Network Economies and Growth

Gennaro Zezza
Università di Napoli

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Abstract

Recent developments in economic growth theory have focused on increasing returns as a source of self-accelerating growth in countries or regions. Several empirical contributions have investigated wether increasing returns can imply divergence in growth rates, or per-capita income levels, across regions, against the hypothesis of convergence implied by more orthodox growth models.

In this paper we wish to contribute to this debate by analyzing the role for those network externalities associated to the fast-growing share of industries which use the Internet or other information networks as a mean of production.

The evidence on the impact of new information technologies on growth is still mixed: several authors point out that investment in Information and Communication Technologies (ICTs) have significant effects on productivity, thus accelerating growth, while others note that faster growth can better be explained by less stringent monetary and fiscal policy, with investment in ICT being a consequence of growth rather than its cause.

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Gennaro Zezza – Dipartimento di Teoria Economica e Applicazioni – Via Rodinò, 22, 80100 Napoli. Tel. +39-081-2537447 Fax +39-081-2537454 Email: gzezza@unina.it

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1. Introduction

The prolonged expansion of United States GDP in the 1990s has given rise to a growing body of literature[1] which has associated growth in US output and productivity with the diffusion of Information and Communication Technologies (ICTs).

Before the slowdown which started in the last quarter of 2000, the extraordinary length of the expansion, together with its small variance as compared to previous cycles, with a decline in inflation and unemployment, and a strong rise in stock market value of firms in the ICT sector, led several authors, in the press as well as in important financial institutions, to start talking of a *New economy*, a new world where technology could grant sustained growth at negligible inflation costs.

As lately as March 2001, some authors[2] estimated a structural break in US GDP *trend* growth, consisting in an upward shift connected to the *new economy*, thereby suggesting the Federal Board not to underestimate real output growth in setting its targets for monetary policy.

Along with theoretical and empirical research, many international institutions as the United Nations[3], the World Bank[4], the Oecd[5], the European Commission[6], the G8 group[7], started projects for development and growth which shifted their focus to diffusion of ICTs as the key instrument to help regions lagging behind to catch-up. It is therefore of great importance to have a proper understanding of the effects of ICT diffusion on local and global growth rates, on a region relative position in international markets, on the international and regional division of labor.

This is even more true since "at present we do not know all that much with any certainty about the causes of long-term economic growth"[8] and "current thinking about economic growth has often failed to grasp the complex causal nature of the social world, assuming that the components and processes of the economy are the same across countries"[9].

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[1] For a recent review see Jentzsch (2001).
[2] Cogley (2001).
[3] See the United Nations Development Programme: Information and Communication Technology, at http://www.undp.org/info21/index5.htm
[4] World Bank: Global Information and Communication Technologies, at http://www.worldbank.org/ict/
[5] Oecd Information Society initiatives, at http://www.oecd.org/dsti/sti/it/infosoc/
[6] See the eEurope Action Plan. Most countries in the EC have undertaken (or are developing) national action plans along the same directives.
[7] Digital Opportunity Task Force – Addressing the global digital divide, at http://www.dotforce.org/
[8] Kenny – Williams (2001), p. 2.
[9] Ibid. For a critical review of econometric analysis of growth see also Durlauf (2000).

At the time of writing[10], however, much of the optimism which has surrounded the "new economy" is vanishing: GDP growth in the US has gone down to a modest 1.2%, and prospects of stagnating demand have prompted US Federal administration to a generous una-tantum transfer to households, and the Federal Board to cut interest rates to a level which standard keynesian textbooks associate with the "liquidity trap", with no apparent effect on internal aggregate demand (yet). Even so, some commentators believe that

> "Despite the collapse of many dot-coms and the shuttering of many e-marketplaces, the fundamentals behind B2B [Business to Business] e-commerce and its impact on the New Economy remain strong. Efficiency improvements and cost savings already achieved through B2B e-commerce have likely led to higher productivity growth, lower costs and reduced pricing power, which should allow the US economy to grow faster without inflationary pressures."[11]

A widely shared view is therefore that the *New economy*, which explains the extraordinary behaviour of the US economy since 1995, can for the greatest part be tracked down to a supply-side shock connected to the introduction and the diffusion of ICTs. Along this view, countries and regions which are lagging behind the United States should turn to the *New economy* at a fast pace in order to close their gap.

In this paper we wish to review some evidence and alternative explanations concerning US growth and the New economy, and point to a distintinction between the effects of ICTs on efficiency, costs and productivity on one side, and to the effects on markets structure stemming from network effects and increasing returns to scale on the other, to give some first indications on how ICTs may affect growth, and regional convergence.

The rest of the paper proceeds as follows: section 2 will review the debate on the relevance and meaning of the term "New economy"; in section 3 we will offer some macroeconomic evidence on US growth in the 1990s, as compared to previous cycles; in section 4 some data on ICT diffusion across countries will be discussed; in section 5 we will review the literature on ICT and growth; section 6 will present some first results on network effects, and some preliminary conclusions will be drawn in section 7.

2. *New* economy vs *Network* economy

Along with the diffusion of the Internet, the media and several influential commentators have increasingly tried to convince us that industrial economies, starting with the United States, had entered a transition process from an "old" economy characterized by unemployment, inflation and

[10] August 2001.
[11] Siems (2001), p. 5. See also Baily and Lawrence (2001).

slow output growth, to a "new" economy driven by ICT diffusion, a decreasing role for the government, increasing competition on a global scale, and deregulation of markets, especially for labor. We will restrict our attention to ICT diffusion, trying to delimit its boundaries in a perceptible way.

The term *New economy* has quickly entered every-day language since its introduction, although several authors pointed to its irrelevance, ambiguity and vagueness[12]. Efforts have been taken to define the "new" economy either in terms (a) of its apparent effects on output, inflation, productivity and the stock market, or (b) in statistical terms, including specific sectors closely connected to the production of goods and services which are directly linked to the exchange and processing of information.

Definition (a) is based on the assumption that the prolonged US expansion, characterized by GDP and per-capita GDP growth rates above average, low inflation and unemployment, cannot be viewed as a cyclical phenomenon, but takes its origin from structural breaks deriving from ICT diffusion, globalization, and other structural changes in the product and labor markets[13].

> "It appears that the economy can sustain a higher growth rate than most people thought plausible just a year or two ago. In that limited respect, at least, we appear to be in a 'New Economy'"[14].

The assumed hypothesis is that ICT diffusion increases efficiency, leading to declining inventory costs, enhanced productivity and therefore lower labor costs per unit of output, etc. Besides, inflation is kept low from the increase in information available to firms and consumers, through the Internet, and from an increase in competition which is supposed to derive from growing information.

This view usually implies a downward shift in the NAIRU, prompting central banks to revise upward their monetary targets based on trend growth.

Another definition which is not quantitative in nature points to the increasing relevance of transactions in knowledge and information, and to the hypothesis that "ICT products themselves behave like knowledge"[15], i.e. their distribution is aspatial – does not depend on the geographical location of producers and consumers – and consumption of a product does not inhibit others from obtaining the same product. In this respect, knowledge has the same characteristics of a public

[12] See among others Paulré (2000), Visco (2000). According to Paulré the concept of a "New economy" first appeared on *Business Week* in 1994.
[13] This view seems to be shared by the US Federal Reserve, and the Bureau of Economic Analysis. See among others Fraumeni and Landefeld (2000), Davies et al. (2000), Federal Reserve of Dallas (1999), Paulré (2000). Jentzsch (2001) classifies definitions of the term "new economy" among several authors.
[14] Blinder (2000), p. 8.
[15] Quah (2000), p. 9.

good, and the increase in the share of consumption devoted to ICT and knowledge products and services becomes the central characteristic of the *New economy*. Attention is thus shifted from the supply-side effects on costs and productivity of ICTs to the demand side.

