the exception of Sweden, the distinction between leading and slow adopters in Europe replicates the distinction between high and low contributions of ICT to aggregate growth. Moreover, the same line can be drawn between fast and slow growers. This interpretation is therefore consistent with the neoclassical tale described by Stiroh (2001), and the lag in European adoption of ICT (say, five to seven years) is the key for understanding the modest contribution to growth. If this is true, and following the US experience, one could expect a more relevant contribution of ICT to growth in Europe in the next future, and possibly several years of rising per capita output.

Schreyer (2000) offers a different position, arguing that the gap in the growth contribution of ICT between the US and other G7 countries is not completely explained by the time-delay in the adoption of ICT technologies. In fact, the modest contribution in the first half of the 1990s in Europe and Japan occurred despite significant investment in ICT. Schreyer suggests that both a methodological bias (namely, different measurement techniques) and the lack of a strong ICT-*producing* sector in continental Europe could be part of the solution to the puzzle. We will come back on this in the next section. Recent evidence on the growth contribution of ICT across industrial countries seems to reinforce some skepticism on possible "automatic" prospects for productivity growth in Europe. In a study adopting an harmonised price index and a new method for the treatment of software (considered as capital expenditure and not as intermediate consumption), the authors come to the conclusion that, while the role of ICT is relevant and increasing in the US, Canada, Australia and Finland, there is no evidence of an increasing contribution of ICT to growth in other industrial economies over 1995-99 (OECD, 2001). In order to better understand the main features of the US model of productivity growth, and the possible requirements for extending it to Europe, let us move onto the next section.

2c. Production versus utilization of ICT: the issue of comparative advantage

The main macroeconomic features of the US growth story in the 1990s can be summarized as follows. In the labour market, we observed a rise in employment rates and a fall in unemployment, while at the same time there was a sustained increase in labour productivity. These developments seemed to allow for a structural change in the behaviour of the labour market, shifting down the "natural" rate of unemployment or the NAIRU (non-accelerating inflation rate of unemployment), and thus leading to a low dynamics of aggregate prices in the presence of prolonged growth. Exceptional investment rates in historical perspective and very low personal saving rates, possibly due to the anticipation of future income growth (also reflected in high stock market values), explain the widening US current account deficit; at the same time, the strong value of the dollar is mainly interpreted as a side effect of the US growth prospects.

US productivity growth in the second half of the 1990s was strong both in ICT-producing and ICT-using sectors. However, the data show a clear distinction between the role of *technical progress* in the ICT-producing sectors, and the role of *labour productivity* growth in the ICT-using sectors (Jorgensen and Stiroh, 2000; Oliner and Sichel, 2000). Moreover, much of the acceleration in aggregate US productivity growth after 1995 can be traced to accelerations in the pace of technical progress in ICT-producing sectors - measured as faster relative price declines in these high-tech industries. No strong evidence of spillover effects has been found; hence the neoclassical constant-returns-to-scale paradigm looks appropriate as a heuristic framework to analyse the New Economy (Stiroh, 2001). Finally, *software* capital accumulation seems to have played a relevant role in US productivity dynamics in the second half of the 1990s (OECD, 2001).

To what extent the US success story is (or was?) accounted for by the existence of a strong ICT-*producing* sector, which is lacking in several countries in Europe? In other words, is it there a question of comparative advantage in high-tech industries that is consistent with a windfall of technical progress in the US but *not* in continental Europe? Another issue concerns the role of structural factors in the recent comparative performance of the OECD economies, and in particular the impact of national factor markets in the different outcomes on the two sides of the Atlantic (and the Pacific as well). For instance, if we agree that the financing of innovation is clearly one of the key issues, as it deals with the Schumpeterian perspective on the role of financial markets that is more appropriate in a dynamic approach, then the contribution of capital markets to the development of the New Economy is crucial.

As far as the issue of comparative advantage is concerned, Roeger (2001) calibrates a two-sector-two-skill growth model of the US and European economies, featuring both an ICT-producing and an ICT-using sector, and skilled and unskilled labour. His model also allows for adjustment costs in the capital and labour markets. .. . However, the main point is that even if one includes differential adjustment costs in Europe and the US in the model, the productivity growth gap is not explained by the features of factor markets. The main point of Roeger's is that higher rates of *TFP growth or technical progress*, and not lower adjustment costs, are at the core of the productivity growth leap in the US; in turn, TFP growth is associated with the comparative advantage the US have in the production of high-tech goods, hence comparative (dis)advantage and not Eurosclerosis in general must be blamed for the inferior growth performance in Europe.

If Roeger (2001) is right, namely there is no European comparative advantage in ICT *production*, then it becomes crucial for Europe to perform very well in ICT *utilization* – and even more so for Italy where there are no clues of a (forthcoming) ICT specialization.

Only a satisfactory performance in ICT utilization can contribute to close the growth gap between Italy (and Europe in general) and the US. In this sense, it becomes relevant to investigate a number of issues: first, what was the record of aggregate ICT investment in the Nineties, and has the endowment gap with the US been filled so that we can now expect that the growth gap be filled as well? Second, has ICT investment been spread economy-wide, or has it stayed confined in a few productive branches? Third, what are the main features associated with sectoral patterns of ICT investment, and is ICT intensity higher in industries where the potential for productivity growth seems larger? We will in turn explore such topics for the Italian economy.

3.Aggregate patterns of ICT expenditure in Italy

3a. Price deflators and real quantities

ICT goods, as many other high-tech goods , have been characterized by a rapid price decrease in the last decade. This price decrease started in the US already at the end of the 80s and spread to all other industrialized countries. In the US statistics this swift decrease appeared almost instantaneously by using hedonic price definitions.[1] The same did not happen in other European countries, where a factor-cost approach or even traditional production price indexes have been applied. As a result, the price decrease in European data is much lower than the price decrease that took place in the same period in the US. Not knowing what exactly caused that difference (whether a true different dynamics of European prices or the presence of a downward bias in the statistical procedure), some studies (i.e. OECD, 2001) adopted the so-called "harmonized price deflator" that has been obtained by using the US ratio between non-ICT and ICT prices. In other words, this assumption imposed a sort of relative-price purchasing power parity (PPP) assumption where the only difference among the various European ICT price indexes dynamics is the different dynamics of the non-ICT goods prices.

In this paper we take a different approach and use only domestic sources to obtain price indexes for ICT expenditure. However, for a further check and so as to link our analysis to previous studies, we use US price indexes to check whether there are major differences only in the *dynamics* of the ICT expenditure: although non meaningful interpretation can be attached to the Italian quantities obtained with US price indexes, we are interested in comparing the change over time of such hypothetical quantities.

Figure 3.1 shows the dynamics of the Italian and the US price indexes for ICT expenditure. The Italian price index is obtained by computing the total real ICT investment (by adding all the components expressed in real terms) and considering its ratio to the total nominal ICT

[1] For a critical interpretation of the use of hedonic price deflators see Gordon (2000) among many others.

expenditure. For the US we use the price index of the aggregate “Information processing equipment and software”.[2]

[FIGURE 3.1]

It ought to be noticed that during the 90’s the Italian price index has been partly influenced by the increasing Italian Lira/Dollar exchange rate. Actually, the Italian deflator is calculated taking into account the prices of imported capital goods that explain around 50 percent of total price for the ICT sector.

Figure 3.1 shows that the dynamics are very different. The US price index is decreasing during the whole time span, whereas the Italian deflator lowers slightly only in 1996 and 1997. At the end of sample the gap between the percentage changes of the two indexes widens and the maximum difference is observed for 1998; a slight convergence appears in the last year of our sample (2000).

As a consequence, this divergence in the time pattern of the two indexes causes a different time profile also for the constant-price values of ICT expenditure. Next step is then to show the deflated Italian ICT expenditure by using both the available price index in Italy and the US index. Since the difference in the two computed series for total ICT is simply due to the difference in the change of two price deflators (already illustrated in the previous figure), we include the dynamics of some components of the total ICT expenditure, i.e. (i) strict computer hardware and (ii) software.[3]

[FIGURE 3.2]

First, the figure highlights that there have been different time changes in the two examined components. In particular, we ought to notice that major gaps between the Italian-deflated and the US-deflated series are observed for the computer hardware, but are less pronounced for the software component (this means that the two price deflators are not so different in the software component). Actually, in the year 2000 (with respect to 1999) the hardware price decrease shown

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[2] More precisely the data are obtained from the Bureau of Economic Analysis, Table 7.6. *Chain-Type Quantity and Price Indexes for Private Fixed Investment by Type*.

