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INFORMATION AND COMMUNICATION TECHNOLOGY. THE CASE OF ITALY.

bakalářská práce

Autor: Elisabeth Ben Thabetova

Vedoucí práce: Ing. Tomáš Frömmel

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I declare that I have written this thesis on my own, with the help of the cited literature.

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Elisabeth Ben Thabetova

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Abstract

The aim of this research is to point out the main features of Information and Communication Technology, its spread in Italy at the beginning of the current century and the effect and performance ICT investments have within the economy. The theoretical part focuses on the reasons behind the importance of ICT studies and the roots of field researches. The practical part underlines Italy's late in comparison to rest of the European countries and formulates a hypothesis based on the researches made in 2002 by Bresnahan, Brynjolfsson and Hitt around organizational changes within firms. The results of the research suggest that there is a significant interaction between investments in ICT and organizational changes and that these variables are complementary. Output is positively affected by implementation of ICT together with organizational changes; however, when occurring alone, ICT investments and organizational changes have low and negative impact on output. This result is significant to solve the problems of the low performance of ICT in the country, as it suggests firms would profit the most from a modern technological reorganization of management structures and business processes and, therefore, implementation in such direction should be made.

Keywords: ICT, Productivity, Italy

JEL Classification: C51, D24, L23

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Introduction

The first studies on the contribution of Information and Communication Technology (ICT) on economic growth were conducted at macro levels in the late '80s and early 90s and essentially showed little or sometimes non-existent contribution to factors affecting economic growth. Subsequently, however, studies on the topic showed how this trend began to reverse; at the same time, however, the demand for IT products fell. This paradox, known as the Paradox of Productivity, led on one hand to a debate on the real effect of ICT in the economy and, on the other, stimulated economists and researchers to new analyses and research methods and to the adoption of even more extensive databases to figure out ICT trends and effects. However, some years have passed before economists became aware of this particular situation and the Paradox of Productivity started to be highlighted in statistics database. The approach used in most of the studies on the impact of ICT on growth, is based on the neoclassical theoretical approach of a production function. The empirical approach on ICT effects on economy distinguishes between three different levels of research: the country-level, the sectoral level and the enterprise level.

The hypothesis of the presence of a new economy, which growth is supported by innovations in the ICT sector, is connected to three circumstances:

- ICT progress,
- Accumulation of ICT capital,
- Growth of labour productivity.

There is a widespread belief, supported by international empirical evidences, that one of the causes of the slower growth of productivity in Europe - and in Italy in particular – in comparison to the United States, is the poor dissemination of the Information and Communication Technology (ICT). Not surprisingly, the American boom coincided with the extraordinary development of the Internet, started in 1995, and with the investments in computers by American companies. The fact Italy is not an ICT-producing country is a historical fact, probably irreversible. More surprising and mysterious is the fact Italian

companies are slow new technologies adopters: new technologies are now standardized worldwide and easily available on the market, but Italy seems not to follow this worldwide trend. The research examines the level of Italian productivity and level of ICT investment in the country, the reason which influences Italian disadvantage in ICT adoption at the beginning of the century and its potential long term consequences for the economy. The thesis is organized as follows: the first chapter will give a short theoretical background on the concept of productivity, the second chapter will analyse three different approaches to measure ICT linked to economic growth, mostly through an empirical perspective.

The third chapter will analyse the diffusion of ICT in Italy from an empirical point of view and through the comparison of the data with other European economies, answering the hypothesis question of what is influencing Italian economy from the perspective of ICT investments of firms in different industrial sectors, size, and locations. Finally, the last chapter offers statistical empirical analysis on the Italian manufacturing sector, through a wide database of Italian firms conducted between 1997 and 2003, and attention will be focused on the interaction between ICT and organizational changes.

1. ICT and Productivity

1.1 Growth and productivity in economic history

The theme of technological progress linked to the growth has always attracted the interest of economists. Already Smith (1776), considered the founder of modern economic theory, wrote about it. According Smith, after the division of the labour, workers perform better due to the fact their ability evolves, the time saved between transitioning from a work to another and the invention of machines, which enables one worker to do the work of many, facilitating and fastening it.

Already in 1789, the Scottish economist realized more than ever the importance of current issues such as labour productivity, education investment, research and development implementations, and the development of Information and Communication Technology (ICT).

The most important classical economists, starting with Smith, continuing with Mill (1848) and Ricardo (1817), reflected the importance of concepts such as technical progress and labour productivity. Also important was the contribution by Josef Alois Schumpeter (1911), who emphasized the importance of human capital affecting growth through the creation of innovations.

According to his view, there is a process of "creative destruction" which affects economic growth as a result of a random sequence of innovations that, once introduced into the marketplace, make obsolete the old technologies and products.

Harrod (1939), Domar (1946) and Kaldor (1965), keeping a Keynesian background, were the first who created an economic growth model. However, Robert Solow (1956) was the first economist who proved economic growth system is affected by savings, which define capital accumulation, population growth linked to workforce and technological progress. Technological progress, however, is considered as exogenous and therefore this aspect alters the way economic growth is determined. Endogeneity problem was taken into account and examined until three approaches, taking technological progress as an endogenous parameter, were established.

Lucas (1988) allocated importance to the role of human capital, Arrow (1962) focused on the impact of education in relation to human capital and the last approach solves the exogeneity issue by assuming technological endogeneity as result of research and development specifically implemented (Romer, Grossman and Helpman, Aghion and Howitt, 1986).

1.2 The Paradox

ICT linked to economic growth was studied at macro levels between 80s and 90s and did not contribute much to the studies around this specific topic. However, not much time has passed until some interesting studies were presented. Meanwhile researches on the topic were progressing, however, the United States experimented what is known as the Paradox of Productivity.

The Paradox of Productivity, caused a debate on the real impact of ICT on economy and stimulated economists and researchers to new analysis and more refined and extended research methods and databases.

"We see computer age everywhere but in the productivity statistics."[1]
Solow, R.M. (1987), "We'd Better Watch Out", New York Times, July 12, Book Review, n° 36

Oliner and Sichel (1994, 2000), elaborated data on US economy between 1970 and 1992 estimating ICT contributed in a ranged between 0.16% and 0.28% to GDP growth.

[1] Solow intended to highlight the weak impact of ICT on economic growth in the decades seventies, eighties and nineties.

The Productivity Paradox explained.

Resume: THE PRODUCTIVITY PARADOX OF INFORMATION TECHNOLOGY by Erik Brynjolfsson

Although productivity is the best macroeconomic tool to analyse the contribution of IT to the economy, investments in the field are difficult because of the few efficient qualitative measures to base firm's investment decisions on.

In the early 1970s US economy faced an important productivity slowdown while the use of IT increased significantly. Productivity in non-manufacturing sector seems to be stagnating in relation to the manufacturing sector (see Graph A). This lead to conclusions stating the negative correlation between these two measures has not have any impact on the country's productivity or even IT investment were the direct reason of the decrease in productivity. The following, are the author's examinations and respective comments:

Economywide productivity and the Information Worker

The research by Roach (1989) sustained statistically a slowdown of productivity per output per information worker (also called "white-collar") and an increase in the productivity per output of production worker (also called "blue-collar"). The gap in the between of 1970s and 1980s showed a growth of productivity per blue-collar worker increase by 16.9% while the white-collar productivity grew by only 6.6%. This phenomena was a cause of debate, because the informational workers' sectors experienced a strong injection of IT investment in the same period. Through the examination Brynjolfsson suggests that to be able to measure the returns from IT using the traditional calculation adopted for the calculation of other goods, significant changes have to be made in the capital stock. Weak contribution of IT to productivity is demonstrated by the estimation of coefficients of a regression function.

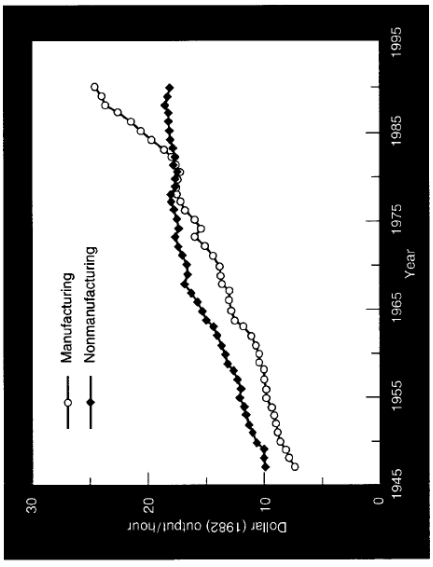
The Productivity of IT Capital in Manufacturing

Several results were driven out, from different authors[2] using different dataset. Almost all of them faced limitation due to the reliability of the dataset and the statistical significance of the results. Brynjolfsson and Hitt conducted a research using larger and more accurate dataset (greater statistical significance) to estimate factors more accurately, leading to result showing that returns on investment on IT capital were more than 50% per year. Brynjolfsson itself states that, since the estimation on other non-IT production factors is significant in all the previous studies, IT estimation has most likely something "*special*"[3] in itself.

The Productivity of IT Capital in Services

After 1970s productivity slowdown has been mostly a matter of the service sector, result which is significantly different from the trends of previous years, were the manufacturing and service sectors were comparable. Although experiencing an increase in employment, the share of output from IT dropped. Since service sector uses more than 80% of the totality of IT in an economy, this led to the thought of low IT productivity. Strassman (1990) research showed how productivity of IT in different firms could be either very high or very low, demonstrating the fact a good implementation of IT is needed when injected in the firm's economy. The adaptation of measurement to the service sector is more difficult than for manufacturing sector and classifications may be unreliable. An effective way to measure for IT is that to connect it with other variables as well, as reengineering work, when introducing IT changes[4].