A similar view, with emphasis on how innovation is diffused, can be found in some contributions[16] of the "evolutionary approach" which, though they don't enter the debate on the meaning of being in a *New economy*, do not rely on models based on steady-state, or shifts in the production function due to technology, but rather emphasize the importance of innovation – a force which implies divergence between innovative regions and the rest of the world - and imitation, which enables followers to catch-up on innovators. Following this approach, we may state that there is nothing "new" with ICTs, but rather that the complex transformation of economic systems we are observing needs to be studied taking into account economic and non-economic factors.

Other contributions to the debate on the *New economy* choose a more quantitative approach for defining this term, to provide some ground for empirical testing of hypothesis, international comparisons etc. For instance, the New economy has been defined as the sectors producing electrical equipment, machinery, telephone and telegraph, software[17]. Others[18] propose a definition which is more centered on IT. An economy should be labelled "new" if

1. The economy's information sector contributes more than 25% to the GDP growth rate.
2. In the economy's business sector, the Internet is adopted as an infrastructure for economic transactions by at least 25% of all businesses.
3. At least 25% of all households have a computer and access to Internet.

Where the "information sector" is defined as including "the industries of software and software services, hardware, communications equipment and communications services."[19]

Although the latter definition, as we shall see later on, is more congenial than the former to the aim of this paper, it fails to distinguish between the effects of ICTs to all sectors of the economy. A country or a region can import or imitate ICTs and apply them in its traditional sectors of specialization, say, for providing tourist information to foreigners. The country or region could therefore successfully enter a "new" way of doing business, satisfying only condition (2) of the definition proposed above.

In our view, the term "new economy" is still too vague to be of any use, and could perhaps be misleading by mixing up different kind of innovations – such as advances in microprocessors speed

[16] Fageberger and Verspagen (2001), Verspagen (2001).
[17] Nordhaus (2000).
[18] Jentzsch (2001)
[19] Jentzsch (2001), p. 12.

and the internet – which are likely to have completely different impacts on growth (although the internet will not evolve without improvements in microprocessors!).

We would rather adopt a different approach, which keeps the effects of the introduction of (personal) computers separated from the ability to have computers (and other media) interact over a *network*. To sum up the distinction, we wish to separate the impact of personal computers which, in our view, is limited to an improvement in individual efficiency – which has also been questioned, as we shall see later on – and may lead to a reduction in costs of production and/or a step increase in productivity, from the impact of connecting computers and people over a network such as the Internet, which reduces different kind of transaction costs and may thus have an impact on the structure of firms and markets, and leads to a diffusion of network effects to several kind of "new", as well as tradional, goods and services.

Before reviewing the major contributions on the relation between ICT diffusion and growth, it is worth examining some evidence on the U.S. expansion, which has been at the basis of much of the thoretical and empirical contributions to be discussed later on.

3. U.S. growth in the 1990s.

The U.S. economy has been experiencing a prolonged period of growth, starting in 1992, with a sensible acceleration from 1995 onwards. Indeed, inspection of figure 1 reveals that the current expansionary period[20], starting in the last quarter of 1991, is already the longest (39 quarters up to the second quarter of 2001) in the post-war period, having exceeded in duration the 1960s 38-quarters expansion. The economy growth rate started to slow down only in the last quarter of 2000, and though the latest available data show that output is hardly rising in 2001, the US economy has not entered a recession yet.

This period of prolonged growth has been carachterized by other relevant features: in particular, unemployment has lowered to levels which were well below the estimated NAIRU, whit negligible effects on inflation. Moreover, up to the year 2000, expansion in output has been accompanied by an extraordinary growth in market price for equities, especially for companies related to ICTs: a financial bubble which was not perceived as such from investors, and gave rise to a strong wave of optimism among households and firms. The term "new economy" has been associated with these phenomena, to stress that what the US economy was experiencing was not due to cyclical factors, but rather to a structural change in economic behaviour which could lead to a permanent upward shift in US productivity growth rate.

[20] By "expansion" we simply mean a series of positive real GDP growth rates.

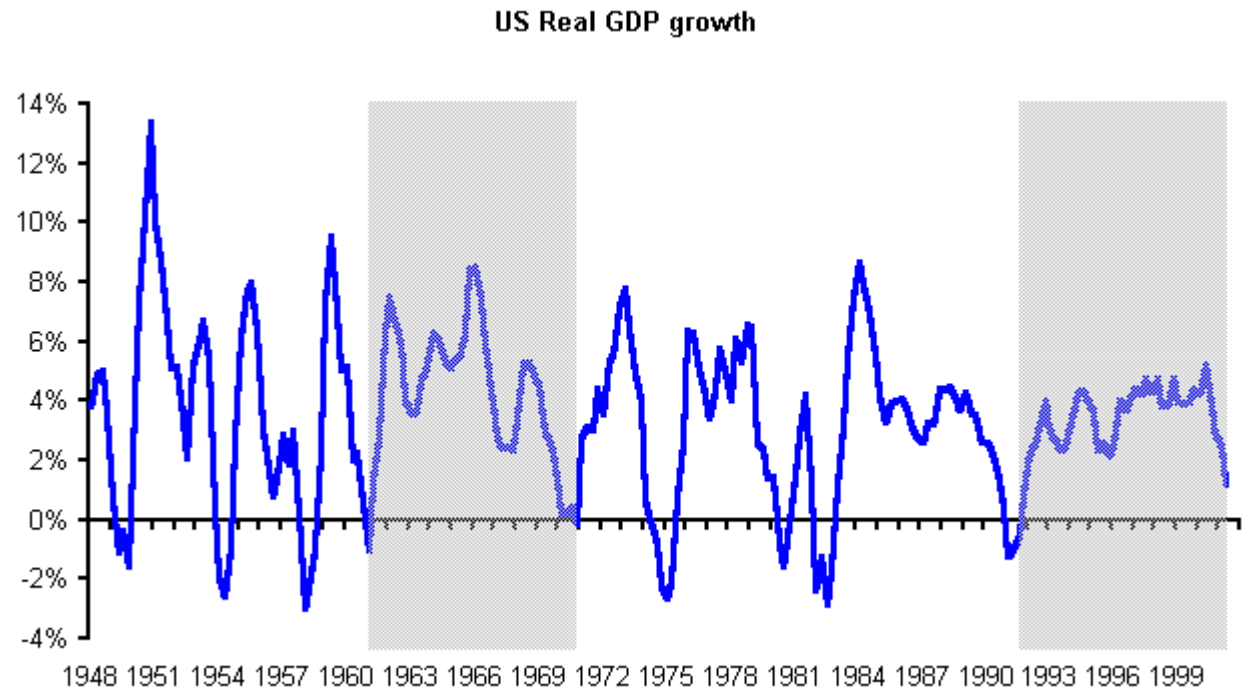

Figure 1. Annual growth rates in 1996 prices GDP. Source: BLS

In other words, many commentators analyzed US growth in the 1990s against a neoclassical model of steady growth, where a supply-side shock to productivity, arising (exogenously or endogenously) from the introduction of ICTs, had created a structural break, and therefore higher growth rates in output and productivity, as well as the end of unemployment and inflation, could be expected for the foreseeable future.

Figure 2 reports the growth in output (solid line) and output-per-hour (productivity, dotted line) in U.S. non farm business sector[21]. This chart confirms some characteristics which were already present in figure 1 for GDP: growth rates variability has been decreasing in the 1990s; and the strong expansion is due to growth rates which are not extraordinarily high, but have consistently been above the average for the previous period.

Another aspect is crucial to our discussion: productivity growth had been well below average in the last part of the 1970s and up to 1994, and has started rising steadily since. However, since the difference between the two curves is given by the growth in hours worked, up to 2001 a large part of the growth in output was due to an increase in hours (employment, and hours worked per employed person), rather than in productivity.

[21] We have used 4-quarters moving averages to smooth the series, since we are interested in medium and long term aspects of growth.