[3] The US statistics present price indexes specifically for “Computer and peripheral equipment” and “Software”. This distinction is more difficult in the Italian statistics; hence we used the general sector “Computers and other appliances

in the Italian data is not matched in the US data. Second, 1998 is still the year of biggest differences for both the hardware and the software aggregates. Although such differences are not able to change the sign of the percentage change (as in 1993 for software and in 2000 for hardware), they are the highest for both hardware (over 40 percent) and software (over 10 percent).

As it will be discussed in following sections, 1998 is a dividing year where the dynamics of the own-computed Italian prices of ICT goods greatly differ from what shown for the US. One possible interpretation is that the Italian ICT sectors have been more shielded in 1998 rather than in other years and the decrease in ICT prices has still continued, but at a lower pace.

In the remaining of the paper we will use strict Italian deflators since we deem that a contemporaneous PPP hypothesis for the ICT goods, although more likely than for other sectors, is still too strong an assumption. However, as explained in Appendix 1, since there might be a downward bias in the price data because of the deflation method, we will keep in mind the increase in the gap observed in 1998 between the price series.

3b. **Main features of ICT investment**

We now turn on the main characteristics of the aggregate Italian ICT expenditure. According to the European Information Technology Observatory, in 2000 the Italian ICT expenditure as a percentage of GDP reached 5.5%, compared to 3.9% estimated in 1997 (EITO, 2001). Following the remarkable growth of the late 1990s (almost 15% per year), the weight of the Italian ICT market in Western Europe has reached 12%, being closer to the shares of the most technologically advanced European economies - Germany with 22%, the United Kingdom with 18% and France with 15% – than to the still modest shares of other Southern European countries (Spain with 6% and Greece with 1%) (Iammarino et al. 2001). Therefore, in Italy, the gap in ICT adoption that characterized most of the European countries during the 90's is currently being filled.

Here we provide an outline of the evolution of ICT expenditure in Italy during the 90's using only national data. Breaking up gross capital formation into ICT and non-ICT investment and dividing the whole time period into two sub-periods, namely from 1992 to 1995 (period 1) and from 1996 to 2000 (period 2), we initially look at the weight of ICT investment over *total* investment. In period 2, ICT investment accounts for 15.3% of total investment showing a rise of 3% if compared to 12.3% registered in 1992-95 (Figure 3.3).

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for informatization" (code 30020: *Manufacture of computing machinery*) for the former and an aggregation of sectors 72200, 72400, 72601 and 72602 (see the legend in the appendix) for the latter.

[Figure 3.3]

The growing relevance of ICT investment in the second half of the 90’s has outpaced investment in other types of capital goods thus implying a substitution of ICT capital for other types of capital. As a matter of fact, to the higher share of ICT investment corresponded a smaller share of construction (6%) and a relatively lower share of other capital goods[4] (42.4%) (Figure 3.4). On the other hand, also the share of both transports and equipment shows a small increase, respectively of 1% and 2%.
Looking at the same figures for the United States, we find that the share of ICT investment accounts for 12.4% of total investment in 1979 and for 15.2% in 1981 thus leading to think that in Italy there is approximately a ten years gap in the adoption of ICT. Furthermore, it is interesting to notice that during the 90’s while in the U.S. the average weight of ICT investment over total investment was about 23%, in Italy it was around 14%.
At the moment the Italian ICT market is expanding and it is expected to grow further in 2001[5]. At a first sight it seems that the Italian ICT market is experiencing what the American market experienced five years ago. Thus it is reasonable to expect that the positive impulse produced by the increasing ICT investment over the Italian economic growth will be evident in the near future. As it is widely known, to the higher investment in the goods embodying the new technologies corresponds a larger capital deepening that stimulates an acceleration in the overall productivity growth both by increasing labor productivity growth and by encouraging changes in the organization of production which in turn could lead to improvements in productivity growth.

[Figure 3.4]

In the second half of the 90s, the average propensity to import has increased by 3.8%. In particular, there has been a rising average propensity to import capital goods (Figure 3.5).

[Figure 3.5]

[4] This aggregate includes intangible capital goods and some service activities such as legal assistance, rental agencies etc.
[5] EITO (2001).

The weight of imports of ICT[6] goods with respect to total imports of capital goods increases by 2.5% in period 2. At the same time also the share of both equipment and transports raises by 3.8% and 5.2% respectively.

It is worth to stress the high weight of ICT imports accounting for 37.3%. This result should be considered in the analysis of the contribution of ICT to growth. In fact, one of the leading factors stimulating overall productivity growth is the higher productivity in the innovating sector. Thus if only a small part of ICT goods are produced in the country it is very likely that the stimulus to productivity growth from the ICT production sector would be lower (see Roeger, 2001).

3c. Dynamics of the ICT expenditure in the 1990's

As we showed above, the weight of the ICT expenditure in the gross capital formation is non-negligible and has been increasing in Italy in the last decade. Now we want to look more thoroughly at the yearly dynamics of this type of investment expenditure, compare its time profile with other investment components and observe the relationship with the recent business cycles.

[FIGURE 3.6]

Figure 3.6 reports the ICT expenditure growth rates together with the growth rates of the remaining part of the gross capital formation; moreover, the GDP growth rate is shown. The ICT expenditure looks very correlated with the business cycle: although the number of observations is very low, the sign of the growth rate in ICT expenditure is always the same as the sign of overall growth in the economy (differently, we have a decline of the non-ICT, remaining component although GDP grows in 1994). We also notice that the average response of ICT expenditure to GDP growth is higher than one, but much lower in 1998 and 2000. The year 1998 is peculiar since we observe a higher response of the non-ICT component than ICT. In section 3.1 we have noticed that 1998 is a special year also for the price gap between Italy and the US and how this can be due by the computation of the price index in Italy (which is affected also by other non-ICT components that are impossible to disaggregate, see Appendix 1): hence, the lower growth rate in 1998 may have been caused by the presence of a higher aggregation error that has biased downward the Italian price index more than in other years.

[6] Software excluded.

[FIGURE 3.7]

A sort of average propensity to invest in ICT and non-ICT goods is presented in Figure 3.7. The graph shows the ratios ICT investment-GDP and non-ICT investment-GDP and we ought to notice that, excluding 1992, the former ratio is increasing monotonically (except for the slight decrease in 1998) over the sample period. The increasing ICT investment-GDP ratio is the result of a persistently higher growth rate of ICT investment with respect to GDP rate of change. This may represent a rising attitude to invest in new technological means of production.

As already mentioned, 1992 and 1998 are two exceptions. In 1992 the ratio is equal to 2.8% and is slightly higher only in 1999 and 2000. As it is already shown in previous figures with the 1993 drop, in 1992 the level of the ICT-type investment was substantial. The unfavourable economic situation (high public debt, exit of the Lira from ERM, threatens of being left out from EMU) certainly lowered expectations of future profits by the firms and the data show this had also negative consequences on the spreading of ICT investment goods. Even 1998 is a special year since the positive, but low, growth rate in ICT investment caused a decrease in the ICT investment-GDP ratio.

[FIGURE 3.8]

A more detailed picture of the comparison between ICT investment and other forms of investment is presented in Figure 3.8, where we disentangle the more relevant components of the non-ICT investment of Figure 3.7 (i.e., machines and other industrial equipment, transportation equipment).[7]

Besides the generalized contraction in 1993 (where the ICT investment presents the lowest decrease), the ICT aggregate grows always more than other industrial equipment (except for 1998). Once again, in 1998 we observe an unexpected fall in the growth rate of ICT equipment, which can be the result of a downward bias in the computation of the price deflator (as discussed above).

Within the ICT total it is important to disentangle some components that are more meaningful for the "New Economy" paradigm, i.e. computer hardware and software. We adopt a very strict definition of those categories: in our analysis they coincide respectively with the sole sectors[8] 30020 ("Manufacture of computing machinery") and 72200 ("Software consultancy and supply"). In real

[7] ICT investment does not include software.

[8] The economic activity classification (ATECO 91) follows the Nace Rev.1 up to the fourth digit level, while the fifth level, that is used in the present analysis, is a further disaggregation of the fourth.

terms the weight of these sectors into the overall ICT aggregate ranges between 13 and 18 per cent for hardware, and 16 and 22 per cent for software; hence, they represent an important share of total ICT. In Figure 3.9 we show the dynamics of hardware and software together with the growth rates of total ICT and total investment. The picture introduces some new elements in our analysis. First, notwithstanding the 1993 decline, the software component never decreases. Second, accumulation in hardware is very active in the first part of our sample, reaches a peak in 1997, but after then the growth rate lowers and is even negative in 2000. On the contrary, software acquisitions do not diminish in the last years, although there is the decline in growth in 1997. Next, either hardware or software (sometimes both) has always presented higher a growth rate than the total ICT aggregate, but in two years: in 1994 and, more concerning, in 2000. Since total ICT has increased in those years, this latter result means that other components have driven the growth of overall ICT.