Graph A.:Productivity in Manufacturing and service secotr compared



Source: Commerce Department Census of Shipments, Inventories and Orders using BEA deflator (Data for 1991 are estimates.)

[2] Loveman (1988), Weill (1990), Brynjolfsson and Hitt (1993).

[3] E. Brynjolfsson adopts the word "special" itself.

[4] Hammer (1990)

However, when in 2002 they adopted a wider dataset, their findings showed that US productivity growth had increased significantly since the second half of the 90s, phenomena that appeared to closely related to the development of Information and Communication Technology. Although, demand for IT products decreased significantly in the same period. This paradox, led to an even deeper debate on the real impact of ICT on economic growth, which stimulated economists and researchers to implement analysis, more refined research methods and even wider databases.

The Paradox of Productivity is seen as an economic theory shock, in a period, which experienced a rapid growth of Information and Communication Technologies; therefore, very soon, the paradox was analysed from a theoretical point of view. Steinmueller (1999) attributed to ICT three important effects on the economy:

- Induction of productivity gains;
- Induction of formation and growth of new sectors;
- Induction of adoption of new original organizational models

The phenomena was questioned and possible explanations evaluated. The most accredited assumptions created to answer it can be subcategorized into five different strands:

1. *Absence of the paradox* – There is no acknowledgment of the fact that productivity growth may result from computer-related benefits and therefore ICT may not increase productivity. Consequently, it is allowed to state there is no paradox with respect to productivity (Jorgenson e Stiroh, 1999).

2. *Occurrence of measurement errors* – ICT benefits are usually derived from improvements in the quality of a product, time savings or customer service, aspects which usually are not included in statistical analysis regarding productivity. However, theory does not hold because, if measurements errors would have occurred in the past years, calculations would always have led to wrong results, which did not happen. (Danison, 1989)

3. *Presence of management level errors* – Effective company management appears to be complementary to a successful ICT implementation. Organizational changes, could indeed affect the new capabilities related to the adoption of ICT, thus making the event too wasteful or leading to unproductive investments in

this direction. This hypothesis could also explain the different dynamics of success when ICT implementation and changes related to it, occur. (Porter and Millar, 1985)

4. *Low technological capital share* – ICT still represents a small fraction, although growing, of the existing stock of capital (equivalent to 3-4% in the case of the U.S.). Consequently, even in the case in which the shares of this type of capital are particularly high, the share of gross income associated with the computer is still small. This would lead to the conclusion that, despite the large capital investments in IT, computers have had little impact on growth. (Schreyer, 2000)

5. *Modality of diffusion process of technology* – Time is necessary so that the benefits of ICT on productivity can bring first results. The hypothesis (supported among others by P. David, 1999 and Qing and Plant, 2001) suggests a similarity between the IT revolution and the technological and economic revolution triggered by the advent of the dynamo. The decline in productivity associated to the early adoption of a new technology are, in this case, linked to the fact that the economic system needs time to adapt to new production proposal, or requires a learning phase and adaptation during which is learnt how to fully utilize new technologies.

The Paradox of Productivity is not only a great challenge to find answers to in economic history, but also a great source of researches connected to the phenomena, because different application and approaches to calculate the efficiency and the performance of ICT in the economy were adopted, to an extent as has never been done before.

2.1 ICT on growth - Measurement Approaches

The approach used in most studies concerning the effect of ICT on growth, is based on the neoclassical theoretical framework, therefore on a production function that sets the output level (Y) and the factors of production (inputs). Analysing the empirical literature concerning ICT effects on growth, following the approach of most researchers, three research levels are distinguished: the macroeconomic level (country level), the sectoral level (industrial level) and the enterprise level (firm level).

2.1.1 Country level

First significant studies, which provide empirical answer to the Paradox of Productivity, are those of Jorgenson and Stiroh (2000) and Oliner and Sichel (2000), on the United States.

According to these authors, the hypothesis of the presence of a new economy - growth related to innovations in the ICT field, lies in the connection between three circumstances:

- ICT progress
- Accumulation of ICT capital
- Growth of labour productivity

In particular, for example, in Oliner and Sichel (2002), the analysis model is based on neoclassical assumptions derived from Solow, such as the assumption of perfect competition, constant returns to scale, perfect mobility of factors of production, profit maximizing choices. Then, growth rates of each variable (working hours, stock of ICT capital: computer hardware, software, communication equipment and other tangible capital, quality of works and Multi Factor Productivity[5]) are considered. MFP (Multi Factor Productivity) can be decomposed in the contribution to the MFP of each sector.

[5] "Multifactor productivity (MFP) reflects the overall efficiency with which labour and capital inputs are used together in the production process. Changes in MFP reflect the effects of changes in management practices, brand names, organizational change, general knowledge, network effects, spillovers from production factors, adjustment costs, economies of scale, the effects of imperfect competition and measurement errors. Growth in MFP is measured as a residual, i.e. that part of GDP growth that cannot be explained by changes in labour and capital inputs. In simple terms therefore, if labour and capital inputs remained unchanged between two periods, any changes in output would reflect changes in MFP"- (OECD Data)

Manufacturing sector, to which is estimated the growth of labour productivity, is divided then into five sub-sectors: hardware, software, communication equipment, semiconductors and non-ICT goods and services.

The analysis suggests the occurrence of an increase in labour productivity between the first and the second half of the 90s (0.89%). The rapid capital deepening is linked to a greater use of IT, which contribution is approximately 3/5 of the increase. Lower is the contribution of other forms of capital, while the contribution of the quality of the work seems to be even negative.

Even Jorgenson (2001), reaches similar conclusions. In its analysis, the Swedish economist highlights the contribution to growth in terms of Average Labour Productivity (ALP). In this case, the contribution of capital deepening linked to ICT on the growth of Average Productivity is of 0.89% over the period 1995-99 while the ICT contribution to the growth of MFP in the same period amounts to 0.50%.

Europe does not seem to be influenced by the positive impact of the new economy and the performance is worse than the one recorded by the American economy. The different European economic situation may depend on both the importance of the presence of a massive ICT manufacturing sector in the US, which is characterized also by a different economic and productive environment, for example in terms of structure of labour and financial markets and of industrial relations, which differ consistently from those in the EU.

Investment in ICT in European area are lower compared to American values, but within the framework of adoption there are no substantial differences between the various European states. Most recent data still suggest an increase in investment in new technologies in the European area, especially increase occurred after 2000, and despite the Europe-US gap in level of investment is not fully filled, the catching up of European countries seems to be faster than it was in the past.

Based on their commitment over the years in increasing investment in ICT we can divide the European countries under the categories of "*slow adopters*" and "*rapid adopters*".

Countries like Italy, Ireland, Spain, Greece and Portugal, which spend around 6% and invest around 2% on average of their GDP in ICT goods, are being considered *slow adopters*. The average of spending and investment in other countries of the European

Union considered to be *rapid adopters*, is around 50% higher (for rapid and slow adopters, 9% and 3.7%), values not distant from the American level.

Table – Contributes to growth of ICT investments by few OECD countries.

		Australia	Canada	Finland	France	Germany	Italy	Japan	United Kingdom	United States
growth of output	80-85	3.39	2.66	2.80	1.48	1.13	1.54	3.31	2.59	3.35
	85-90	3.79	2.90	3.42	3.46	3.59	3.04	5.14	3.90	3.31
	90-95	3.37	1.79	-0.70	0.97	2.22	1.44	1.33	2.12	2.64
	95-99	4.72	4.09	5.62	2.60	1.73	1.93	1.10	3.48	4.43
	95-2000	**4.62**	**4.20**		**2.81**	**2.06**			**3.55**	**4.40**
					contribution (percentage points) from:					
IT and communications equipment	80-85	0.22	0.28	0.14	0.11	0.09	0.11	0.08	0.10	0.36
	85-90	0.35	0.27	0.18	0.15	0.13	0.13	0.16	0.20	0.32
	90-95	0.31	0.21	0.00	0.11	0.16	0.10	0.14	0.13	0.29
	95-99	0.57	0.36	0.11	0.19	0.14	0.12	0.29	0.25	0.61
	95-2000	**0.56**	**0.38**		**0.19**	**0.15**			**0.25**	**0.62**
software	80-85	0.05	0.04	0.04	0.03	0.01	0.02	0.00	0.01	0.07
	85-90	0.16	0.09	0.08	0.05	0.03	0.06	0.02	0.03	0.11
	90-95	0.16	0.08	0.01	0.02	0.06	0.01	0.00	0.02	0.14
	95-99	0.21	0.11	0.09	0.08	0.07	0.04	0.00	0.03	0.25
	95-2000	**0.23**	**0.12**		**0.08**	**0.07**			**0.02**	**0.25**
total ICT	80-85	0.27	0.32	0.18	0.14	0.10	0.13	0.09	0.12	0.44
	85-90	0.51	0.36	0.25	0.21	0.16	0.20	0.18	0.23	0.43
	90-95	0.47	0.28	0.01	0.13	0.22	0.10	0.14	0.15	0.43
	95-99	0.78	0.47	0.20	0.26	0.21	0.16	0.29	0.28	0.86
	95-2000	**0.79**	**0.51**		**0.27**	**0.22**			**0.27**	**0.87**
total capital services	80-85	1.63	1.14	0.68	0.69	0.58	0.72	1.01	0.70	1.25
	85-90	1.97	1.15	0.83	0.91	0.80	0.86	1.38	1.10	1.10
	90-95	1.35	0.63	0.03	0.73	0.99	0.62	1.33	0.74	0.97
	95-99	1.74	0.92	0.15	0.75	0.81	0.82	0.97	1.05	1.69
	95-2000		**0.97**		**0.78**	**0.83**			**1.04**	**1.71**

Source: OECD

A measure of this impact is different for example in the contributions from Colecchia and Schreyer (2001) and Van Ark et al. (2002a, 2003) and especially Schreyer et al. (2003). The first two have shown that the ICT sector has attracted significant investments, especially due to the progressive decline in prices of IT, which, at the same time encourage investments in other capital-intensive industries.