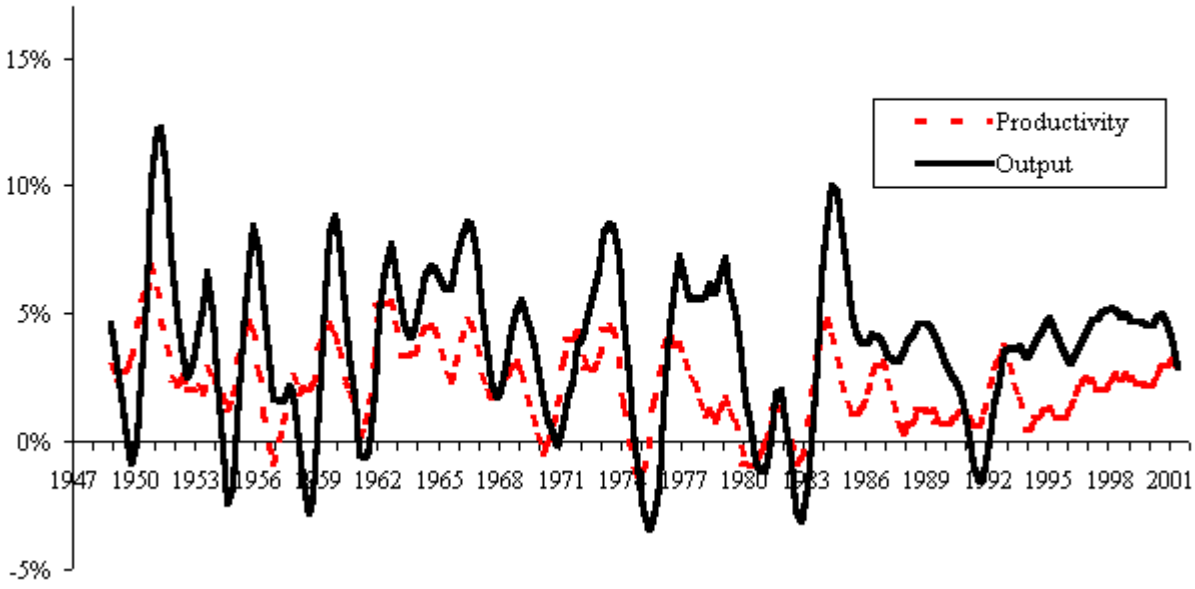

Figure 2. Annual growth rates in 1992 indexes. Source: BLS

If the 1990s expansion is due to ICT, it is worth examining the output of the durable goods sector, which includes computers, telecommunication equipment, etc.

The data in figure 3 give some further indications: output in the durable goods sectors started to grow at a fast pace only in 1992, while growth in overall business sector output had already started growing in the last quarter of 1991. Productivity in the durables sector exhibits high growth rates in the last part of the 1990s, while the difference between output growth and productivity growth is less significant than for the overall non-farm business sector. Therefore, the extraordinary growth in durable sectors output has not been associated to a strong increase in hours worked, or in a large and growing increase in employment.

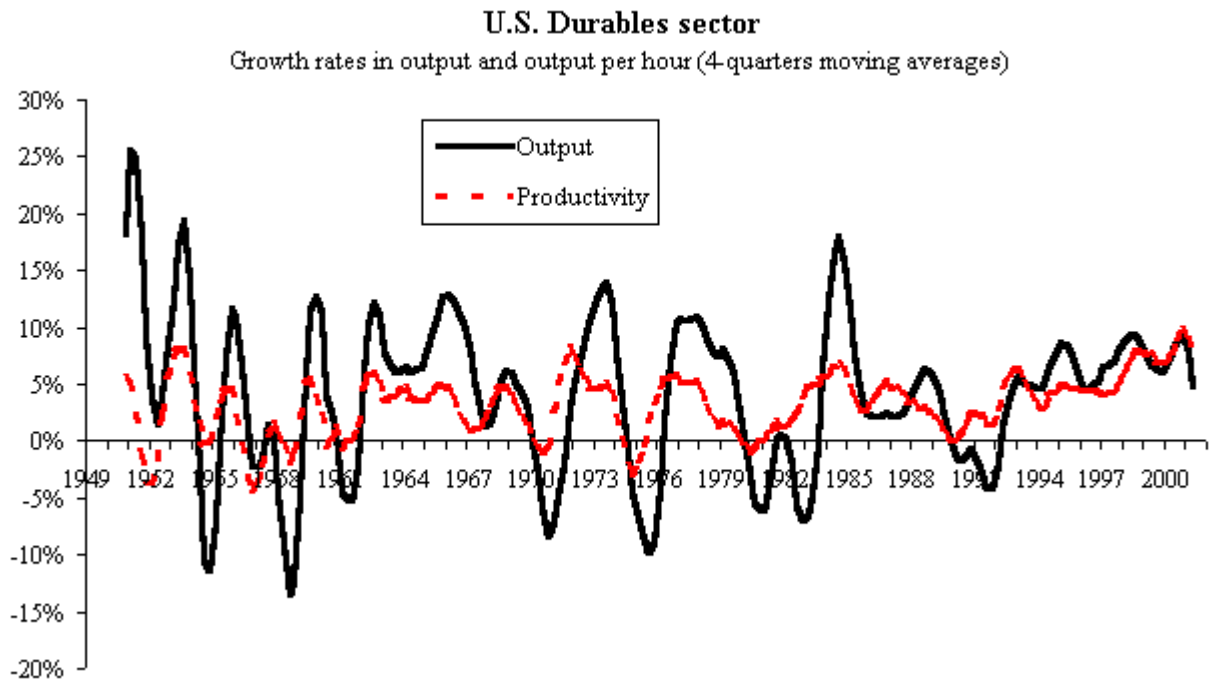

Figure 3. Annual growth rates in 1992 indexes. Source: BLS

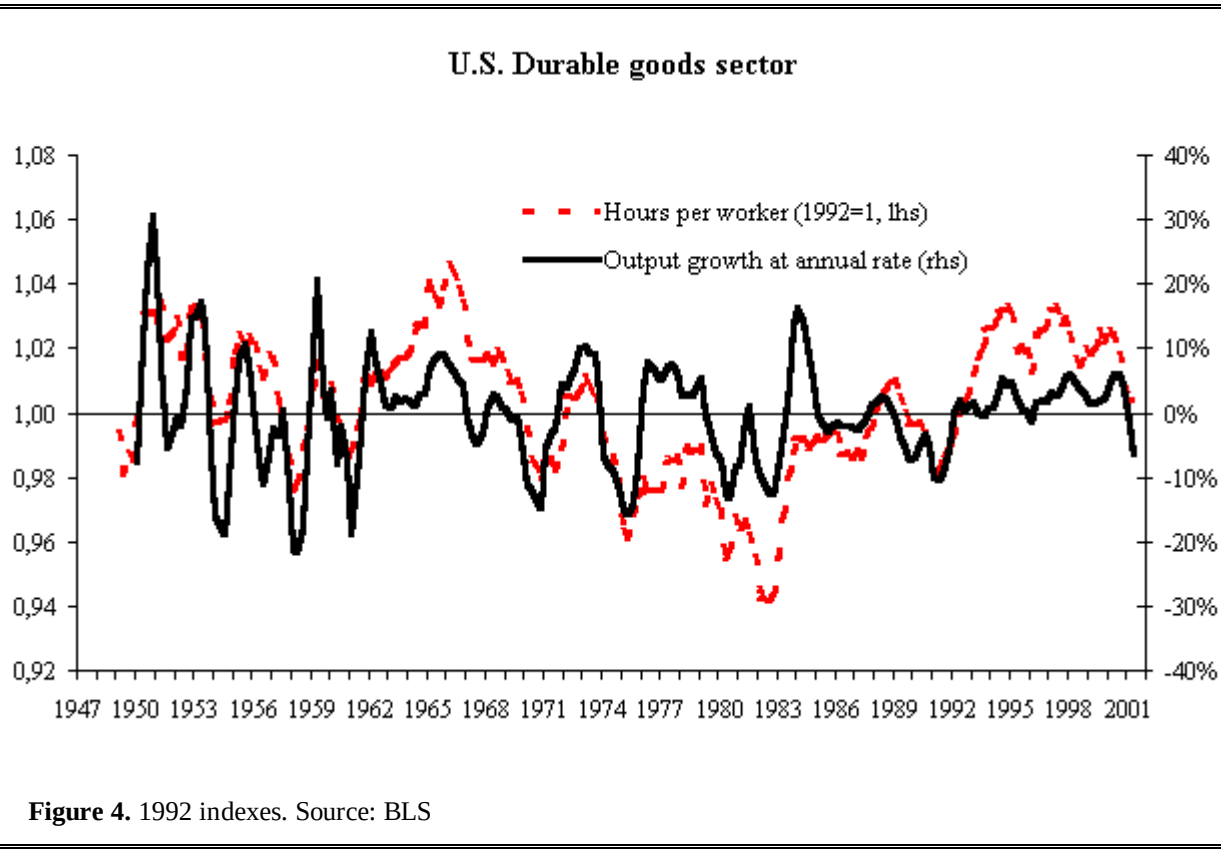

Figure 4. 1992 indexes. Source: BLS

Figure 5 reports some data on real fixed private investment other than residential. There is a large increase in the investment share on GDP from 1992 (9%) to present (14.7%) which is almost