Concluding, the aggregate data have shown that the Italian economy presents a rising propensity to invest in ICT-type investment during the period examined. In 1992 the ICT expenditure was already at an appreciable level, but the generalized crisis in the economy suddenly decreased the appeal of the new technologies; the economy recovered from such effects only starting in 1999, where we observe a new push towards the ICT equipment. Hardware and software behaved differently: the former with a sustained dynamics up to 1997, the latter with a continuous increase since 1993.

However, besides this general analysis on the overall time profile of the aggregate ICT investment, it is necessary to investigate its *diffusion* among the different sectors of the economy, which is considered one of the ways the new economy is able to affect growth (see Section 2).

4.ICT Diffusion Across Economic Sectors: the Italian experience

We mentioned above the role of new-technologies *diffusion* across the whole economy: this can indeed be a relevant channel to affect long-run growth in the economy by itself, either because diminishing returns to investment are in place at the firm or industry level, or because network externalities are rather strong in the ICT case and can be fully exploited if the new technology is spread across many sectors. In this section we take advantage of the availability of detailed data (up to the 5-digit level) regarding the ICT investment in Italy. In particular, the data are referred to the ICT investment (all the components of the OECD definition) performed by the 101 sectors, which the whole economy is disaggregated in.[9]

[9] Data are yearly and only in nominal terms since deflators at such disaggregated level are not available. More exactly, all the data can be entered in yearly matrices where the acquiring sectors of the whole economy (the 101 sectors) are in the columns and the selling ICT sectors are on the rows.

Table 4.1 ICT Diffusion in the Macro-Sectors

Sector	**Agricolture**		**Industry**		**Commerce**		**Financial Interm. and other services**	
Year	***92-95***	***96-00***	***92-95***	***96-00***	***92-95***	***96-00***	***92-95***	***96-00***
ICT Investment	28.2	54.1	14918.1	20544.7	13302.3	19296.6	1894.0	4078.6
% of Total Investment	0.2	0.3	19.2	20.2	23.8	23.4	1.9	3.9
Per capita ICT Investment (mln Lire)	0.02	0.04	2.73	3.82	2.16	3.09	2.23	4.72
Per capita Total Investment (mln Lire)	7.48	12.26	14.21	18.91	9.10	13.19	117.67	122.27
Hardware (30020)	3.3	6.1	1996.1	2651.5	1185.6	1894.9	243.5	147.5
% Hardware on ICT Investment	11.7	11.3	13.4	12.9	8.9	9.8	12.9	3.6
Software (72200)	11.4	19.0	2032.5	3072.5	1332.8	2028.4	1039.4	1960.4
% Software on ICT Investment	40.2	35.0	13.6	15.0	10.0	10.5	54.9	48.1

Elaboration on Italian National Accounts data (ISTAT)

A general overview is contained in Table 4.1. We aggregated all the 101 ICT-buying sectors into six macro-sectors and we reported the most relevant four in Table 4.1.[10] The table reports the total ICT investment for each macro-sector in the first four and last five years of the sample; moreover, we present data on the hardware and software acquired by the four macro-sectors.

Not surprisingly, the table shows that the industrial sector is the most important buying sector and is followed by commerce and other services (including financial services). All sectors including agriculture present a relevant increase in (average) ICT expenditure between the first (1992-1995) and the second period (1996-2000). The highest percentage increase occurs in the advanced-services sector, where the ICT expenditure in the last period is more than twice as much as in the 1992-1995 period. This result is partially expected since advanced services (including financial services) are more likely to use intensively new technologies.

Indeed, this feature is confirmed by the data on the ICT "intensiveness" of the different sectors. In the table we show the level of per capita investment (both ICT-type and total) of all sectors for each sub-period. Apart from agriculture, the other three sectors had comparable ICT investment-labour ratios in 1992-1995. Instead, in 1996-2000 the change in the investment-labour ratio is different among sectors and the advanced services become the most "ICT-intensive" sector. This result is in line with what happened in other countries where the (broadly-speaking) financial sector has been one of the most active ones in using the new ICT goods and showing increases in labour

[10] The construction sector and the remaining sectors of the economy are not reported in the Table 4.1 since they are deemed as less important for the present analysis.

productivity.[11] For comparison, we have also reported the total investment-labour ratio for all sectors and the most recent data show that ICT investment-labour and total investment-labour ratios are comparable: by ranking the sector according to the ICT investment-labour ratio we obtain the same order as using the total investment-labour ratio.

The table shows also the hardware and software expenditure; in this case we observe some important differences. First, expenditure on hardware equipment increases in all sectors but the advanced-services sector, where there is a significant contraction; this occurs together with the substantial decrease of the percentage of hardware in the total ICT expenditure (i.e., only 3.6% of ICT expenditure has been hardware in 1996-2000, but it was 12.9% in 1992-1995). On the contrary, software expenditure increases in all sectors and is quite high for all sectors. Second, notwithstanding the contraction in hardware, for advanced services over 50% of the total ICT expenditure is in hardware and software (in 1992-1995 over 2/3 of the ICT expenditure was in hardware and software). Moreover, we ought to remember that the data we are discussing are in nominal terms; hence, given the price decrease reported for some ICT goods (especially computer equipment), the decrease of the *nominal* expenditure in the advanced-service sector may not necessarily correspond to a decrease in the quantity of new acquired ICT goods.

Hence, the data presented in Table 4.1 show that there has been a general increase in ICT expenditure in the Italian economy and this increase was distributed in all the relevant macro-sectors. It is then interesting to go back to the disaggregated data in order to evaluate whether the general increase in ICT expenditure of the economy has been followed by more diffusion in the 101 sectors of the whole economy.

[11] See the *Economic Report of the President* (2000) for the USA (Table 1.2, p. 32).

Table 4.2 Number of Branches (among 101) Buying from the ICT Sectors

ICT Sectors	1992	1993	1994	1995	1996	1997	1998	1999	2000
Office Machines (30010)	97	96	96	96	94	94	94	94	94
Computers (30020)	98	97	97	97	95	95	95	95	95
Electronic Valves (32100)	5	2	2	0	0	0	0	0	0
Broadcasting Media Tools (32201)	38	33	33	33	32	31	30	30	30
Telecomunication Tools (32202)	98	85	85	85	84	84	81	81	81
Repairing of Electrical/onical tools (32203)	92	50	49	49	47	47	39	39	39
Receiving Media Tools (32300)	72	62	59	58	58	58	58	58	58
Electrical/onical Measurement Appliances (33201)	48	38	38	38	37	37	35	35	35
Other measurement appliances (33202)	78	62	62	62	61	57	56	56	56
Sailing, meteo tools (33203)	32	23	23	23	22	20	20	20	20
Precision Measurement Tools (33204)	25	21	19	18	18	18	17	17	17
Repairing of Scientific Tools (33205)	6	3	3	3	1	1	1	1	1
Machines for Industrial *rocess Control (33300)	29	29	29	29	29	28	28	28	28
Consultancy for Computer Installation (72100)	97	96	96	96	96	96	96	96	96
Software (72200)	100	99	99	99	99	98	98	97	97
Data Processing (72300)	89	88	88	88	88	88	88	88	88
Databanks (72400)	31	31	31	31	31	31	31	31	31
Computer and Office Machines Maintenance (72500)	97	96	96	96	96	96	96	96	96
Telematic, Robotic Services (72601)	93	92	92	92	92	92	92	92	92
Other ICT Services (72602)	88	87	87	87	87	87	87	87	87
Percentage of total	65.65	59.5	59.2	59	58.35	57.9	57.1	57.05	57.05

Elaboration on Italian National Accounts data (ISTAT)

A first rough measure of the diffusion is presented in Table 4.2, where we report the number of sectors (out of the total 101) that acquired investment goods classified as ICT. The number of buying sector is reported for every year and would indicate an increase in the diffusion of ICT if the number of buying sectors increased. First of all, the table shows the ICT categories that are very spread in the economy: computers, computer-related services (installation and maintenance) and software, were bought by over 95% of the economy in 2000. But the table highlights that the number of buying sectors has been monotonically decreasing: in the time span 1992-2000 the number of buying sectors has increased for no ICT good and for only one sector (databanks) this number has been unchanged. The drop in the number of buying sectors is different among the ICT categories: there is a decline of a few units for computers and computer-related services or software, but there is a big drop for the telecommunication tools (from 98 in 1992 to 81 in 2000 out of 101).