According to Pilat (2004), the most important factor that explains the different rates of growth of the US and Europe, is related to the different use of the work (labour utilization[6]). In the first half of the 90s many OECD countries have been characterized by a large growth in labour productivity and a decline in labour utilization, while countries

[6] Usually measured as changes in hours worked per capita. (OECD Data)

like the United States, Australia, New Zealand, have maintained a stable mix of productivity growth and labour utilization. In the second half of the 90s however, many European countries experienced an increase in the number of workers (thanks to fruitful policies on unemployment), but this process was accompanied to a reduction in productivity. Other OECD countries saw instead in the same period an increase of both factors, proving that there is not necessarily a trade-off between employment and productivity.

2.1.2 Industrial level

Authors, such as Stiroh (2002a, 2002b, 2004), repeated the US economy attempt with more recent data (ranging in particular from 1987 to 2000), showing a significant return from IT capital investments and a faster productivity growth in sectors with high capital intensity. This, as other studies at industrial level have focused on the approach of Total Factor Productivity (TFP), in which IT coefficients tend to be not significant. For example Basu et al. (2003) showed a negative correlation between ICT capital and TFP on a study of the United States between 1977 and 2000. They assume also workers are correlated to the future organizational level of the industry as they construct it. Their observations showed a TFP growth deceleration during the acceleration periods of investment in IT capital, which would explain the reason for the slowdown in TFP growth in Europe when member states are in the initial stage of IT investment. However, following the same method for the same period, but referring to the United Kingdom, the same authors, found the exactly opposite result.

Most studies[7] have generally shown that a large part of the economy is using ICT capital in manufacturing. The production of electronic goods has certainly played an important role in the development process of many newly industrialized countries, including the countries of Southeast Asia: Hong Kong, Singapore, South Korea, Taiwan, Indonesia, Malaysia, Thailand.

The ICT production may in fact increase the overall growth of an economy in two ways. Firstly because the demand for ICT goods is growing faster than the demand for other

[7] Basu et al. (2003)

sectors and the expansion of production may be faster than usual average, especially through the exports-oriented production. In this case, ICT is a push to the growth through its direct contribution to GDP and to the creation of jobs, but also through indirect contributions such as the stimulus to the development of upstream and downstream services.

Secondly, since the production of high-tech goods requires highly advanced manufacturing processes, these productions are associated with a high labour productivity. Thus, the expansion of the ICT sector can positively influence the growth of labour productivity of an economy as a whole.

2.1.3 Firm level

The third source of ICT impact analysis concerns firm-level studies; To date, unfortunately, the data for this type of analysis are not even available for all OECD countries and many authors[8] have used data from private sources or obtained independently.

The first attempts to estimate were made by Brynjolfsson and Hitt (1995, 2002, 2003). The data used mainly referred to hardware stock owned by companies, telephone lines and similar; in 2003, the two authors analysed more than 600 companies.

While this approach provides a more accurate picture of the kind of stock in every specific relevant unit, on the other hand the data are not always representative of the companies creating the risk the analysis can be distorted.

In that period, firm level studies have also benefited from the creation of statistical databases in many countries, enriched in recent years of data on the ICT business use. However, unlike for country and industrial level analysis, firm-level studies are characterized by a wide range of sources and methods, which on one hand are confusing, but on the other hand allow to stronger empirical evidences. Firm level analysis showed ICT use has a positive impact on business performance in the majority of OECD countries.

[8] For example: Brynjolfsson and Hitt (1995, 2002, 2003)

The most important example is considered Australia, a country where the impact of ICT is among the strongest. According to Gretton et al. (2004) ICT produces to this country around 0.2 percentage point of MFP growth every year, most evident in the areas of finance and insurance.

Also Clayton (2005) got similar results for the UK, where he found a significant ROI on ICT investments in services, more than manufacturing sector.

Interesting is also the researches about the effects on the competitiveness of businesses arising from the use of ICT, which can improve efficiency, as it allows to gain market share and reduce production costs, increasing general productivity.

The effect on competitiveness were analysed also at the level of foreign firms. Clayton (2005) for example, emphasized the importance of multinational American companies in the United Kingdom who had higher productivity resulting mainly from the use of computers; in this case, the positive effect was related to an important application of ICT on e-commerce.

Sometimes the economic environment can facilitate the positive impact of ICT. As for Hatiwanger et al. (2003) who examined the relationship between growth and the decision to invest in technology, in a dataset of enterprises in Germany and the United States.

The predictable results lean toward greater effects for American corporations and the authors attributed this result to the different environment in which the two regions were operating: the American environment allows greater experimentation because of modest barriers incoming and outgoing than in many European countries.

Also the company size can be an important factor. Clayton and Waldron (2003) confirmed the intuitive thought, that the adoption of new technologies is proportional to the size of the company. They provided evidence referring to around 2000 British companies. Those with more than 250 employees were more likely to use network technologies such as Internet and to possess a website than smaller companies.

The same study, however, revealed another important detail: among businesses who had a website or were already using Internet before 1995, only 50% practiced e-commerce. The percentage dropped to 20% for companies that had adopted the network technology from 2000 onwards. The authors wanted to demonstrate how well the benefits of certain

Information and Communications Technologies can emerge sometimes only after a certain amount of time.

2.2 How does innovation in ICT stimulate the economic growth of a country? Two different approaches.

Information and communication technology is part of the field of research and development (R&D) in which the innovative process is endogenous and, therefore, different from the Solow approach to the topic. There can be distinguished three fundamental theories:

-Lucas (1988) and the human capital,

-Arrow (1962) and the learning by doing,

-Romer (1990), Grossman and Helpman (1994), Anghion and Howitt (1998) where research and development innovating process is analysed.

The research wants to analyse two different approaches to the topic.

2.2.1 The contribution of Grossman and Helpman

Grossman and Helpman constructed a qualitative competition model based on innovation and imitation process. Innovation is closely linked to the creation of new processes and new products while imitation is the mechanism by which recently spread knowledge is examined and copied, to obtain different formulations of an innovation. These two forms of learning constitute what can be identified with the term "technological progress." The approach proposed by these two economists, unlike that of Romer[9], stresses importance on the variety of final goods and not on the availability of capital goods. Each product is placed in a specific step of the quality scale and the life cycle of the product stimulates

[9] Romer, 1986, creates the model based on the process of the learning by doing. The models refers to two types of externalities for the market, in the process of creating innovations. One type is related to the complementarity of the new innovations, the other on the positive externalities of an innovation that was not successful.

innovation by promoting technical progress and stimulating growth as well. The product cycles in producing technological improvements in terms of final goods is extremely important and it is necessary to define how these final good are developed. To this specific purpose, Grossman and Helpman believe that the interaction between innovation and imitation assumes importance when some kind of relation occur between an industrialized country (developed country) and a middle-income country (developing country). Information coming from developed economies to developing countries, are of incentive to carry out a research activity and the possibility for the successful entrepreneurs to acquire a temporary market power in relation to the production of the new innovative goods. This advantage, resulting from the greater quality of its products than those available on the market, remains until imitation occurs. Entrepreneurs of the less industrialized countries, in fact, are seeking to import product designs and manufacturing techniques developed elsewhere in hopes of getting annuities arising also from lower labour costs. Such imitations guarantee good earnings through the acquisition of increasingly large market shares, until those products become obsolete following the introduction on the market of new assets, which are the result of researches carried out in the most advanced economies and stimulate new product cycles. It can be concluded that the contribution made by Grossman and Helpman aims to formalize a model of product cycles in which competition, resulting from the mechanisms of innovation and imitation, generates an endogenous impetus to the search for new products and new processes and consistently stimulates the growth of an economy. The idea of the differences in the equilibrium balance in the long term between different economic systems, widely developed in the endogenous growth models, is basically proposed as well in the approaches considered here. It is quite natural to think that countries generating more innovations have greater advantage and have more opportunities for growth than those for which the only source of technological improvements is the imitation.

2.2.2 The contribution of Aghion and Howitt

The theoretical contribution of Aghion and Howitt puts attention on the process of research and development adopting the Shumpterian idea of creative destruction. According to Shumpter, growth comes exclusively from the technological progress based on competition between the research companies. Each innovation consists of a new

technology capable of allowing the production of a final product more efficiently than before. This means that R&D companies have, through their discoveries, the monopoly rents that are only temporary in the sense that it vanishes when new technologies overcome the previous ones. The creative destruction mechanism that affects innovations is a very strong incentive for research institutions operating in the market: it increases efforts both from financial and intellectual perspective and this is a strong fuel, which recharges the growth process of an economy. There is one more theory, known as the evolutionary theory of innovation, which is significant in a similar way. The approach abandons the perfect competition assumption and it is interesting because it can perfectly fit the real world. Growth is always generated by some inventions, but it is seen mostly as a competition between existing companies on the market and decisions rules are derived from experience, rather than from an optimization process.