entirely attributable to purchases of computers and software[22]. Investment other than IT, which includes industrial and transportation equipment, went up from 6.6% as a share of GDP at its lowest level in 92q1 to 8% at the beginning of 2001, while investment in IT grew more than 4 GDP percent points in the same time span. Again, it is worth noting that investment starts rising, as a share of GDP, in the second quarter of 1992, when GDP was already recovering from the previous downturn.

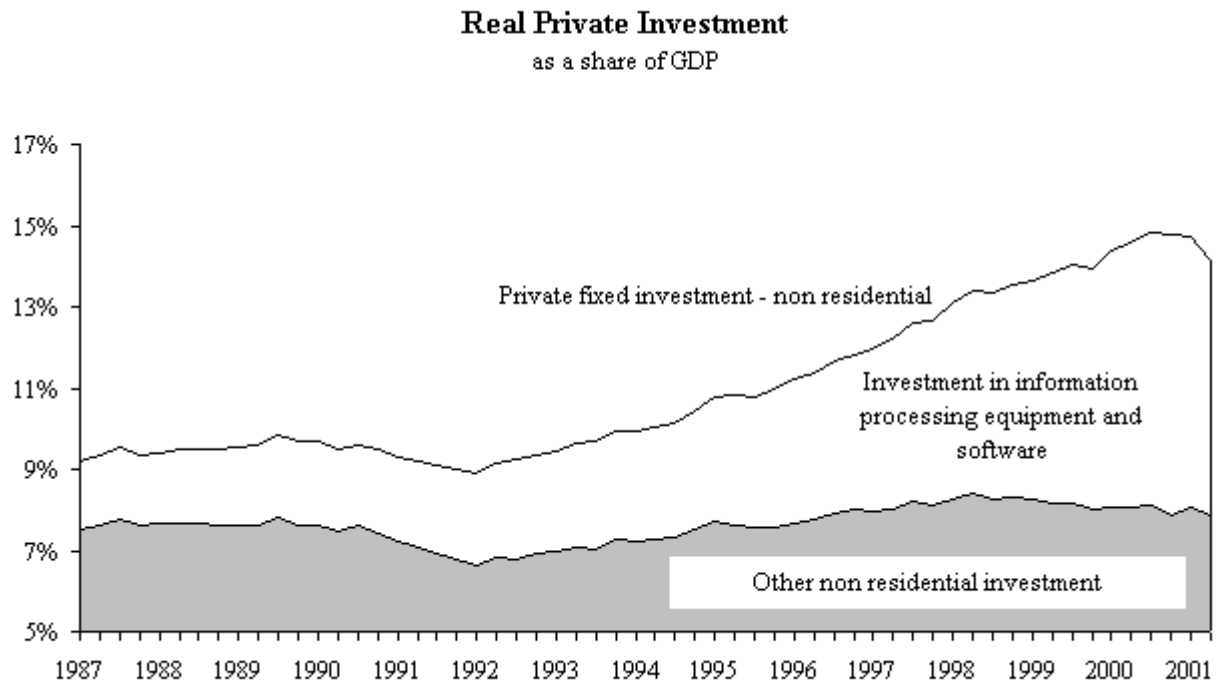

Figure 5. Real private fixed investment in 1996 chained dollars. Source: BEA and BLS

As we have seen, and as we will discuss more extensively in section 5 below, the optimistic view about the *new economy* is that the introduction of ICT can be considered a supply shock which (a) has led to the emergence of new and rapidly growing industrial sectors characterized by sustained productivity and declining prices, and (b) is spreading its effects across traditional sectors in the economy, mainly services, with generalized effects on productivity.

This aspect is confirmed by examination of figure 4[23], which reports output growth in the durable goods sector along with an index of hours per worker. The latter figure is strongly procyclical, and seems to confirm that the strong output growth has been obtained with a sensible

[22] The effects of changes in statistical measures for the IT sector, which could explain all or part of the increase in investment, will be discussed in the next section.
[23] Data for output in figure 4 are actual growth rates, rather than the moving averages which were obtained from the same data for figure 3.

increase in employment effort, analoguos to what is visible for the 1960s expansion: it must be the case, therefore, that employment in the durable goods sector has grown less that what could have been assumed, if hours per worker had remained more stable.

Other contributions are less optimistic[24], and discarding the effects of ICT diffusion on productivity explain US growth in productivity only with the increasing share on value added of ICT and other sectors exhibiting strong productivity. According to this view, there is no benefit to productivity in adopting ICTs in other sectors of the economy.

A completely different explanation for U.S. performance over this period[25] ignores the supply-side role of ICTs in US growth, and tracks down the strong growth in the US economy in the 90s to demand-side effects. According to these authors, US growth has been mainly sustained by an extraordinary increase in private sector debt, which has been sustainable since US monetary and exchange rate policy have been such to attract foreign capital into the US, thereby leading to a sharp increase in financial asset market prices (a "financial bubble") which exherted a wealth effect on US consumption. Inflation has been low, in this view, since real wages were successfully kept low, and a strong dollar allowed for a sharp increase in imports, whose prices were low. For these authors, supply-side shocks to productivity are of lesser importance, since the macroeconomic consequences of a demand-pulled growth are not sustainable, as we are already experiencing. Asset prices have started to fall, reversing the wealth effect which fuelled consumption, and bringing a downward revision to expectations, which are likely to generate a further fall in consumption and investment. With US exports kept low by the strenght of the dollar, and a surplus in government balance, there is nothing preventing a strong recession, which could turn into a hard landing if foreign investors should start selling the US assets which have been accumulated during the boom of the 1990s. Some simulations based on alternative assumptions about household's behiavour towards reducing their debt point to a relatively long period of slow growth, with rising unemployment[26].

This view may be more consistent with the lagged response of investment to output which we have stressed before.

[24] Gordon (1999) and (2000).
[25] Brunner (2000), Godley (2000), Godley and Izurieta (2001).
[26] It is interesting to note that Godley and Izurieta draw a parallel between articles on the *New economy* appeared in the US in the late 1990s with articles on the UK "miracle" of 1989. According to them, the strong growth in the UK was fuelled by private sector debt, too, and ended up in a severe recession.

4. Internet diffusion

It is worth adding some evidence on how ICTs, as symbolized by the Internet, are diffusing across countries[27]. Internet users as a share of population are already stable in the U.S., while access is still increasing in the world at exponential rates, as figure 6 shows.