Hence, the data roughly shows that there has been a general decline in the number of sectors buying ICT capital goods in our sample. The last line in Table 4.2 shows a scaled sum of all the sectors buying ICT capital goods: if the number were 100, it would mean that all sectors buy all ICT capital goods. The table illustrates that this diffusion index has been monotonically decreasing since 1992 with a halt only in the year 2000.

[FIGURE 4.1]

This measure of diffusion may however be too rough and may neglect the *quantity* of ICT investment by each sector. Therefore, in Fig. 4.1 we report two concentration indexes (i.e., the Gini index and the R-concentration ratio) that are computed for each year over all 101 sectors of the economy. We recall that the higher the value of the index, the higher the concentration and, hence, the lower the diffusion. Once again, the main message from this picture is that in 1992 the diffusion of ICT investment was much higher than in the following years. Moreover, we notice that the contraction of ICT expenditure in 1993 was accompanied by more concentration.

[FIGURE 4.2]

In the same spirit, Fig. 4.2 shows the Gini indexes for some ICT sectors in order to see whether the aggregate analysis would hide the diverging behaviour of some relevant sub-sectors. In particular, the picture confirms the general tendency of increasing concentration for databanks-type expenditure (categories 72300 and 72400). On the contrary, expenditure on computers and telecommunication tools seems to become more widespread over the years (especially 1994 and 1995), except for 1993.[12]

[FIGURE 4.3]

A final measure of the ICT diffusion is illustrated in Fig. 4.3. By assuming that a given type of technology can be considered "more diffused" if a larger fraction of its is acquired by different sectors from those that produce it (or import it), the Figure presents the percentage of ICT expenditure that is acquired by the same, say, "producing" sectors (for only some categories of ICT expenditure). In particular, the last histogram on the right shows the total ICT expenditure and the data seem to point to a less concentrated and more diffused expenditure over time. The single ICT categories have different percentages and some of them (like computers and telecommunication tools) show that only very negligible fractions are acquired by the own producing sector. The other categories (software, computer-related services, databanks and data processing, etc.) have a rising

[12] This result may indicate that expenditure on computers and telecommunication tools has been much more dependent on the cycle.

fraction: from a slightly lower 10% in 1992, the percentage of ICT investment acquired by the own producing sectors increases to over 14% in 2000. High disaggregation is not the explanation of the result since we get the same results when considering a more aggregate level (30 branches).[13]

[FIGURE 4.4]

Therefore, this additional analysis seems to confirm that the Italian economy had a more diffused ICT expenditure in 1992 than in the following years. In order to check whether there has been at least a long-run tendency to a widespread ICT expenditure and capital formation, we have finally considered the average growth rates of ICT expenditure between 1992 and 2000 in all the 101 sectors of the economy together with the initial expenditure in 1992. Figure 4.4 shows this in a graph including also a correlation line. The slope of the line is negative and therefore implies a sort of convergence of the ICT expenditure levels: the higher average growth rates have been experienced by the sectors that had lower ICT expenditure in 1992. The two final figures (Figs. 4.5 and 4.6) present the same analysis but for hardware and software. The conclusions are different for the two categories. The convergence tendency seems to characterize the hardware categories (i.e., the computer category, 30020), but not software where the tendency has a definite positive slope.

[FIGURE 4.5]
[FIGURE 4.6]

In conclusion, although at the aggregate level all the macro-sectors show a definite increase in ICT expenditure, many clues of our descriptive analysis point to a non-increasing diffusion of ICT expenditure during the 90s. The data show that in 1992 ICT expenditure was less concentrated than in the successive years. Hence, the recession that followed the Lira devaluation in September 1992 had a negative consequence on both the level and the diffusion of the ICT expenditure, which lowered and became more concentrated in the following years. However, differences exist among the various ICT categories: computers and software have been highly diffused during the whole sample period.

[13] The results of the more aggregated analysis are available upon request by the authors.

5. Sectoral Determinants of ICT Investment: an Econometric Analysis

By now, we have analysed the aggregate trend of ICT investment in Italy, and we have got mixed signals about its diffusion across the whole economy. In this section, we focus on some *sectoral* features that can explain and predict the intensity of ICT investment (namely, the ratio of ICT investment to employment). We are interested in such an issue not only to provide a preliminary screening of the main features of the strong ICT investing sectors, but also to answer the following question: is ICT mainly used in sectors where the potential for productivity growth is higher, due to other factors such as R&D expenditure?

In our dataset we can exploit both the sector and the time dimension so as to estimate a very simple model of repeated cross-sections (or, loosely speaking, with panel data). The dependent variable is the ICT investment flow divided by the number of workers. Among the regressors, we include a variable representing the cost of capital, i.e. an interest rate. Actually, sectoral interest rates are available, although only for short-term maturities.[14] Second, the capital intensity of the sector is important since more capital-intensive sectors may have a higher demand for ICT investment under the assumption of complementarity between ICT and non-ICT capital. In fact, in Section 3 we noticed a high correlation between ICT and non-ICT investment that we now want to test in a formal econometric set-up. Third, ICT investment can be correlated with research and development (R&D) activities of firms and sectors. However, caution should be paid to the results because of possible contemporaneous causality and endogeneity. Finally, we include government production subsidies[15] that are usually very influential and significant to the general investment activities of firms and sectors.

All the variables (except for the interest rate) have been divided by the sectoral labour units in order to avoid dimensional effects, and then log-transformed. Moreover, we modelled sector heterogeneity as a fixed effect with sectoral dummy variables. The equation to be estimated is then the following:

$$\left(\frac{ICT}{L}\right)_{i,t} = \alpha_{0,i} + \alpha_{1,i} r_{i,t} + \alpha_{2,i}\left(\frac{K}{L}\right)_{i,t} + \alpha_{3,i}\left(\frac{SUBS}{L}\right)_{i,t} + \alpha_{4,i}\left(\frac{R\&D}{L}\right)_{i,t} + \varepsilon_{i,t}$$

[14] We considered a nominal interest rate in our analysis. The results would not change with the real interest rate since no sectoral inflation rates are available and the same inflation rate had then to be used for all sectors.
[15] Current capital transfers to production issued by the government.

where ICT stands for ICT investment, L for labour input, *r* for the sectoral interest rate, K for the capital stock, SUBS for the governmental subsidies, R&D for the sectoral expenditure in research and development.

Although data were available for the whole economy, we restricted the analysis to the most relevant sectors excluding agriculture (sectors 1 and 2), mining (sectors 3 and 4), and all those sectors where the Public Administration has a very high share (like education, health, etc.; hence we excluded sectors 26-30).

Table 5.1. Estimation Results

Variable	*LSDV*	*IV (all but int. rate)*	*IV (only subs. And R&D)*
Int. Rate	**-0.047** (0.008)	**-0.041** (0.009)	**-0.041** (0.009)
(K/L)	**0.676** (0.338)	***0.678*** (0.391)	***0.678*** (0.352)
(Subs./L)	***-0.096*** (0.052)	-0.171 (0.128)	-0.171 (0.128)
(R&D/L)	**0.073** (0.030)	***0.114*** (0.060)	***0.114*** (0.060)
adj. R sq.	0.948	0.946	0.946
SSE	0.215	0.219	0.219
n. obs.	168	168	168
d. of freedom	143	143	143

Note: LSDV=Least Squares Dummy Variable; all IV's are lagged variables; standard errors in parentheses; boldface means significative at 5%, italics at 10%.

Table 5.1 summarizes the results from the estimation. In particular, we have estimated our equation in three different ways: with a simple fixed-effect method (LSDV), with fixed effects and instrumenting all independent variables except for the interest rate (second column), and with fixed effects and instrumenting only subsidies and R&D expenditure (third column).[16] We decided to resort to instrumental variable because of the possible contemporaneous causality for the R&D expenditure; also subsidies may be affected by contemporaneous causality since applications for governmental support may actually include overall investment and, therefore, possibly also ICT expenditure. In some sectors where ICT expenditure is very high and a large portion of the capital stock is ICT capital, we may have a contemporaneous effect of ICT investment on the overall capital stock. As a matter of fact, the two additional estimations serve as a robustness check for the initial results.

In the first column (LSDV) the estimated coefficients have the expected signs for most of the variables: the interest rate affects negatively ICT expenditure, although with a very low semi-elasticity; highly capital-intensive sectors invest more in IC technologies, but the elasticity is below one; R&D expenditure is a significant predictor of ICT expenditure. Government subsidies are not so significant (the p-value is 6.9%) and with the wrong (negative) sign; this evidence seems to point that government subsidies did not certainly help increasing and spreading IC technologies at the sectoral level. It is probably very interesting to notice that the semi-elasticity to the interest rate is lower than the elasticity to R&D expenditure.