2.2.3 Different perspectives

Between late fifties and the early sixties fundamental contributions by R. Nelson (1959) and K. Arrow (1962) were published on the economic characteristics of basic research and the scientific knowledge that it produces. The main arguments developed by the two authors represent the foundation of the economy of science. Both authors emphasize the following aspects:

a) **The uncertain economic value:** basic research has economic value for a business if it can be used to make more productive applied research, which aims to find solutions to practical problems and to realise goods, which can be sold on the market. However, since the basic research explores the frontiers of knowledge, the results are highly uncertain. There is also a long delay to be considered between the start of a basic research project and the creation of something that has a marketable value, especially because the economic value of basic research is difficult to predict and to judge. This uncertainty and the delay problem causes most companies, concerned primarily with survival in the short term, to assign to basic research projects less value than such projects would have for the society. The question is spontaneous: what is the value for the basic research companies? If the results of basic research results were published and shared with other enterprises the productivity of applied research would increase and, given the resources invested, it

would be possible to increase the output of innovation. This would lead to greater economic development.

b) **The uncertain private returns:** companies have difficulties to draw private profits from basic research, because it produces general and abstract knowledge. It is difficult to keep that knowledge internally or establish clear property rights of an asset that has the nature of a public good (given the non-rivalry in consumption and difficult excludability). The results are that basic research results are actually "given away" to competitors, who can take advantage and can use the new knowledge applied to goods. This means the incentive to commit resources in this type of activity are low. Consequently, businesses are funding basic research with smaller amount of resources than would be socially desirable. The divergence between private and social returns of basic research creates a systematic failure of the market in allocating resources to basic research, which, in the absence of action to find a remedy to the situation, results in under-investment, ie in investments, which are below the level that would be socially optimal. If market forces are inadequate to achieve the socially optimal level of scientific research as a result of this market failure, the state should, as a consequence, take responsibility to fund much of the scientific research. The argument of market failure was the main economic reason of public financing of science in the last fifty years. The case of basic research in the economy has become a classic application of social welfare and a much-quoted example of how academic studies can influence public policy.

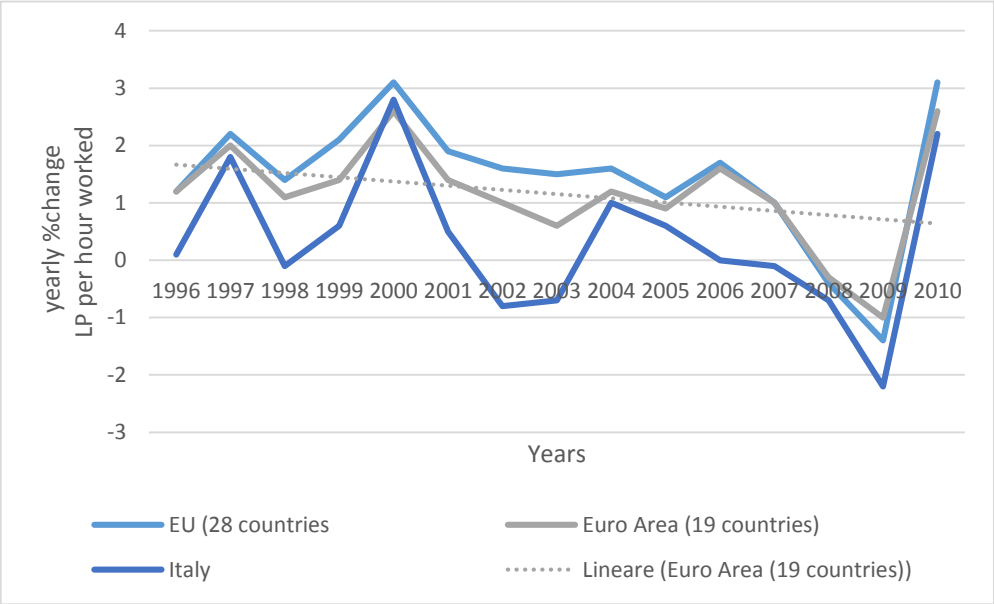
3. ICT and Productivity in Italy

Labour productivity per hour worked is an efficient measure to analyse productivity trends in countries. According to Eurostat, measuring productivity per hour worked is more effective than measuring it in relation to person employed as it deletes the difference between part-time and full-time employees, for a better comparison between countries and years.

3.1.1 Labour productivity – cross-country analysis

Except from a very negative growth of labour productivity per hours worked for all the below examined countries, direct subsequence of the world crisis dated 2008, trends are above or within average set by the Eurozone average (Graph 3.1.1). Italian situation is significantly different from the most significant European economies and the totality of EU and Eurozone countries. The benchmark is the Eurozone countries, which have a yearly percentage growth of labour productivity of 1.15 between 1996 and 2010. In the same time framework, Italy's average is 0.33, which is almost four times less than the economy's average. Italy touches its pick in 2000 (2.8%), year corresponding to highest diffusion of Internet in the country and in Europe and therefore, probably affected by it. It touches the lowest level between 2002 and 2003 (-0.8% and -0.7%).

Graph 3.1.1 - Labour productivity per hour worked



Own elaboration of data. Source: Eurostat. Data deflated per GDP=2010.

3.1.2 What is labour productivity influenced by?

Labour productivity can be influenced by workers' skills and qualification, morale of workers, technological progress, substitution of capital to labour, rules and regulations and capacity utilisation.

What we are interested in for the purpose of this study is:

- **Workers' skills and qualification:** Labour productivity can consistently increase when a specific training among employees of a company occurs
- **Technological progress:** when a technological change occurs within a company, the outcome is always one of the factors mainly affecting labour productivity, as the processes are more efficient and the results effective.

3.1.3 ICT and Productivity – cross-country analysis

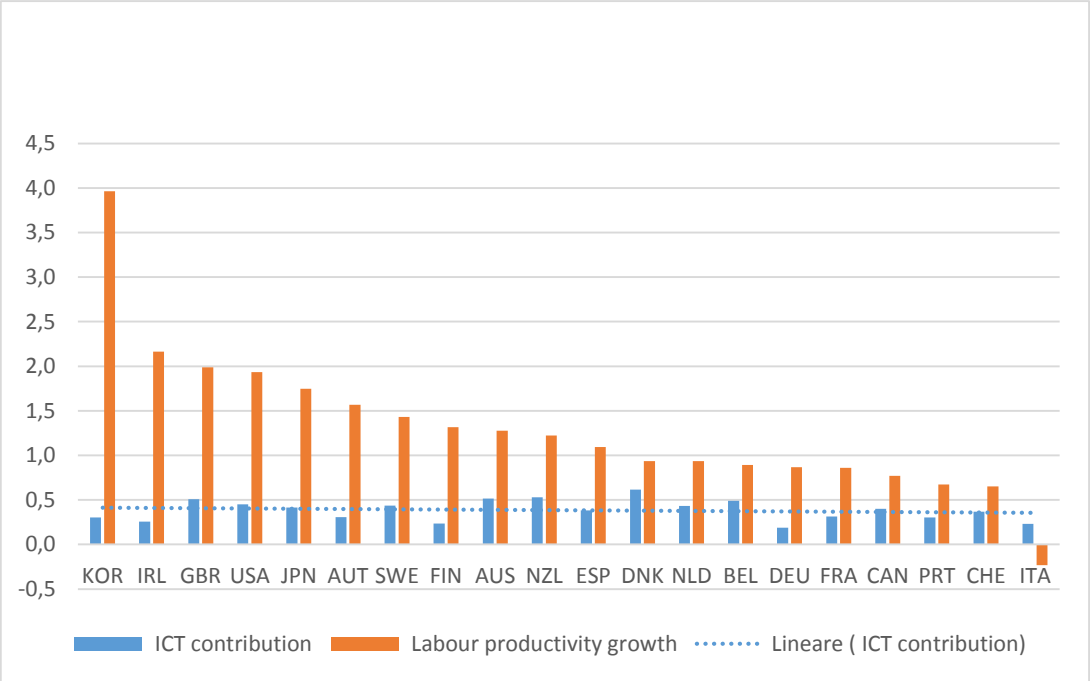
When we compare Total Economy Data between the US and the euro countries, published by the Conference Board, from 1995 to 2008, labour productivity of the US (1.8%) is almost double than labour productivity yearly growth rate of Eurozone countries (0.8%). One of the factor, which lead to the success of US economy in the past 15 years, is the spread of ICT in every sector of economy, from the tertiary sector, from innovation to assurance, and financial, to those traditional ones as tourism, healthcare, business and transports. In the US, new technologies were first applied to the tertiary sector and only then, to the manufacturing sector with the same intensity.

European situation is heterogeneous: we can easily distinguish excellent performance within Scandinavian countries, while the situation of Spain and Italy, since 2000, shows a decreased productivity grow rates. International empirical evidence explains one of the factors, which influences the most the scares growth of labour productivity among European countries, especially in Italy, is the fact ICT is not widespread as in the US. In 1995, the America economic boost happened meanwhile American companies started their investment in Internet, which therefore affects its GDP growth by almost one percentage point yearly.

In Italy ICT investment were focusing on the industrial sector in the initial stage followed only, since 2008, by an increase of the share of the ICT investment in services. It is fundamental to consider the fact that some of the services sectors are characterized by strong regulations that decrease the pressure for competitiveness and therefore the process of innovation faces a significant slowdown.

Examining data from 2000 to 2009 taken from the OECD official dataset, we can see how Italy is the only country where labour productivity growth in relation to ICT investments is negative. The trend shows and average of 0.4 while Italian value is -0.2, which is significantly low in relation to the values of the examined economy (Graph 3.1.3 (a)).