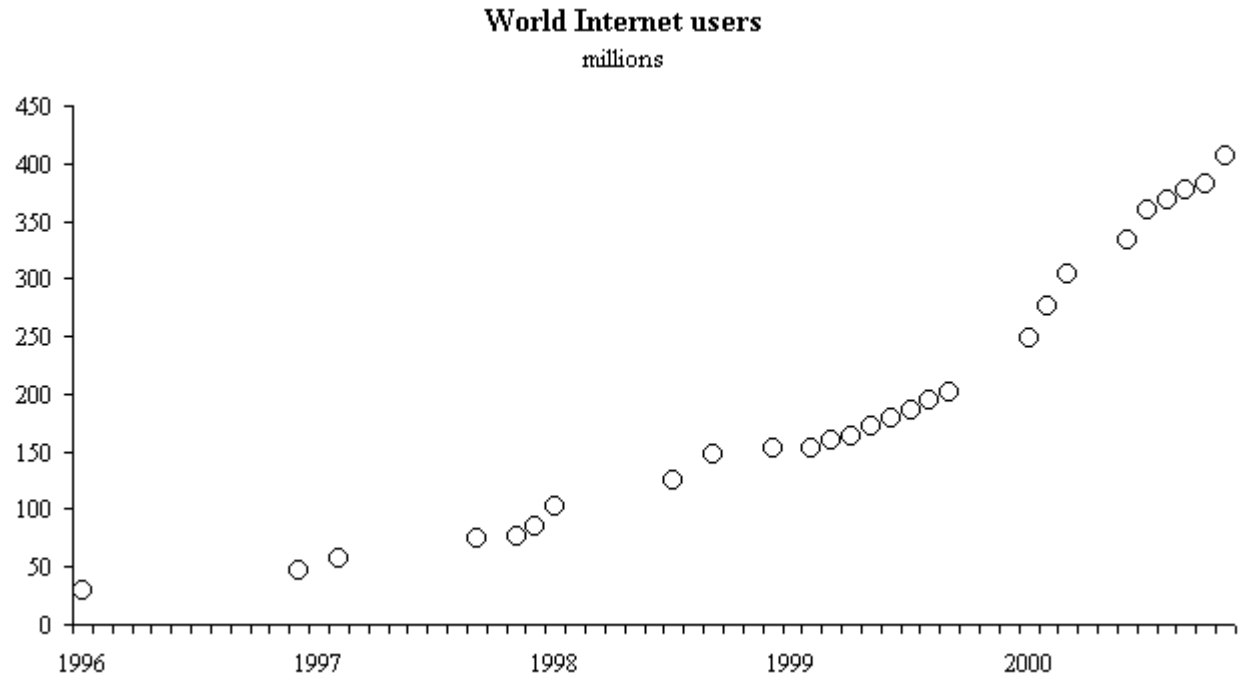

Figure 6. Different sources, collected from NUA - Internet surveys - http://www.nua.ie

From figure 6 we can easily assume that Internet access will keep growing at a fast pace, since other countries have a long way to go before reaching the same level of penetration achieved in the US.

Figure 7 gives some evidence on how the Internet is diffusing across countries. Since the purpose of this paper is to sketch the relation between ICT diffusion and growth, it would be interesting to provide some empirical evidence of causality going from Internet diffusion to GDP levels. However, we do not have sufficient data yet to assemble such tests, and we have therefore relied on a preliminary analysis of the relation between GDP per-capita level, in US dollars, and Internet diffusion[28].

[27] Altough we are focusing mainly on the US economy, several contributions have started investigating the relation between ICTs and growth for other countries, usually adopting the same framework of ICT introduction as a supply-side shock. See Andersson (2000), Bassanini et al. (2000), Daveri (2000), Scarpetta et al. (2000), Schreyer (2000).
[28] The chart in figure 7 is based on 57 countries. Data for GDP are relative to the latest available year in the UN database (1998). Data for population are relative to 2000. Internet access is relative to March 2001, obtained from

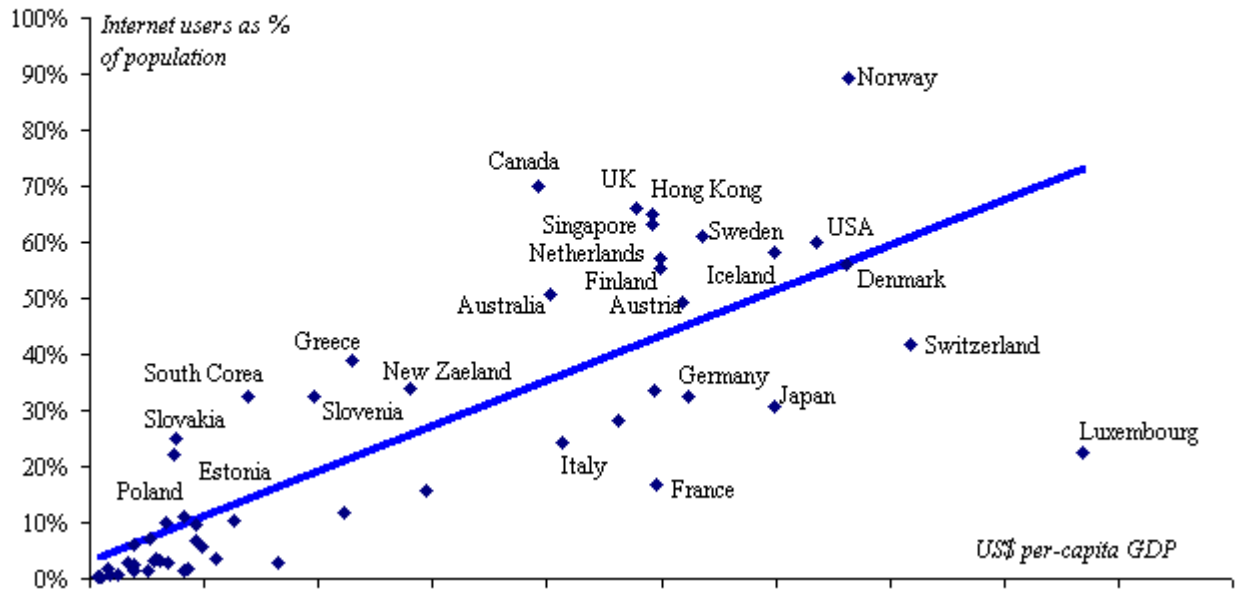

Figure 7. Sources: United Nations, Netsizer. See footnote 26

As expected, per-capita GDP is an excellent predictor of Internet diffusion, as shown by the regression line, which exhibits highly significant coefficients[29]. What is interesting from figure 7 is that our analysis captures some clusters of countries which are known to have made significant efforts to favour the diffusion of ICTs, especially through government intervention or, on the contrary, countries which have been less prone to innovation. Countries above the regression line are characterized by a level of Internet diffusion which is over what could be assumed from their GDP level: these include some Northern european countries such as Iceland, Norway, Sweden; some rapidly developing countries in Eastern Europe such as Estonia, Poland, etc. These countries are either characterized by successful growth in ICT industries, which now account for a significant share of total production, or by government policies directly aimed to diffusing the use of the Internet, perceived to be an important instrument for human capital growth.

Among the countries below the regression line we find Italy, Germany and France which, though advanced in absolute terms in ICT diffusion, are lagging behind with respect to our simple indicator.

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www.netsizer.com. Since we are interested only in the relative position of a country, difference in periods should not dramatically change our results.

[29] We do not present regression results since we are well aware of their weakness, in the absence of a broader set of relevant explanatory variables. We hope to obtain more robust econometric evidence from extensions in the current line of research. For an illuminating discussion on econometric problems in cross-country models related to growth see Kenny – Williams (2001).