The other two regressionsgenerally confirm the initial results although with some loss in explicative power of some variables (subsidies are no longer significant even at the 10% level, the capital stock and R&D expenditure are significant at the 10% level instead of 5%).

The strong and robust association between R&D and ICT investment intensities can be viewed as an important result: ICT-investment intensity is not only correlated with relative capital-labour rates, but even more significantly with the R&D effort of industries, hence presumably with their process and product innovation performance. If one believes that R&D expenditure raises TFP, our findings point out that larger ICT investment tend to occur in sectors where the potential for productivity growth in the medium-long run is larger; this also suggests that ICT investment could be more effective in increasing the potential growth rate in Italy.

6. Conclusions and future work

Our main research hypothesis is that the ICT gap was among the determinants – not necessarily the main, but a relevant one - of the insufficient growth record in Europe, and especially in Italy, during the 1990s. Moreover, if Europe has a comparative disadvantage vis-à-vis the US in ICT *production*, then it becomes crucial for Europe to perform very well in ICT *utilization* – and even more so for Italy where there are no clues of a (forthcoming) ICT specialization. Only a satisfactory performance in ICT utilization can contribute to close the growth gap between Italy, and Europe in general, and the US.

With a focus on the Italian economy, we find that aggregate ICT investment has been sustained in Italy in the last decade, but the progressive diffusion of ICT technologies throughout the economic

[16] We have used the same variables, but lagged once as instruments of the current variables.

system cannot be taken for granted Our analysis shows mixed evidence on the rising diffusion of ICT, being it already quite widespread in 1992. Certainly, the recession in 1992 has stopped the diffusion of ICT in the whole economy.

As far as the features associated with sectoral patterns of ICT investment are concerned, we find a strong and robust association between R&D and ICT investment intensities, that we interpret as a positive signal. ICT investment intensity is not only correlated with relative capital intensity, but even more significantly with the R&D effort of industries, hence presumably with their process and product innovation performance. If one believes that R&D expenditure raises TFP, our findings point out that larger ICT investment tend to occur in sectors where the potential for productivity growth in the medium-long run is larger: this suggests that ICT investment could be effective in increasing the potential growth rate in Italy towards the US standard.

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Appendix 1

A1. The deflation method

As most other industrialized countries, in Italy there is no publication of the price indexes related to ICT expenditure. Hence, we resorted to data with different levels of disaggregation. More precisely, the sector data on Italian investment are obtained from a 20 by 101 flow matrix[17] where the rows represent investment by economic activities (ATECO91) producing ICT capital goods, and the columns investments by branch of owners. The 20 ATECO were selected from the 151 ATECO producing investment goods on the basis of the OECD (2000) definition according to the ISIC classification (International Standard Industrial Classification, Rev.3). Note that the 151 ATECO can be fatherly aggregated into 101 branches.

Nominal values are available yearly at the 151-ateco level, but real quantities are not. However, nominal and real values are available at a higher level of aggregation - the 101-branch level. Therefore, it is possible to obtain unit-value indexes, i.e. a measure of the price index, at this higher level of aggregation. Hence, we have obtained real quantities for the ICT-producing sectors by applying the price index of the relative branch (among the 101 available) to the nominal values of the (151-ateco) ICT producers.

Although no other method is possible due to lack of highly disaggregated data, one important drawback can occur. Practically, we apply the price index of an aggregate (101-type) branch to a part of that branch (i.e. only those sectors that belong to the ICT definition within a 151-ateco disaggregation). Hence, if the (151-type) ICT sectors are only a small part of the relative (101-type) branch, we incur in an aggregation error when obtaining the real quantity. However, among the 6 branches we considered, the ICT sector accounts always for 100% of the branch except for the branch 49, where it accounts for 60%. Hence, the aggregation bias that we introduce by using 101-branch unit values on 151-ateco sectors is probably negligible.

[17] See Bracci, Costanzo, Jona-Lasinio (1999).

Appendix 2

ATECO91 – The ICT industry (excluding goods-related services)

Manufacturing

30010 Manufacture of office and accounting machinery

30020 Manufacture of computing machinery

31300 Manufacture of insulated wires and cable

32100 Manufacture of electronic valves and tubes and other electronic components

32201 Manufacture of television and radio transmitters

32202 Manufacture of apparatus for line telephony and line telegraphy

32203 Repairing of television and radio transmitters and apparatus for line telephony and line telegraphy

32300 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods

32201 Manufacture of instruments and appliances for measuring

33202 Manufacture of gas water and other liquids meters for measuring, checking, testing

33203 Manufacture of navigational aids, hydrological, geophysical and meteorology instruments

33204 Manufacture of instruments and appliances for other purposes, except industrial process control equipment

33205 Repairing of scientific and precision instruments (optical ones excluded)

33300 Manufacture of industrial process control equipment

Intangible services

64200 Telecommunications

72100 Hardware consultancy

72200 Software consultancy and supply

72300 Data processing

72400 Data base activities

72500 Maintenance and repair of office, accounting and computing machinery

72601 Services of telematics, robotics, computer graphics

72602 Other computer related activities

Figure 3.1 Italian and US Price Dynamics for ICT Expenditure
(percentage variations)

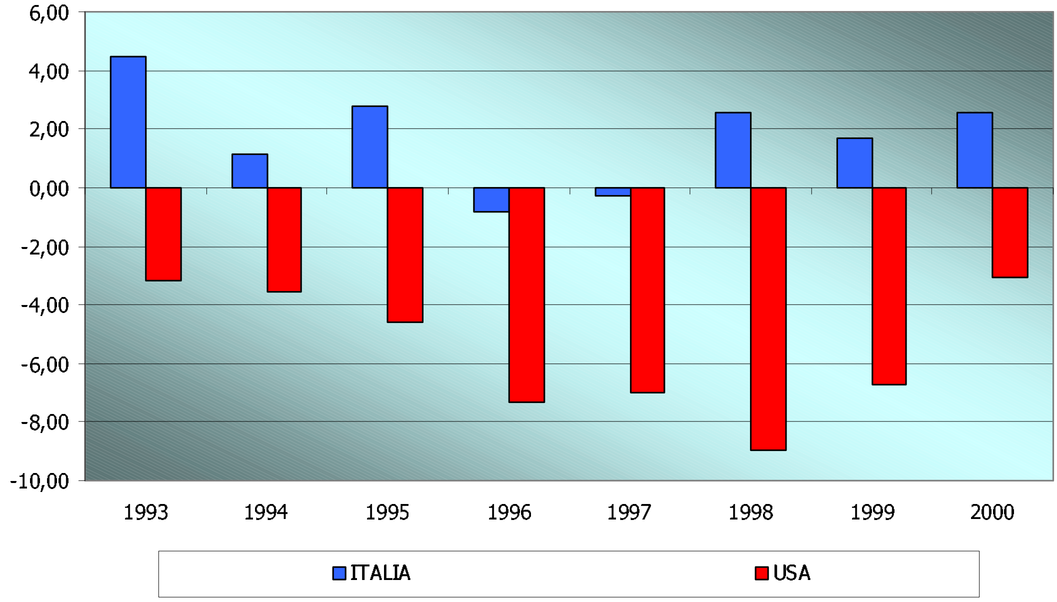

Figure 3.2 Dynamics of Various ICT Components in Italy with Italian and US Deflators
(percentage variations)