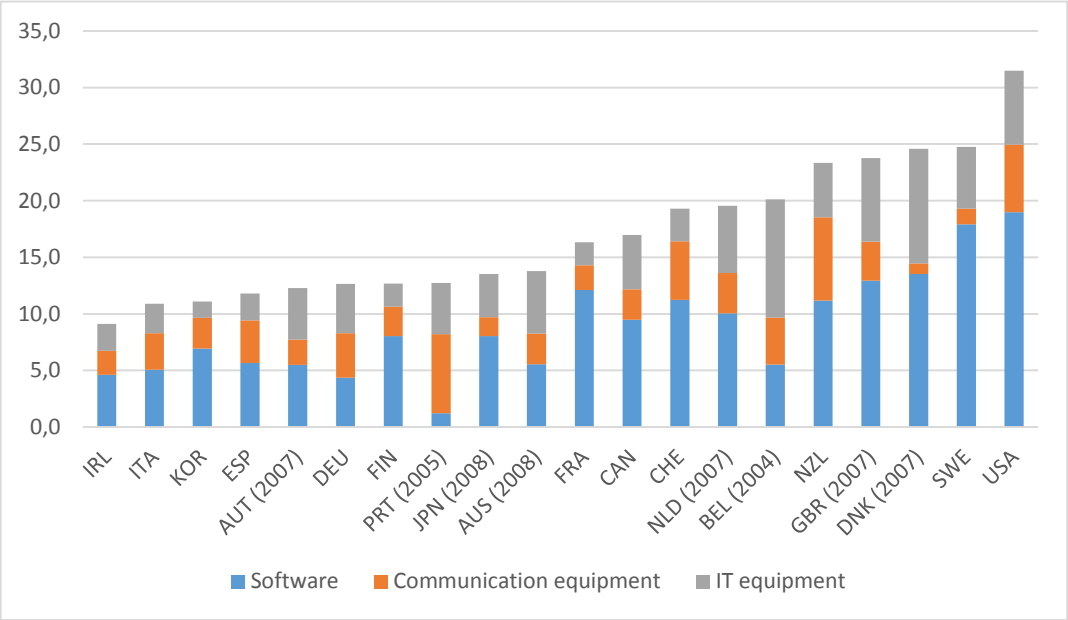
Graph 3.1.3 - Contribution of ICT capital growth to labour productivity growth, 2000-09



Own elaboration of data. Source: OECD, Productivity Database, June 2011.

When comparing the levels of ICT investment among OECD countries calculated over the share of total fixed non-residential investment, where ICT is composed by investment in software, communication equipment and IT equipment, Italy is the second country with the lowest investment in ICT: only 10.9% was invested in information and communication technologies, compared to 31.5% of the top investing country, the United States. The software section is the one where investment injection is the highest. (Graph 3.1.3(b))

Graph 3.1.3 (b) - ICT investment by asset in OECD countries, 2009



Graph 1.3 Source: OECD, Productivity Database, June 2011.

Italy has never been considered a country producer of ICT and that aspect of the Italian economy will probably never change. What is interesting is that Italian companies are not even adopting those new technologies, which are easy to import, since standardized worldwide and easy to find on the market.

3.2 ICT diffusion in Italy

The greatest gap with more advanced countries appears concentrated among small businesses and in the services sector. This disadvantage is substantially influenced by the small size of firms that affects investment decisions and consequently the willingness to spend in new technologies. In fact, 56% of the total spending on IT in 2008 is attributable to the 0.1% of companies with more than 250 employees (2651 companies), while 20% of total spending includes about 4 million businesses with fewer than 50 employees.

Small businesses therefore provide a relatively small contribution to the growth in spending on IT.

In Italy, the size of firms limits the development in the ICT industry, which is dominated by small enterprises (with 79,000 on average less than eight workers, OECD, 2004), and thus it negatively influences the investment on R&D sector, in which ICT is included. It is hardly imaginable that the Italian industry could perform the way as other international markets competitive in the ICT sector. In fact, for a successful implementation of market injection of ICT capital, it should be implemented to the sub-fund, of each company, of every each business function.

According to Schivardi (2000) Italian national production system influenced the diffusion process of ICT for its peculiarities among other European or OECD countries.

In particular, what is most likely to influence the spread of ICT in Italy are structure and size of firms, sector specialization and territorial imbalances.

3.2.1 Size of firms

Italian economy is characterized by a prevalence of small and medium companies within the territory as well as of the presence of small medium-sized enterprises that in most of the cases implement a lattice structures[10].

The structural dimension of these firms is affecting significantly the way technological progress is absorbed and implemented; new technologies adoption process is decelerated in particular when cost barriers occur. In addition, these companies may have organizational process which are informal and idiosyncratic and this may contrast new technologies adoption. Although, when correctly selected, they may be easy to adopt for, just, the firm size. ICT can break down some entry limits, as it could be lowering the cost in the distribution network sector and it can be well suited for specific network structures. The U.S. economy firms implemented their ICT investments with a process of deverticalisation, which increased their efficiency.

[10] The size of an enterprise is defined, for convenience, by the number of employees. Usually, small-medium enterprises are those with less than 50 employees; large enterprises have over 50 employees.

Italy, therefore, provides an interesting case to test for the interactions between ICT and organization of companies and sectors.

From the survey conducted by Banca d'Italia (Bank of Italy) emerges a strong correlation between the firms' size and the process of adopting ICT. Variables, such as the number of PCs per 100 employees or expenses for buying and maintaining ICT for 100 workers, show clear dimensional imbalances when large enterprises are compared with small enterprises. (Table 3.2.1)

Table 3.2.1 - Degree of spread of certain technologies in Italian industrial enterprises

	Cost of purchase and maintenance of ICT per 100 employees		PC per 100 employees		Enterprises with a computer connected to Internet		Enterprises with a website		Enterprises with an sector dedicated to ICT		Enterprieses adopting ERP[1]	
	Total	District	Total	District	Total	District	Total	District	Total	District	Total	District
Size												
Medium-small (50-99 empl.)	62	50	31.4	31.2	95,9	96.2	79.7	72.8	25.6	20.4	10.5	13.5
Medium (100-199 empl.)	85	95	34.6	30.8	97.3	96.7	83.2	83.8	43.1	40.4	25.3	25.5
Medium-Large (200-1000 empl.)	97	101	39.2	35.2	98.4	98.0	84.6	89.2	55.6	47.1	42.7	37.6
Large (over 1000 empl.)	114	99	49.3	41.3	98.9	100.0	92.6	97.3	85.5	52.2	74.9	77.8
Geographic Area												
North-West	95	87	44.4	35.8	97.3	98.0	83.3	86.5	34.7	27.4	22.5	23.0
North-East	94	97	32.9	33.5	97.3	95.4	86.7	84.9	40.9	34.2	20.5	22.7
Middle	95	72	41.8	28.5	96.3	94.3	77.9	77.7	29.5	31.7	17.0	16.4
South and Islands	57	55	29.3	24.2	94.6	92.2	64.3	79.3	30.5	12.4	12.4	3.8
Sector												
Textile, leather and shoes	62	61	25.1	25.2	94.7	94.9	79.0	81.6	36.3	35.7	15.2	15.1
Gum, plastic, chemestry	113	127	57.4	39.1	96.0	94.3	77.3	70.2	45.3	32.0	23.6	20.0
Metal Industry	104	108	38.6	36.3	97.2	96.4	84.5	87.3	35.8	29.6	22.6	26.7
Other manifacturies	72	60	32.2	30.3	97.8	99.2	81.1	87.0	29.8	26.6	17.1	17.1
Other industries	101	182	63.3	105.9	94.4	100.0	72.8	47.5	37.4	47.5	24.8	52.6
tot	92	88	39.2	33.7	96.7	96.6	81.6	84.2	35.4	30.3	20.1	21.3

Own translation. Source: Banca d'Italia. [1]Enterprise Resource Planning

All firms in the sample are connected to Internet and almost all have a website; in contrary, the frequency on which the website is updated shows that only 10% of the companies does it on daily or weekly basis. These which do, are primarily enterprises

with over 1000 employees. A particular trend is the one related to the diffusion of electronic commerce (mainly B2B). Trends show a significant gap between the equally modest values in the lower three size classes of firms and a sharp jump in correspondence to large enterprises (over 1000 employees). This result may indicate presence of threshold effects in the adoption and use of such systems.

3.2.2 Sector specialization

The impact ICT innovation is having on the productivity of a firm depends also on the sector within which a firm operates.

Made in Italy products, for example, are those with the oldest tradition within Italian firms. They are known worldwide, but the enterprises of this sector do not improve internal specialization and do not promote new technologies, lowering the strong productivity gain that may occur when properly adopting ICT innovations. In a country where the tech-sector, producer of ICT, is underdeveloped, the spillover between large and small companies within the same territory is limited and the innovation complementarity lacks. At the same time, those traditionally locally established companies usually face coordination and organizational problems, which could be solved by major internal reconstructions. From the sectoral perspective, those industries, which are considered traditional, as textile, clothing and leather, should adopt technologies such as ERP[11] and MRP[12], as the percentage of enterprises using them is the lowest through sectors (15.2%). Also, metal industry has low percentage of ERP technology adoption, while chemical, gum and plastic sector are more responsive to technology innovations. The workforce structure of companies that belong to various sectors partly explains the differences in technological innovation spread. It can be seen, for example, by the fact industries with a prevalence of white collars have higher values of PC per 100 employees. Higher amount of PC are in those sectors with more than average white-collar employees within the same sector (Table 3.2.1).

[11] "Enterprise resource planning (ERP) is the setting up of electronic information systems. It gathers information about the state and activity of different parts of the body corporate and conveys this information to parts elsewhere that can make fruitful use of it. In particular, ERP systems link together information about finance, human resources, production and distribution". (The Economist,2009)

[12] "Material requirements planning (MRP) is the predecessors of ERP. It covers the period of time from when an item originates, the source materials are identified and acquired, resources are determines, to when development actions are planned"(mrpsofterguide.net,2016)

Overall, the sector specialization has a significant impact on the ICT diffusion in Italy and penetration of ICT in Italian manufacturing system may have been slowed by the characteristics of mature sectors for relatively low capital intensity.