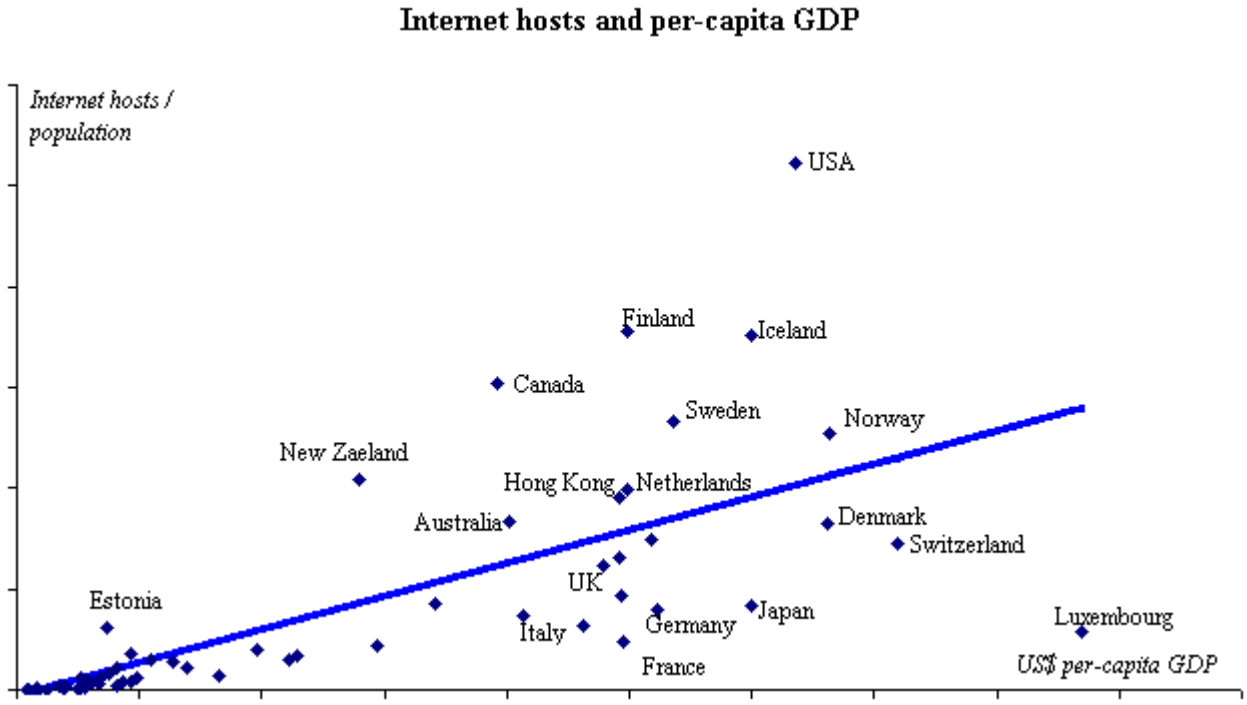

Figure 9. Same sources as figure 8.

Figure 8 complements the analysis in figure 7 with the relation between the number of Internet hosts, scaled by population, and per-capita GDP. The number of Internet hosts is usually perceived to be related to a country's ability to provide services over the Internet, while data on access is more tied to the demand side[30]. As expected, most of the developing countries which had higher than expected Internet penetration among users do not achieve the same result for the diffusion of internet hosts.

5. Computers, productivity and growth

The effects of computers on business productivity has been examined extensively, particularly after the well-known Solow's 1987 paradox "You can see the computer age everywhere but in the productivity statistics", which stressed that the costant flux of investment in computers from US firms from the late 70s had had no apparent effect on measured productivity.

Since then, numerous contributions[31] have tried to estimate the effects of a growing IT capital stock on productivity[32]. The evidence points to:

[30] Data on internet hosts usually over-represent the US, and under-represent other countries, since firms located anywhere may find more convenient to provide their services in a US-based host.
[31] An exhaustive review of the literature is in Brynjolfsson and Yang (1996). For later contributions see, among others, Hulten (2000), Nordhaus (2000), Oliner and Sichel (2000).
[32] For studies at the firm level see, among others, Brynjolfsson – Hitt (1995), Black – Lynch (2000).

a) The computer industry has indeed been experiencing a strong increase in productivity, especially when output is measured taking changes in its quality into account. Some countries, eg the US, Canada and France, have started producing statistics ("hedonic price indexes") for output and prices for some durable goods which try to cope with the problem of changing quality. The new statistics release for the US on this basis have dramatically revised the previously available data, showing a marked decline in computer prices, and a strong increase in productivity. As the share of the IT sector grows, average productivity should start rising[33];

b) The evidence on productivity growth *outside* the ICT sector is still mixed. Many authors[34] have used Solow's growth accounting to estimate Total Factor Productivity (TFP) in all sectors: the idea behind those exercises is that any growth in output which cannot be accounted for by increases in phisical or human capital can be attributed to technical progress generating from ICTs. The problem in correcting for quality improvements, when obtaining statistics on output and prices, is here even more severe, since ITs are intensively used in the service sector, where "correct" productivity measures have always been difficult to obtain. Estimating TFP from growth accounting, moreover, does not guarantee that the increase in productivity stems from ICTs: it could be due to other innovations in the workplace[35];

c) Investment in computers and software requires a considerable amount of training: the effects of this kind of innovations may thus take a long time to become perceptible[36], since the introduction of any innovation requires to divert human resources from production to training. Innovation in software is also a continuous process, and then the training needed to successfully exploit innovations will require a considerable, maybe growing amount of resources over time. Skepticism is also due[37] to (1) the sensible amount of IT projects which are abandoned, leading to a waste of resources, and (2) a large amount of IT innovation which is dedicated to rendering software and IT more "user friendly". This latter effort, which is the basis of many software upgrades, is such that the amount of resources invested has to be compared with an increase in productivity which is questionable (do we become more productive because of a nice graphical interface?): the ability of selecting options among a larger number of choices in a software menu may lead to increased user costs, rather than greater productivity;

d) The net effect of IT investment on profits should be positive: many authors give this result from the assumption of rational behaviour on the part of firms, which should have stopped investing in computers if returns would turn out to be lower than expected. High return from investment in IT, however, may not depend on enhanced productivity related to a standard output, but rather on the ability to obtain new, different goods or services as a result from the introduction of IT. If the quality of goods produced change over time, with lower quality products being substituted by newer ones, it may simply be impossible to measure productivity[38], but if the newer goods are perceived to be of better quality by consumers, the improvement in quality should turn out in higher sales, and profits.

Summing up, the effects of investment in ITs on productivity are difficult to estimate; effects on output growth must take into account the rapid pace of introduction of new products and services. If

[33] It has been pointed out that the low growth of productivity in the first half of the 1990s is related to computers being a very small share of total US capital stock. See Triplett (1998) among others.
[34] Gordon (1999) and (2000), and Nordhaus (2000) are excellent examples of different points of view, though based on different methodological approaches.
[35] See Black and Lynch (2000).
[36] David (1990), (1999), Kiley (1999).
[37] Triplett (1998).
[38] See

we believe that social welfare increases with product quality and product variety, IT is having a sensible impact on welfare, which however will not show up in offical statistics.

6. Networks and the Internet

The ability of connecting computers and people over a network should impact firms and marketplaces in a way which is logically different from the introduction of computers. The availability of a network to a firm reduces transaction costs in transmitting and organizing informations. Firms started to exploit such benefits with the adoption of private networks[39] well before the introduction of the Internet on a large scale. The availability of a private network should (a) decrease the costs of inventories, if information from customers' demand is available rapidly and without costs to the productive plant; (b) increase the efficiency, and reduce costs, in achieving the optimal location of productive resources; (c) reduce other transaction costs related to transmitting and organizing informations in firms' internal decisional process.

Such effects have the same sort of benefits and drawbacks which have been examined for IT diffusion: the ability of a customer to receive products more timely, and maybe tailored to her needs, may not result in any measurable increase in productivity or index of social welfare. Moreover, the introduction of new ways of doing business over a network, and changing protocols in information transmissions, require a considerable amount of training, which again divert resources from production.

A different impact should be obtained with the diffusion of the Internet, ie a public network which can be accessed by firms, government agencies and consumers, irrespectively of geographical distance and at low costs.