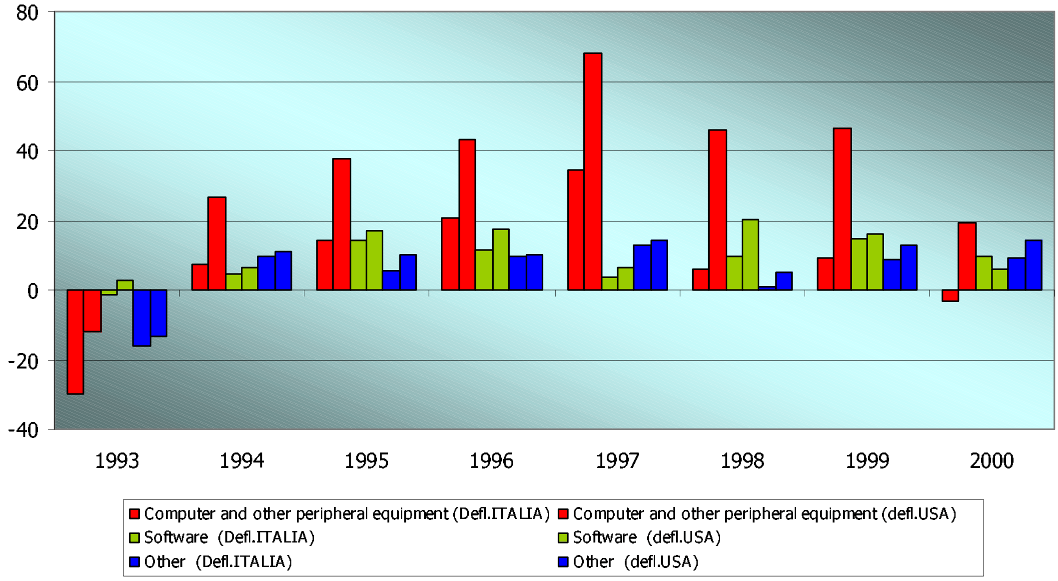

Figure 3.3 Shares of ICT and non-ICT investment

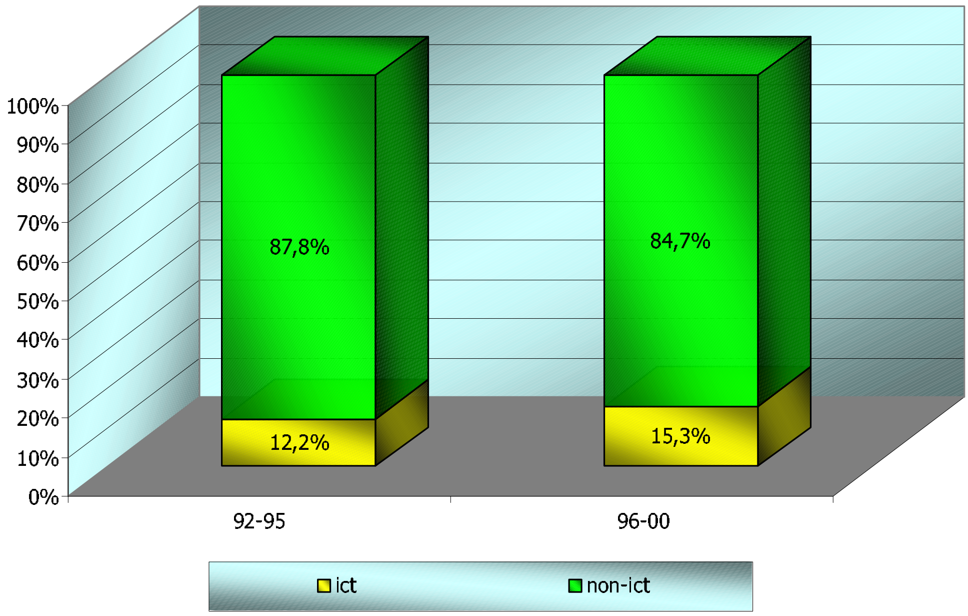

Figure 3.4 Composition of investment expenditure

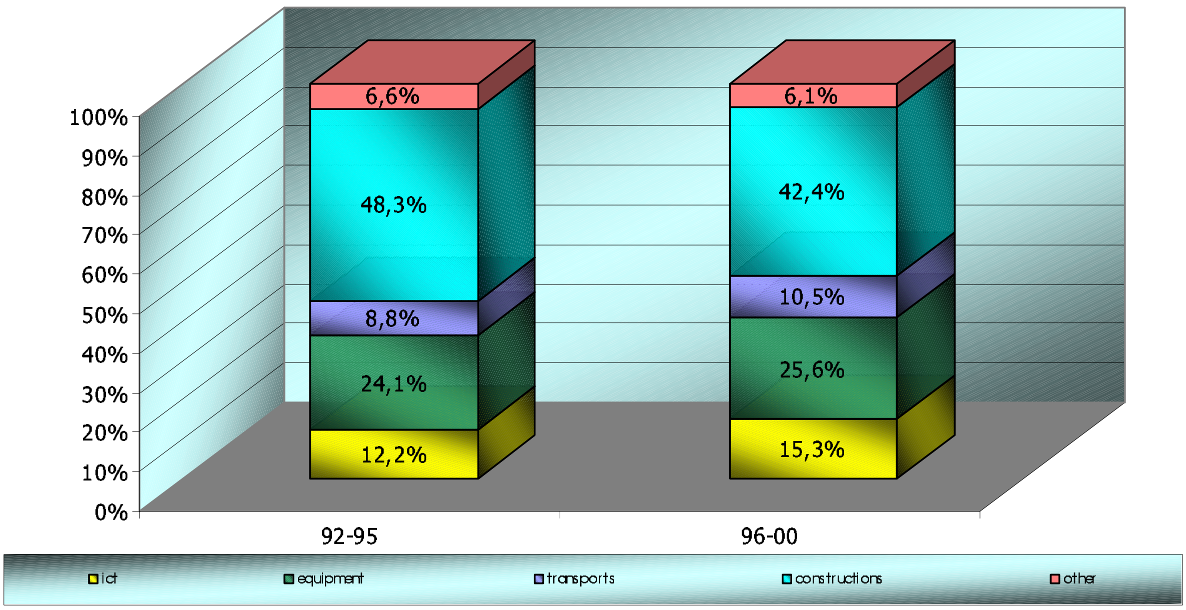

Figure 3.5 Average propensity to import

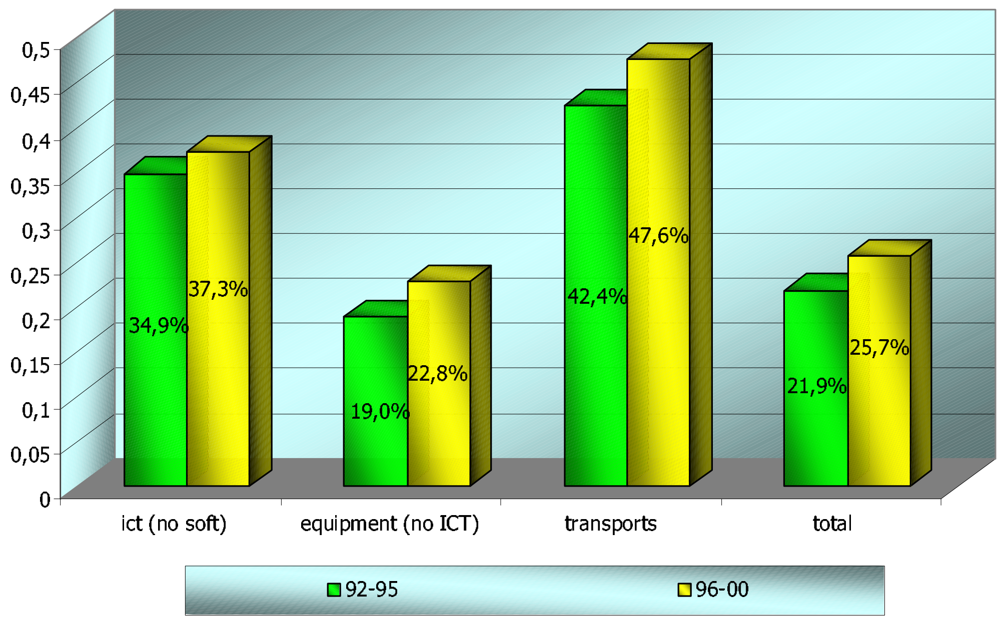

Figure 3.6 Growth Rates: ICT Investment, non-ICT Investment and GDP
(based on real values; 1995=100)

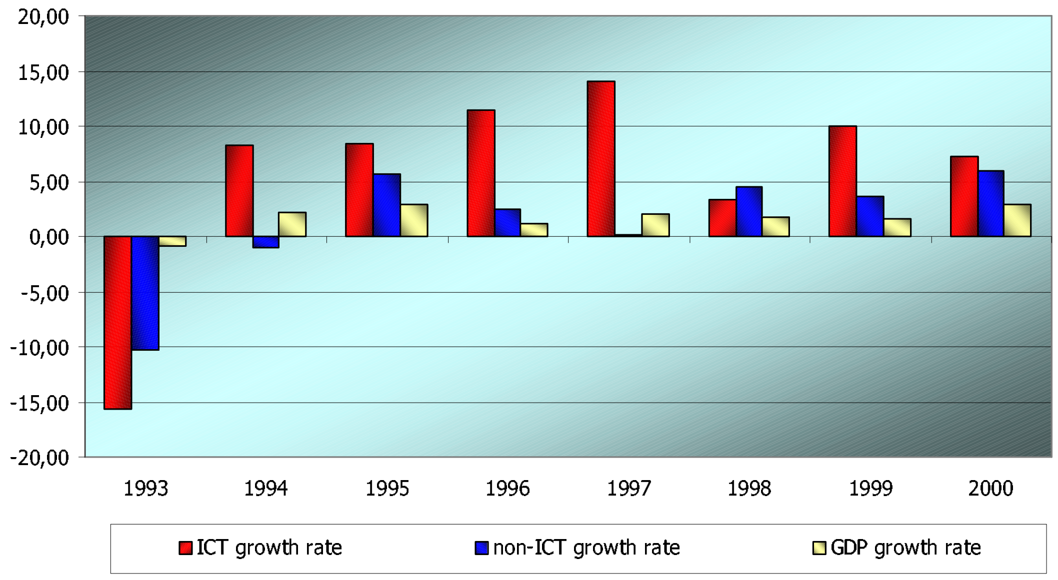

Figure 3.7 ICT-GDT and non ICT-GDP Ratios
(based non real values, 1995=100; ICT left scale, non ICT right scale)