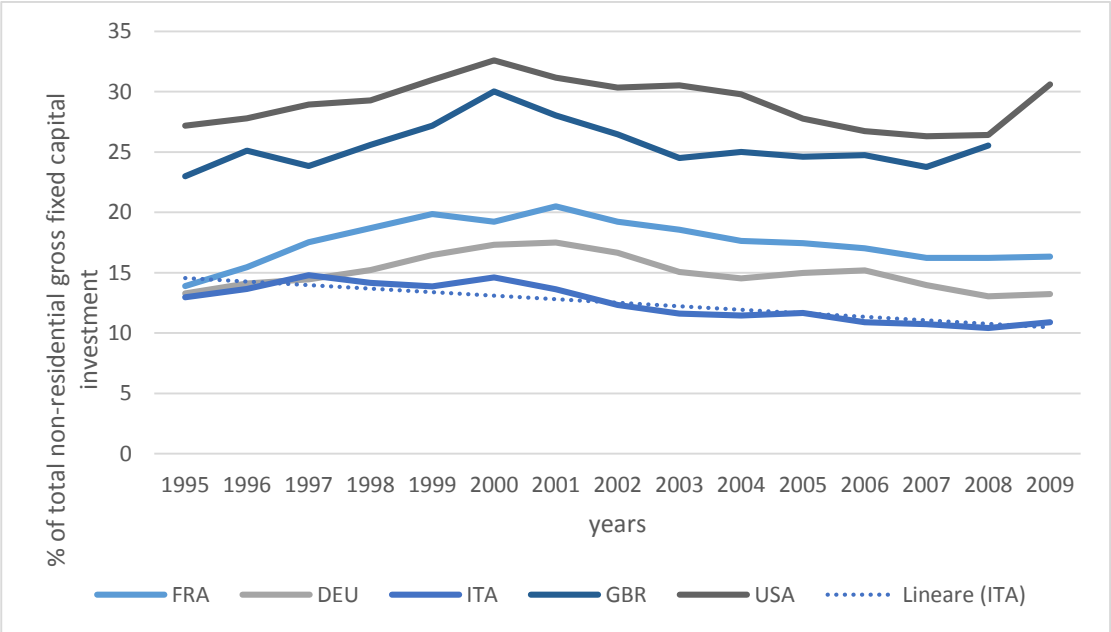
3.2.3 Territorial imbalances

Italian territory can be distinguished in three parts from cultural, traditional, gastronomic and economic point of view: North, Centre and South with Islands. The North, going from the Alps to the Northern Apennines, hosts 46% of Italian population and produces 59.4% of the country's GDP. The Centre, which ends with the region of Latium is usually linked to the South and hosts only 23.6% of the entire population. Italian territory is therefore very imbalanced. Internet access and, especially, its correct use within firms for business, logistic and organizational purposes could solve few of these problems as it may lower transport costs, and make developed markets easier to reach for those periferical markets within the country and thus imbalances could be compensated. These imbalances are clearly displayed also by the scarce availability of ICT assets and skills to eventually adopt ICT innovations in the Centre and South of Italy, which face a delay measured by almost all indicators: PC equipment, Internet, organizational process dedicated to ICT and ICT investments. Companies of the North-West regions are those which implement more new technologies and in a better and more efficient way.

3.3 ICT trends in Italy

ICT investment in Italy, evaluated as a percentage of non-residential gross fixed capital investment, between 1995 and 2009, is 12.51%, a value which is below the average of the entire OECD economy (15.64%), but still competitive. In comparison with the amounts presented by other competitive markets at a world level, Italian average is low – less than a half – than the levels presented in the GBR and USA (25.52% and 29.09% respectively). This suggests there is still a long way to go for Italy to be competitive in a world perspective, also considering the negative trend of Italian ICT investments in this time framework (Graph 3.3 (a))

Graph 3.3 (a) – ICT Investment

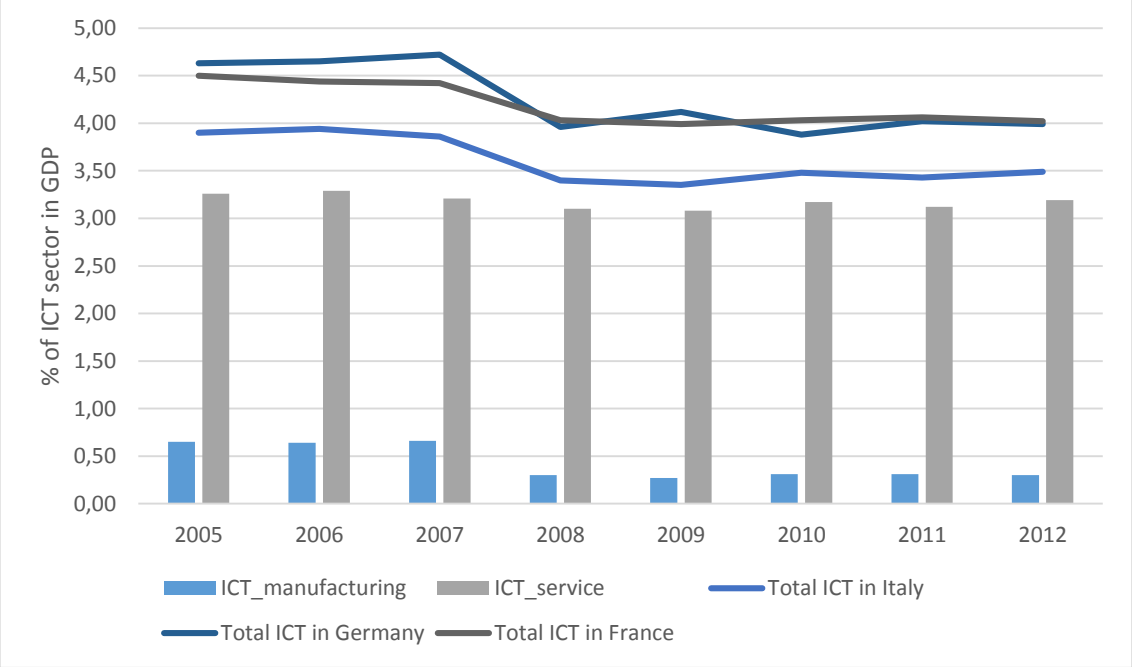


Own elaboration. Source: Eurostat

In 2004, Italy occupies the last place comparing its net exports with European average on IT services, according to Eurostat because of the liabilities in the balance of payments. We can see the values are worsen compared to the previous year (loss of 520million euro in 2004); Countries with steady trends are Ireland and England (increase of 14420 and 4914 million euro respectively, in 2004), followed by Luxembourg, Spain and Sweden.

Also analysing the benchmarks set by Europe and the World comparing ICT investments and the economy's performance, Italy is in strong delay particularly relevant in Information Technology, where the percentage of IT investment to GDP is equal to less than 2%, compared to Europe's average set on 3%, particularly Germany and France with an average of 4.25% and 4.2% respectively. These factors create all together a situation where Italy's late is such that compensating it would require a lot of effort in very different sectors, starting on the gap between manufacturing and services as to be seen in the Graph 3.3 (b).

Graph 3.3 (b) – % of ICT sector in total GDP



Graph: Own elaboration. Source: OECD (2016), ICT investment (indicator).

However, the gap between manufacturing and service sectors is relevant in every economy. The highest results are Finland, at the beginning of the examined time framework (which faced a catastrophic drop in 2012) and Hungary, which have still an average of 2.58% and 1.98%, while the value for Italy is of 0.39%.

3.3.1 ICT within Italian firms

Saturation level is almost reached as for the percentage of firms in Italy, which have at least one PC to use for their business. However, between 2002 and 2008 the percentage employees using PC at least once a week decreased, from 42.17% to 41.88%. A decrease which is significant considering the time framework accounted and the fast progress in IT environment since the beginning of the century, which instead could have forecasted an increase in this variable. Consistent is the gap between the manufacturing sector and

the service sector, accounted to have 7% point more category employees. Considering the size of firms is that with more than 250 employees which faces the most significant slowdown: in 2002, 49.82% of employees uses a personal computer at least once a week, while in 2008 only 45.75%. The reasons behind this behaviour can be various, but the most significant one is the biggest firms were influenced by the world economic crisis faster than smaller firms and therefore faced deeper economic and financial losses earlier.

Employees adopting a computer connected to Internet at least once a week increase by on average 10% points from 2002 to 2008 in every sector of economy as well as the implementation of a personal website within firms. Significant is still the difference between the Northern and the Southern Italy where the gap is relevant in each sector. In 2008, only 46.6% of companies had their own personal website in the south, 63.3% in the north. Internet connection within firms is mostly used for bank and financial services (by 85.9% in 2008) and market competition analysis (by 61.2% in 2008), amounts that are doubled compared to values in 2002.

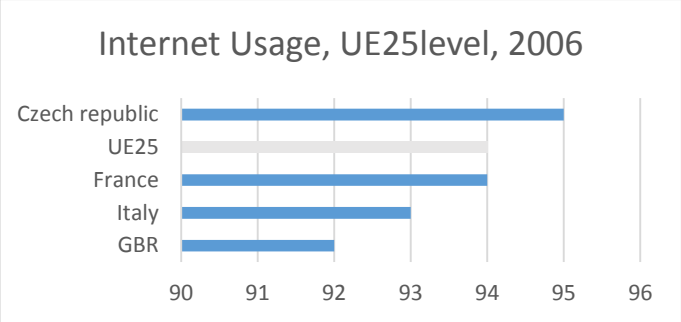
27% of firms in the total economy use ICT implementation on automatized data exchange to receive invoices, while only 12% to set up invoices. The gap is of only 2%points when considering large firms with over 250 employees. Very low are also the results for automatized data exchange related to information on goods and services (firm catalogue), online payments and transportation document.