A recent contribution[40] on the economic impact of the Internet states that it has the potential to to increase productivity growth in a variety of distinct, but mutually reinforcing ways[41]:

1) By significantly reducing the cost of many transactions necessary to the production and distribution of goods and services
2) By improving the efficiency with which goods and services are produced and delivered, enabling firms to carry lower levels of lower inventories of supplies and finished goods, while facilitating restructuring of companies and internal processess
3) By increasing the effectiveness of marketing and pricing
4) By increasing consumer choice, convenience and satisfaction in various ways

[39] By "private" network we mean a network whose access is completely controlled by the firm.
[40] Litan – Rivlin (2001), which summarize several contributions to a book being published by the Brookings Institution. See also Blinder (2000), Garicano – Kaplan (2000), Kaplan – Garicano (2000).
[41] Litan – Rivlin (2001), p. 5

5) By increasing competition, making prices more transparent, and broadening markets for both buyers and sellers[42]

Point (1) above claims that, as with other general purpose technologies, the Internet will make it possible for firms to accomplish the same tasks more efficiently, eg cutting costs. This is especially true for those sectors which rely heavily on processing information, such as several branches in the service sector: health care, insurance and banking, and the government. However, even this "soft" introduction of innovation will not be without adjustment costs. For instance, switching to e-mail for transmission of documents among local governments requires a considerable amount of coordination, the adoption of standards for document delivery, revisions in national laws and regulations, training, etc. As an example, the Italian government was late to start adopting Internet technologies for delivering services to citizens and businesses, and could therefore benefit from imitation on other national experiences: nevertheless, it took several months before different organizations within the government managed to coordinate on protocols, and legislative measures were taken to grant e-mail transmission of information the same legal status of traditional media supports.

Benefits on growth and productivity may thus be yet to be seen[43], and will probably escape statistical recognition, on the same line of reasoning developed above for IT: major improvements are expected to be in the quality and variety of services which become available, in sectors where output has always been difficult to measure[44].

The new Internet technology (point 2 above) will slowly be used to change the organization of processes, to do the same tasks in a *completely different* way. It is sensible to assume that these effects of innovation in the workplace will take much longer to be appreciable, since they require a longer period of "learning on the job".

Points 3 to 5 above will be examined more extensively, since we believe that they may be strictly interconnected with less examined aspects of the potential effects of Internet diffusion.

The Internet makes it possible to access information at low costs irrespectively of geographical distance. This aspect may have deep implications (a) to firms, regarding the size of markets both for

[42] A further important, indirect effect, can be obtained when Internet technologies are adopted by the government to provide services to business and citizens, since these technologies carry the potential to reduce corruption and sensibly reduce the costs of firms location in an area. See Zezza (2001) for a further discussion on these topics.
[43] Some sectors, however, may already have achieved the greatest part of the benefits from networks. This is the case of the banking sector, which has already shifted a large portion of service delivery from human tellers to automatic tellers on networks. It is interesting to note that consumers' satisfaction starts *declining* with an excessive amount of automatization: several services seem to require face to face contact. This aspect has turned out as well in systems of automatic information delivery over telephone lines: firms which had completely eliminated human intervention in providing information to customers had to abandon or modify their systems, because of customers dissatisfaction.
[44] See also David (1999).

input of production and for their output, and (b) to consumers, who experience a reduction in costs of collecting information, and may obtain access to a wider variety of products.

Some authors assume that the greater availability of information will make markets closer to the textbook model of perfect competition, where it is assumed that consumers are perfectly informed, barriers to entry are negligible etc. For these assumptions to hold, we should be observing a decline in price dispersion for those products who are already transacted on the Internet. However, the available evidence[45] does not seem to support these results: analysis of the on-line market for books, which is one of the more successful examples of B2C e-commerce, show no decline in prices or price dispersion, perhaps because firms manage to differentiate, for example by offering different side services, even though they sell the same commodities.

On the consumers' side, the effects on welfare of the information carried by the Internet is debatable. It is now possible to search for information at low costs, but (a) people need to invest resources in learning to manage the new technology, and (b) the pace of increase of the available information is so rapid to offset at least part of the potential benefits: "The cost of physical communication resources has fallen so much that the relatively scarce resource is now the human attention needed to process and understand information."[46]. These effects may have contributed to the decrease of Internet access from some groups in the US: consumers were expecting to significantly reduce transaction costs of obtaining goods and services through intermediaries, but found out that (non pecuniary) search costs are higher, or yield lower quality outcomes. In turn, search costs are prompting new firms (search engines, portals) to intermediate information on the web: consumers searching for product information will thus be increasingly confined to the range of services who have some sort of ties with the new intermediaries[47].

We wish to point out that the degree of competition on product markets may be *reduced* by the progressive diffusion of Internet usage. This may be due to the possibility of economies of scale adding up with *network effects* in many markets where information plays a relevant role.

There are network effects[48] in all cases where the value of a product purchased in a network context to the single consumer increases with the number of consumers in the network. The classical example is the telephone: if consumer's value from telephone calls depends on the amount

[45] Clay et al. (2001).
[46] Van Zandt (2001), p. 1. Van Zandt shows that, under specific conditions which may be applicable to the Internet, "in the absence of mechanisms for allocating the attention of receivers,all senders and many receivers in a network of targeted communication may become worse off when the cost of transmission channels falls.".
[47] Jupiter Media Metrix suggests that either firms cooperate in forming what may be called *Meta-Networks* to help consumers reduce search costs, or they will not be able to survive competitions from already established Meta-Networks.
[48] The literature on network effects and network externalities is rapidly growing. See among others Katz – Shapiro (1985), Economides (1996), Liebowitz – Margolis (1994), (1996).

of possible connections on the telephone network, as the number of users of the network grows, the value of the telephone service will grow exponentially[49]. Some authors[50] point out, however, that firms establishing a new network will serve the market where they expect to obtain the highest returns first: if firms are able to discriminate among users, those who attach the highest value to the network will be connected first. For instance, in Italy several firms are competing to offer high-speed internet connection to the business centre in Milan, while infrastructure development in other regions does not seem to attract resources from the private sector yet.

While accepting the cautionary notes, there is still ground to assume that network effects are at work in most transactions which involve the Internet. For instance, network effects from the adoption of a specific word processor are neglibible when software is used simply as a substitute for a typewriter for personal use[51]. However, when electronic documents have to be transmitted and maybe shared among different people, users may tend to prefer a lower-quality word processor with a large diffusion to a better-quality one which has failed attracting a considerable market share. In this view, once an economy has choosen a specific product, maybe out of an informed selection process, it can get locked-in, unrespectively of that product quality against competitors[52].

Moreover, several – maybe all – information products distributed over the Internet are characterized by economies of scale, eg high fixed costs and negligible marginal costs as sales increase. If we think of word processing software, again, costs of production are essentially related to the R&D expenditures needed to develope of the first prototype of the software, and once the first product has been obtained it can be duplicated at trivial costs. Another relevant source of economies of scale may arise from the logistics of e-commerce for those goods which cannot be delivered in

[49] That is, unless the network runs into *congestion*, a problem which is not addressed here, which dramatically changes the characteristics of benefits from networks.
[50] Krugman (2000).
[51] Liebowitz and Margolis (LM) distinguish among different situations where the value of a specific product increases with the number of users. First, if unit costs of production decrease with sales, as the number of word processors grow consumers will benefit from a reduction in final prices. Other network effects arise from side services associated with a specific product: when a given word processor starts being adopted on a large scale, users will usually experience a greater availability of information on how to use it, of assistance, etc. These kind of network effects are not necessarily associated with the "new" economy, and are relevant for a wide variety of "old" goods. LM stress the difference between network *effects* and network *externalities*: only the latter, arising from effects which cannot be internalized, produce market failures, and thereby require government intervention.
[52] Arthur (1989). We may think of Microsoft Windows O.S., which has become dominant at the world level because of Microsoft commercial policy (bundling the O.S. with computers, etc.). Liebowitz and Margolis strongly object this argument, stressing that only superior quality products will eventually dominate, even in a market characterized by network effects.

electronic form: some firms producing or intermediating "traditional" goods on the Internet face decreasing unit costs for transportation as sales increase on a global scale[53].

The combined effect of economies of scale and network effects may be such that markets will increasingly experience a strong degree of concentration, or monopoly, on a global scale[54].

This hypothesis seems to be confirmed by the available evidence on Internet information intermediaries (portals).