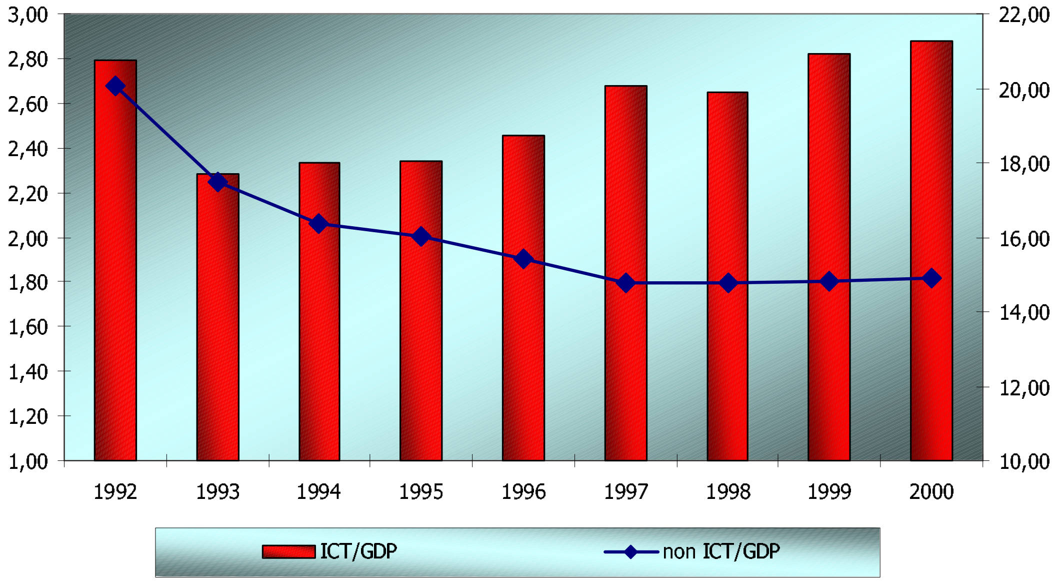

Figure 3.8 Growth Rates of Various Investment Components
(based on real values; 1995=100)

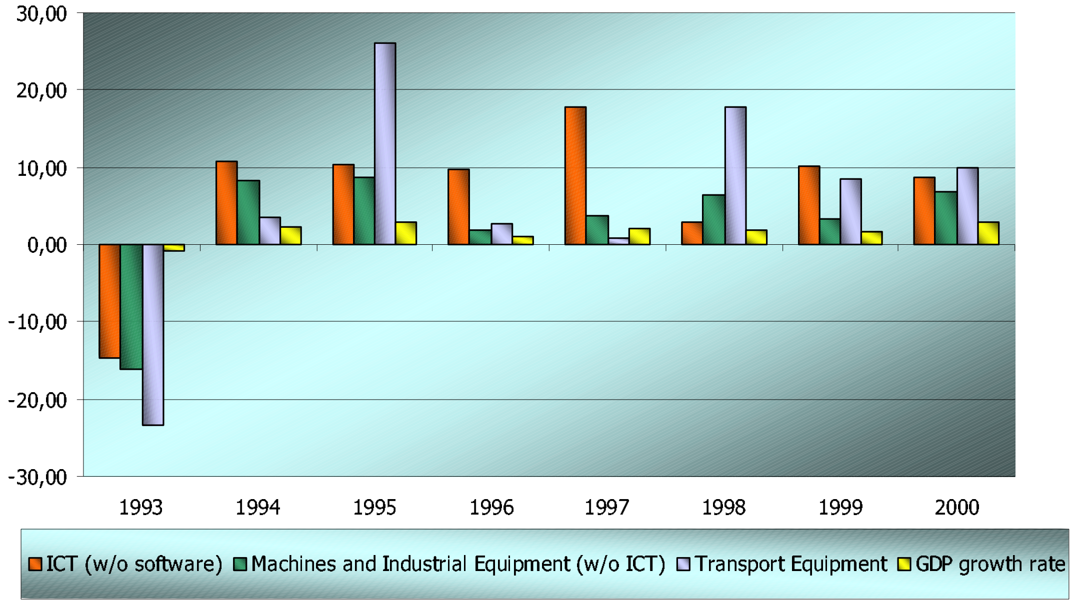

Figure 3.9 Growth Rates of Hardware and Software
(based on real values; 1995=100)

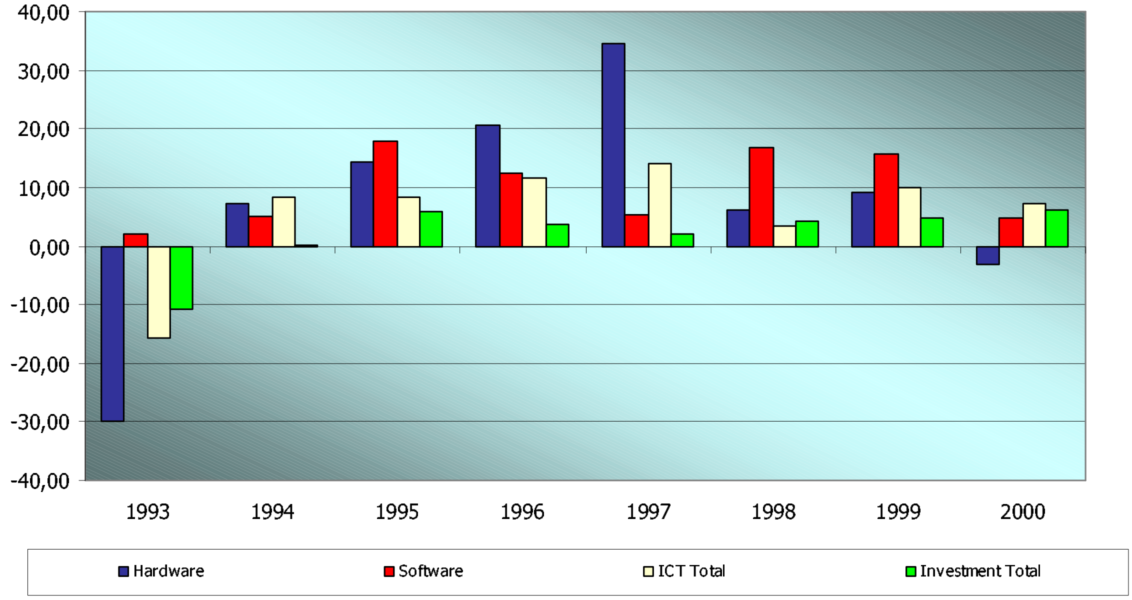

Figure 4.1 Concentration of the ICT investment expenditure in Italy
(R: concentration ratio - left scale; delta: Gini index - right scale)