The reasons behind this aspect might be several, but the most significant ones, according to the data from Eurostat, seem to be the thought implementations in IT within the firm are useless and the trend is similar for nearly 30% of companies. The fact these implementations are considered as useless might be caused by a lack of formation and information available for this specific topic and a strong attachment to the cultural roots. In fact, only around 13% of Large Firms have the same opinion towards it, value which is anyway compensated by the fact more than 50% of these are adopting different strategies which are standardized for communicating with other entities. Generally regular, across the analysis of the sector, size and location, is the perception of either unclear information about the benefits an IT injection in the firm or the bad returns from it. In order to obtain more information or to gain education in this field the most accessible way is through the value taken from IT equipment. But, as we have examined above, employees who use a PC for working purposes at least once a week is still extremely low

as well as E-learning, as a service used by the firms via Internet for employees' formation purpose. Only 16.9% of firms in the total Italian economy is adopting it, 40.66% of these are Large firms (with more than 250 employees).

Using the Internet has now reached saturation levels throughout Europe, with some exceptions. In Italy, the largest number of small businesses (10-49 employees) resulted in a level of Internet use slightly less than the European average (EU25 countries), however, exceed 90 percent of total enterprises with at least 10 employees (Graph 3.3.1)

Graph 3.3.1 – Internet usage, UE25level, 2006



Own elaboration. Source: Eurostat

More differentiated are the data on access to the Internet via broadband technology: despite the efforts made by companies in recent years, Italy lags behind the European average. This is mainly due to the slow adoption of ICT by enterprises with 10-49 employees, and the fact that they account for about 88% of the total population of Italian companies with at least 10 employees.

4. Italian Manufacturing Sector – ICT and output.

4.1 Some insights about the dataset

Even if the trends of ICT investments in Italian economy are increasing, the efficiency of the implementations is still relatively low. Investments in the field occur, while performances are still not exceptional from a quantitative and qualitative point of view. To answer the reason behind this situation, an analysis on a set of Italian firm is used in research purposes. The dataset regarding Italian Manufacturing enterprises was conducted by the group Unicredit-Capitalia in the time framework between 1997-2003. The timeframe analysed is correlated to the period when big changes in the ICT economy occurred.

According to the data of the sample, it can be said that Italian manufacturing system consists of 20% of young enterprises (born after 1990), 53% of "mature" companies (born between 1970 and 1990), and about 25% of "older" companies (born before 1970).

Although the expansion of employment in place since 1996 has definitely been a positive note for the Italian economy, however, labour market is characterized by several critical elements. These include a low level of education of the entire workforce, as well as the low participation of people employed in research and development activities while generally, service companies have a level of education of its employees significantly higher than manufacturing and construction companies. Manufacturing sector shows a share of employees in possession with compulsory education degree only almost two times higher when compared to the shares in the services sector, while the level of university graduates is about three times lower. From 1997 to 2003, the percentage of graduates is growing steadily in specialist sectors and high technology, while the same thing does not happen in the traditional sectors.

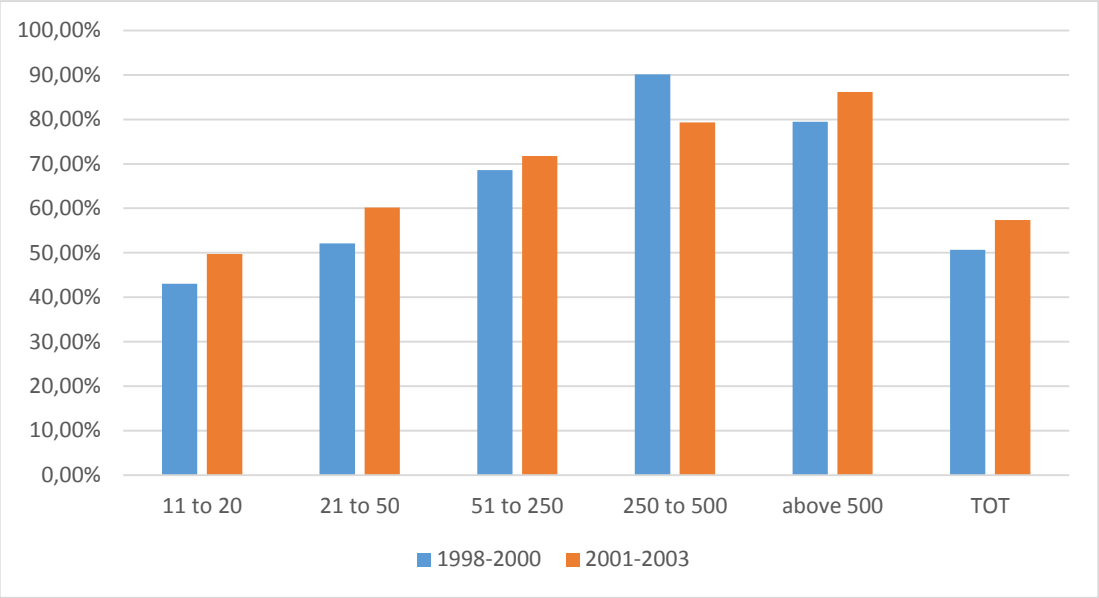
Construction and manufacturing enterprises are more inclined to invest in raw material, machineries and equipment compared to services sector enterprises, while manufacturing

firms invest less in Information and Communication Technologies. The capital intensity of physical investments of manufacturing enterprises, in fact, is considerably higher than that of intangible investment in Information and Communication Technologies. However, the results can be considered balanced between these two sectors.

Whatever is the typology of investment or the sector, a strong positive correlation between the proportion of investments of firms and the firm size was detected. On one hand, firms operating in services applied to production invested more in applications to production systems than in administrative and management systems. This is an important aspect of ICT investment, because it underlines the fact a strategic investment decision occurred while defining where to inject investments, leading to a more efficient use of ICT and, predictably, better effects on productivity growth.

The survey confirmed also a strong positive correlation between the diffusion of innovation, the company size and production sectors: the number of businesses innovation, increase with the growth of company size, noticeable even more when moving from traditional sectors to technology intensive sectors. The propensity to innovate is more evident in small businesses, particularly in those with 21-50 employees, where the percentage of firms adopting innovations has exceeded 60%, a valuable result because close to the levels of media enterprises (Graph 4.1 (a)). Innovations are adopted also by large companies, while among the average size companies, improvements are not very significant.

Graph 4.1 (a) – Percentage of manufacturing innovative firms, per firm size



Own elaboration. Source: Capitalia-Unicredit, VIII and IX research on Italian Industries, 2005.

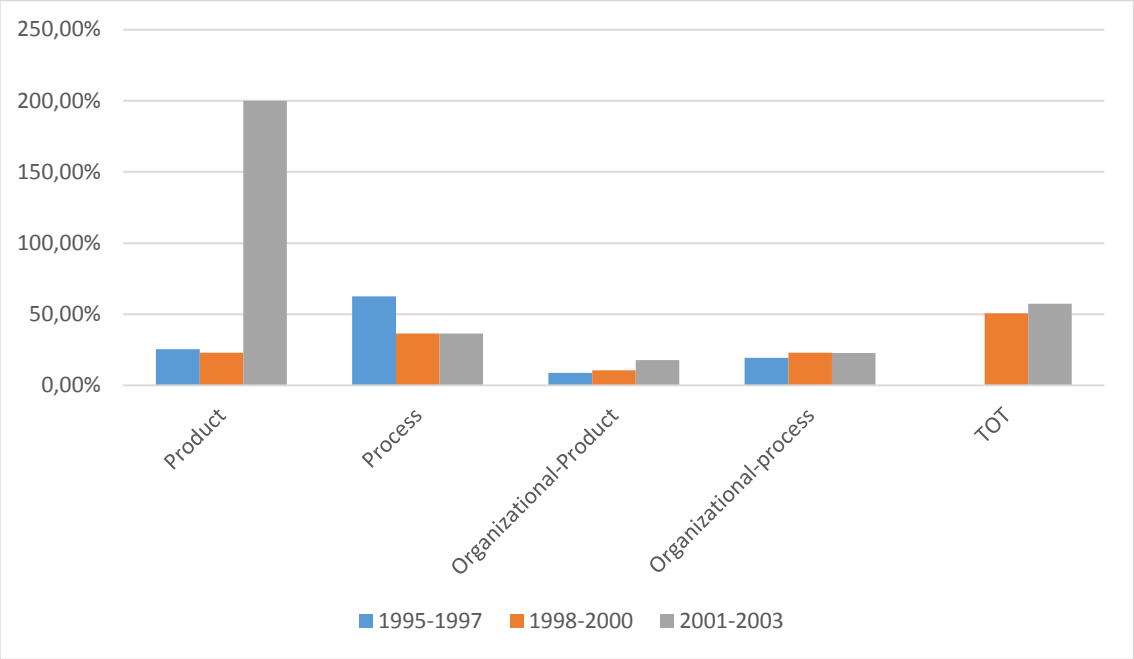
Geographically, innovations are more widespread in the North and Centre of the country, while the South and the Islands have a lower share of innovative enterprises.

In terms of areas, the number of innovative companies has grown to an extent considerably higher than the average of the sample in the high technology sectors, as expected, but also in traditional sectors, where more than half of the companies have innovated.

In conclusion, data show a deceleration of the investment process of manufacturing enterprises in information and communication technology in the period 2001 to 2003.