Table 1. United States. Internet use and "portals" market concentration

	March 1999	March 2000	March 2001
Minutes spent online (billions)	50	73	107
Number of firms controlling 50% of minutes on-line	11	7	4
Number of firms controlling 60% of minutes on-line	110	40	14

Source: Jupiter Media Metrix

Data in table 1[55] document the strikingly fast concentration process which is taking place in the United States. As access to the Internet grows steadily, more than doubling in two years, the leading firms (Yahoo, MSN, AOL, Lycos etc.) managed to capture an increasing share of the market, so that in 2001 half of the time spent on the Internet by US households is dedicated to information services provided by 4 firms alone.

Starting from a situation characterized by a moltitude of small, innovative and rapidly growing firms in Internet markets, this concentration process is due, as JMM points out, to: a) mergers and/or acquisitions between already large firms (AOL-Time Warner is the typical example); b) entrance in the Internet markets of "traditional" large firms, which have the potential to integrate their existing resources with the new market, for instance investing considerable amounts of resources in advertising[56], being able to quickly obtain a critical mass of users; c) economies of scale.

[53] Of course, firms can purchase transport and other logistic services from the outside: since firms offering logistical services seem to benefit from economies of scale, an increase in e-commerce will lead to an increase in the degree of monopoly in the market for logistics.

[54] Empirical evidence on the U.S. economy supporting this view is analyzed in Pryor (2001). We shall not examine the growing literature on bundling, the choice of compatibility in introducing new products etc. For instance, Bakos – Brynjolfsson (2000) show that bundling can create economies of aggregation for information goods, even in the absence of economies of scale and network externalities, leading to winner-take-all markets. Economides – Flyer (1997) examine the choice of incumbent firms entering a market which exhibits network effects: their results also support the likelyhood of non-competitive equilibria.

[55] Data in table 1 and 2 have been kindly provided by Jupiter Media Metrix (JMM), Italy. The data had been presented by JMM in July, 2001. JMM estimates come from a panel of households, who are metered through a specific software which is able to report the amount of time spent on each site. Data for firms are organized according to property, so that access to sites belonging to the same property are properly cumulated.

[56] Noe – Parker (2000) develop a model of competition on the Internet which seems compatible with this hypothesis, eg large amount of advertising, aggressive strategies.

Table 2. Europe. Internet use and "portals" market concentration					
May 2001, European households panel	Unique visitors (000)	Digital Media Reach (%)	Total Usage Minutes (000,000)	Avg minutes spent per usage	
				Day	Month
Total digital media	55.316	100,0	27.875	47,3	503,9
AOL Time Warner Network	20.394	36,9	4.383	26,4	214,9
Microsoft sites	33.367	60,3	2.171	13,6	65,1
Yahoo sites	22.662	41,0	996	9,8	44,0
Lycos sites	20.348	36,8	718	9,0	35,3
Napster digital	6.399	11,6	666	21,9	104,1
T-online sites	12.081	21,8	645	7,8	53,4
Ebay sites	3.846	7,0	406	24,8	105,5
Wanadoo sites	12.549	22,7	319	5,2	25,4
Web.de sites	4.187	7,6	282	10,1	67,3
United-Internet sites	6.789	12,3	242	8,8	35,6
Tiscali sites	11.122	20,1	209	4,9	18,8
Infostrada sites	5.199	9,4	203	7,2	39,0
Terra networks	5.821	10,5	183	6,5	31,4
Seat pagine gialle sites	5.501	9,9	141	4,7	25,7
Google sites	7.731	14,0	129	4,5	16,7
Source: Jupiter Media Metrix					

The same concentration process is on its way in Europe, as documented in table 2, where firms are classified according to the total time usage of their respective sites. The first 10 firms manage to capture 39% of overall time spent on-line by Europeans.

Other empirical contributions[57] have investigated users access to Internet sites: examining access to 120,000 sites, this study also reports that "a small number of sites command the traffic of a large segment of the Web population, a signature of winner-take-all markets"[58].

What implications can be drawn from these preliminary evidence on an increasing likelyhood of markets being characterized by increasing returns, as transmission of information and knowledge grows in importance, and markets are more and more permeated by network effects?

We suggest that:

- The presence of increasing returns may cause geographical agglomeration effects from the Internet to prevail over forces pointing to the dispersion of economic activities[59]. Agglomeration is also driven by the benefits in concentrating human capital for R&D activities[60]. Several contributions in the "new growth theory" literature point to the possibility of increasing returns from human capital, learning-by-learning, etc. These aspects may cumulate with other sources of economies of scale and network effects. The diffusion of ICTs may thus be accompanied by

[57] Adamic – Huberman (1999).
[58] Ibid. p. 3.
[59] See Leamer – Storper (2001) who stress the importance of "handshakes" (proximity) for important features in the transmission of knowledge.
[60] See for instance Beaudry – Green (2001) for a model linking technology adoption and human capital.

diverging growth paths between regions which host successful, maybe first movers, firms, and regions who lag behind. According to the "evolutionary approach"[61], a region introducing innovations will increase its growth pace, diverging from other economies, which can close the gap by imitation. However, if imitation is being limited by the market power of the leading firm, catching-up will become a slow process, which may not be granted by market forces alone;

-In developing economies where firms are not able yet to penetrate world markets the Internet may initially prove to be beneficial, since the implied reduction in transaction costs may be sufficient to remove the existing organizational obstacles to international trade[62]. However, as transaction costs for consumers in these countries are reduced, and maybe trade barriers to imports removed, local firms may suffer from their inability to compete in a world market dominated by large-scale competitors;

- As the number of markets characterized by increasing returns grows, theoretical models grounded on the assumption of perfect competition may yield misleading results.

However, although e-commerce is exhibiting exponential growth, even after the "shakeout" of firms which started in 2000, it still accounts for a very small fraction of overall transactions: most of the effects of the "Internet revolution" may yet to be seen.

7. Conclusions

This paper has offered an overview on recent developments in the literature on economic growth and innovation stemming from the diffusion of Information and Communication Technologies. Even though most contributions in the literature point to ICT as a source of supply-side shock which may rise output growth, and productivity growth in the framework of a neoclassical steady-state model, the available data both for the US and for international comparisons are also compatible with a different story: GDP growth in the US in the 1990s has been sustained by a strong increase in domestic demand stemming from investment and household consumption, which has been financed by increasing indebtedness, and could therefore not be sustainable. ICT diffusion may have played a role in keeping inflation low, along with a moderate increase in wages.

This result does not imply that ICT adoption is without consequences on efficiency and costs. On the contrary, we have reported how major benefits from ICTs should be expected in all those sectors which rely heavily on information, but these (health care, government etc.) usually fall into product categories where accurate measurement of output has always proved to be difficult or impossible. Most of the perceived benefits from ICT will thus not show up in statistics, also since ICT is apparently linked to an increase in products' quality and variety, both of wich are inherently difficult to report in national accounts.

[61] Verspagen (2001).
[62] See Freund – Weinhold (2000).

We have also suggested a logical distinction between the effects of computers on individual efficiency, and the possible results stemming from an increase in markets operating in a network environment.

While some economists believe that the increase in the information set available to firms and consumers, due to the diffusion of the Internet, should result in increasing competitiveness, lower prices and price variability, and therefore greater benefits to consumers, the evidence available so far, in our view, points to a completely different outcome: the presence of economies of scale and network effects, which are apparent in most emerging markets for information, may lead to a *decrease* in the degree of competition on a global scale.

This hypothesis, if correct, implies faster growth for those regions who manage to become dominant in the new markets for information and knowledge, and thereby increasing divergence across countries and regions, in the absence of external intervention, as the share of the *Networked Economy* grows.

Empirical evidence on the economic effects of the Internet is, however, still scarce to provide robust evidence to support our views. As time-series information cumulates on capital stocks in ICTs, growth, and the effects of government intervention for diffusion of new technologies, future lines of research will be able to test appropriately the hypothesis outlined in this paper.

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