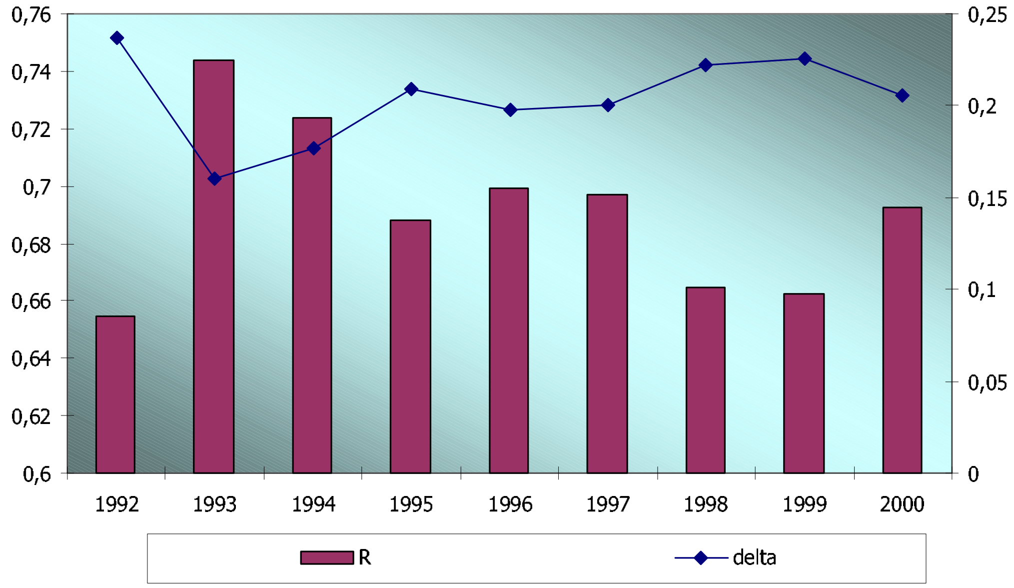

Figure 4.2 Gini concentration indexes for the some ATECO (5-digit) ICT suppliers

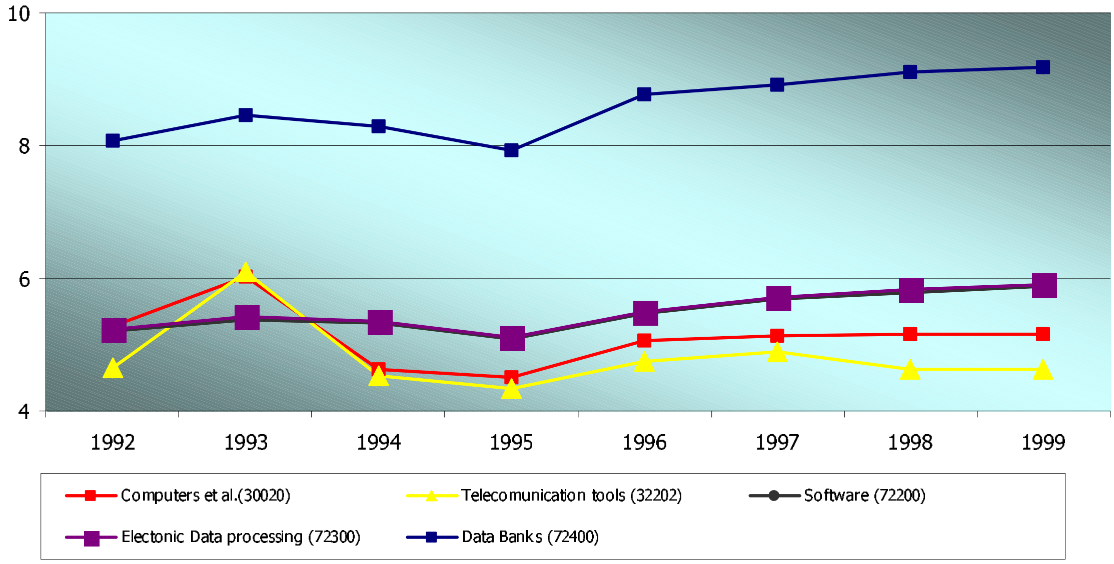

Figure 4.3 Fraction of ICT investment acquired by the same Producing Branch
(percent of nominal values)

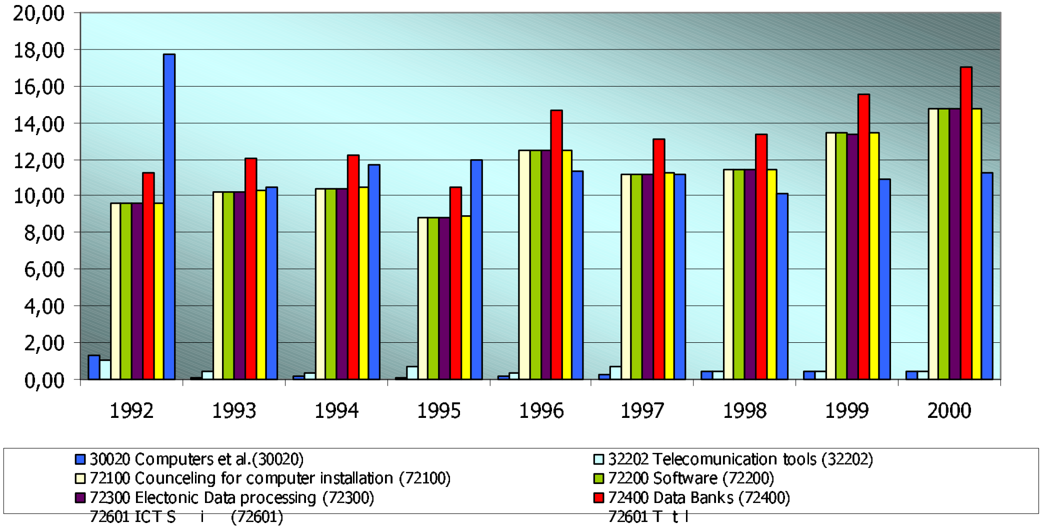

Figure 4.4 Total ICT Investment: Correlation between the initial-year (1992) value and the average growth rate
1992-2000

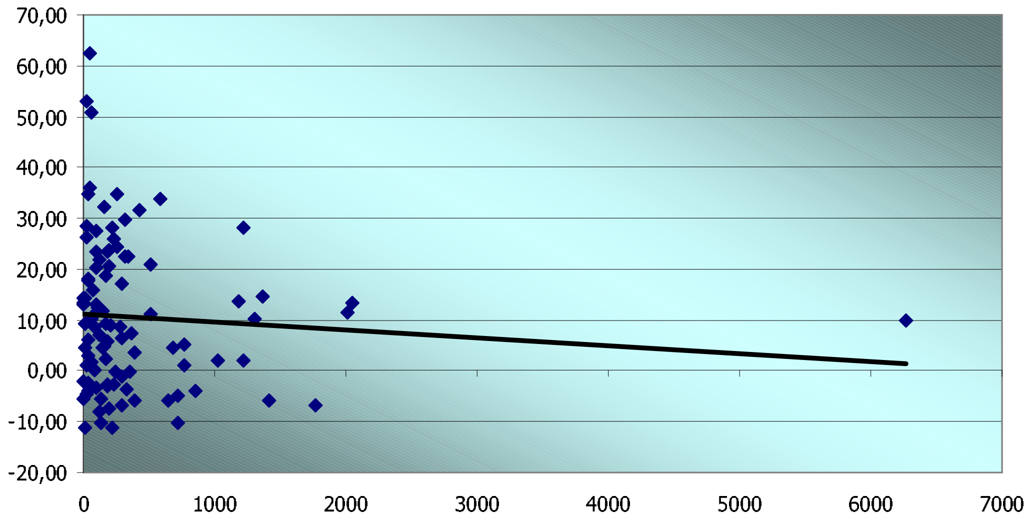

Figure 4.5 Computers (30020): Correlation between the initial-year (1992) value and the average growth rate 1992-2000

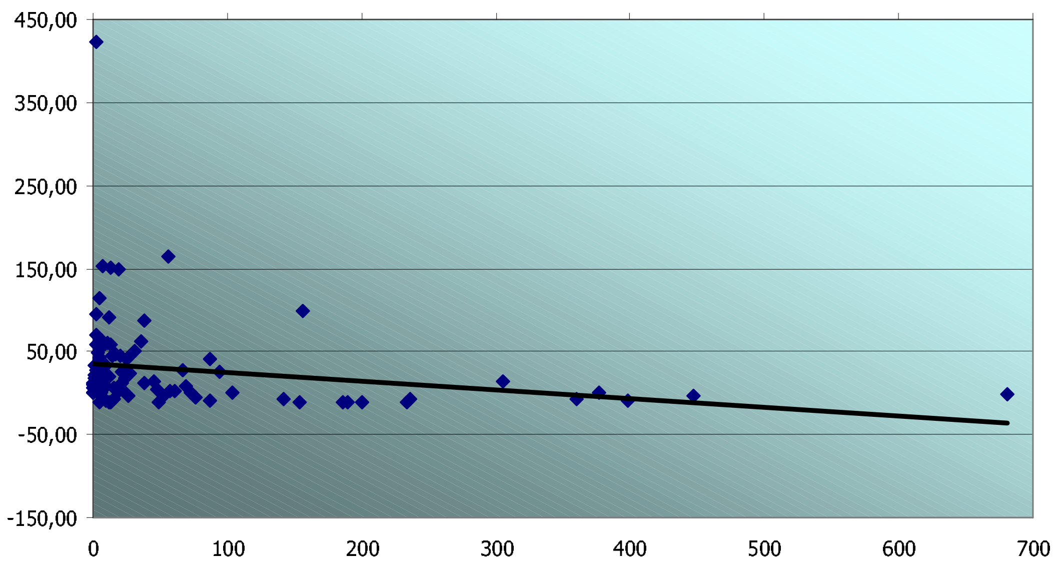

Figure 4.6 Software (72200): Correlation between the initial-year (1992) value and the average growth rate 1992-2000