It is a process not only quantitative but also qualitative, as shown by lower investments in software compared to those in hardware. The business service appear in this field most dynamic manufacturing. Innovation process, which are still the most relevant, are product and process oriented. Significantly lower values are those for Organizational-Product and Organizational-Process, suggesting firms rather focus on ICT investments, more than their correct implementation in the production and process cycles (Graph 4.1 (b))

Graph 4.1 (b) – Percentage of manufacturing firms, per innovation typology.



Own elaboration. Source: Capitalia-Unicredit, VIII and IX research on Italian Industries, 2005.

4.2 Methodology

The aim of this segment of the research is to analyse from a statistical point of view the trends of Italian firms, in particular, the contribution of specific variables to the output of a regression function. The particularity of the model is the adoption of an interaction variable, inspired by the method adopted the method by Bresnahan, Brynjolfsson and Hitt (2002).

To conduct the research a panel from a survey on Italian manufacturing firms between 1998 and 2003 was adopted. The adoption of a panel has several benefits for statistical purposes:

Panel datasets are double dimensional and they combine sectional information with longitudinal information. They are the perfect representation of similar information (n) repeated in different time instants (T). Overall the number of observations in a panel data set is given by n*T. If the panel is balanced, there are no missing values, but if the panel is unbalanced there are some missing values.

The descriptive statistics for panel datasets allows exploring the double dimension, within and between. The within dimension operates with each variable among different time segments, while the size between focuses on the variability of each variable between individuals.

Basically estimations occur via linear model through the estimator of the ordinary least squares (OLS). The most traditional and widely adopted model of linear regression is based on five hypotheses[13] of specification, which make our OLS, BLUE[14]. Since

Since we can not be certain of the value of all the instances in our analysis, we can not affirm the veracity of the Gauss-Markov theorem for our panel data, due to the fact autocorrelation problem might occur. This condition results in the loss of property efficiency of OLS, and the necessity of the adoption of least squares generalized (GLS), which are BLUE despite the presence of heteroskedasticity and/or autocorrelation of the errors[15].

In literature (especially older) are often referred to models with fixed-effects or random-effects models. Such terminology is unsuitable and sometimes misleading.

Because of the large sample size and the restricted temporal continuity, the methodology used in adopted analysis is by random effects. Also, dummy variables are adopted, indicator variables taking value 1 if the quality feature is owned and 0 if it is not.

The reference econometric model should explain what are the circumstances that determine the value of the output, Y.

[13] 1. Linear relation of parameters; 2. Explanatory variables are uncorrelated with the error term; 3. Error terms have zero mean; 4. Error terms have constant variance; 5. Error terms are not related.

[14] If the five assumptions of the linear regression model are true, Gauss-Markov theorem affirms that OLS is BLUE - Best Linear Unbiased Estimator.

[15] Aitken's Theorem

4.3 The Model

Following the method by Bresnahan, Brynjolfsson and Hitt (2002) [1], the model to analyse the performance of Italian firm is structured as such:

$$lYit = \beta_0 it + \beta_1 l\_ictit + \beta_2 l\_invit + \beta_3 gradit + \beta_4 orchit + \beta_5 loc\_southit + \beta_6 emplit + \beta_7 sec\_scienceit + \beta_8 yearsit + \beta_9 lorchictit + \varepsilon it$$

[1]

Specifically, the dependent variable is lY, logarithm of the total output indicating the added value to the output. i, refers to the i-th industry and t, to the t-th time.

The independent variables adopted for our GLS are summarized in the following list:

l_ict	Logarithm of ICT Investment in hardware and software
l_inv	Logarithm of non-ICT investments
grad	Number of employees with a University degree
orch	Dummy variable which takes value of 1 if an i-firm conducted organizational changes in relation to new technological implementations on product or process
loc_south	Dummy variable, which explains the geographic area of the firm. It takes value of 1 when the firm is situated in the southern Italy or in the islands.
empl	Dummy variable of the size of the company. It takes value of 1 when the firm has 51 employees and up.
sec_science	Dummy variable, which takes value of 1 if the firm operates in a science-based sector. It takes value of 0 when the firm operates in a traditional or scale sector
years	Continuous variable, which indicates the age of the firm, from the youngest to the oldest.
orchict	interaction Variable adopted from Bresnahan, Brynjolfsson and Hitt (2004) in order to analyse the impact of the interaction between investments in ICT and organizational changes which occur in a firm, in order to analyse the effect on output

4.4 Results

Relevant results from the STATA regression are summarized in the Table 4.4.

Table 4.4 – GLS regression results

Dependent Variable: lY		
Coefficient	Output	P>|z|
l_ict	0.1178006	0.000
l_inv	0.0041583	0.001
grad	0.079012	0.000
orch	-0.2671932	0.041
loc_south	-0.1244005	0.082
empl	0.778341	0.000
sec_science	0.0667596	0.516
years	0.005675	0.000
orchict	0.324807	0.015
constant	5.853887	0.000

Source: Own elaboration

Results show some interesting facts.

l_ict: The logarithm of ICT investments positively contributes to the added value of output. For each 1% increase in ICT investment, the output increases by almost 0.12%, which underlines a positive effect of ICT investment when injected in a firm. The result is significant and prove the fact an enterprise should be stimulated to invest in IT in order to increase their profits. The theoretical section of this research, which focused on how ICT positively affects the performance of a firm, is therefore statistically proved.

l_inv: When focusing on physical capital investment, the contribution to 1% increase in physical investments allows the output level to increase by 0.004%, which is relatively low in comparison to the performance of ICT investments. The results is significant and it suggests that in the analysed time framework, physical investments to firms have low impact on the firms' performance.

grad: The first dummy variable, increases the output by almost 0.08% when a person has a graduation degree from a University. This increase does not occur when an employee has not have a degree and the dummy variable takes value of 0. When a company has more graduated employees it is supposed to perform better. If at first glance the result seems obvious, it is actually too technical to be taken into consideration: some enterprises are in need of employees with a graduation, while employees without a graduation are necessary for manual works. Therefore, the dummy variable *grad* should be substituted with a variable indicating human capital or labour skills of employees among a firm. Since the topic is wide, it will not be examined in this specific research.

loc_south: The dummy variable indicating the location of enterprises shows a negative relation between the location of an enterprise located in the South of Italy (Southern Italian regions and the Islands) and the firm's output. The reason, according to ISTAT, lies behind the fact Italian enterprises located in the South of Italy, do not cooperate efficiently with each other and do not organize themselves in groups of similar enterprises or enterprises with complementary goods. Italian firms of Southern regions are isolated and tend to be small, thus less productive. Another important aspect of these localities is the difficulty to obtain loans to be injected in the firms, as the costs of credit are almost double than in other Italian localities. The difficult access to credits, therefore, leads to low finances to invest in firms and lowers the possibilities of growth and development. The main reasons behind difficult access to credits are the obstacles set by controversial bureaucracy, low infrastructural levels and widespread criminality.

sec_science: The dummy variable indicating the sector in which an enterprise operates suggests that there is no big difference among firms sectors. The dummy variable takes value of 0 when a firm does not operate in a science-based sector and the value by which firm's output is lowered is not extremely relevant, especially because the result of the output is not statistically significant.

years: This variable, indicating the age of the firm, explains that with each additional year a firm operates in the market, its output increases by 0.0056%. The result is significant and of easy interpretation: the older the firm, the better its knowledge on management and business process and product cycles and, therefore, overall

performance. Experience is extremely important as allowing better adaptability of a firm to different circumstances, such as changes in the market and economic trends, wider database and other tools, which allow better understanding of the inside trends of the firms and outside trends of the country's economy.

empl: The dummy variable about the size of firm, accounted for as the number of employee within a firms, shows an increase of 0.77% when a company has 51 or more employees, result which does not count for smaller firms as *empl* is a dummy variable which takes the value of 0 for firms with less than 51 employees. Italy is known for its strong tradition of small firms, for example for the typical hand-crafted goods produced. However, the limitations of the firms' size are several. According to ISTAT, Italy fell in a so called "mediocrity-trap". In small firms, workers are generally less productive, have lower salaries, work more hours on average and less investments are made on human capital by small sized enterprises. This fact creates a situation where a bottle-neck effect occurs: prices of goods and services are higher and firms are not able to be competitive on the international market, and salaries are low because the only way how to shrink production costs is by lowering labour costs. Small firms fall in a trap, where they are unable to produce gains and efficiency levels similar to large sized firms.

orch and orchict: Organizational changes, which could be either product related or management related, seem not to have positive impact on the added value of the output, even if the results is significant at 95% significance-level. The most important and significant result from the output is showing how organizational changes in the firm do not have any positive impact on the output when adopted alone. As seen before, l_ict influences the output by 0.117%. However, the interaction variable, orchit, which indicates investments in information and communication technologies adopted together with organizational changes, shows very interesting results. In line with the theory (Bresnahan, Brynjolfsson and Hitt, 2002) the results suggests that if organizational changes occur together with investment in ICT (in our case - *orchit*) results are positive and statistically significant. It should be analysed keeping in consideration the fact that organizational changes are considered to be endogenous, as they depend on what motivates the entrepreneur to implement them. According to ISTAT, ICT investment is effective if organizational changes within a firm occur, consisting in changes in the decisional process and investments in high skilled workers and formation and education

of workers. Italian trends in the analysed time framework show difficulties experienced by enterprises in making investments in ICT, seen as a cost more than as an investment and managerial difficulties to understand the IT needs of an enterprise, which the investments should support, situation leading to investments which are not aligned with the strategy of an enterprise. It can be deducted, therefore, that this particular aspect of Italian economy, where the Organizational Product and Process (as seen in Graph 4.1 (b), Paragraph 4.1) did not occur in an appropriate way when almost all modern World countries were experiencing ICT investment boom, is one of the main factors affecting Italy's late in comparison with other world economies (see. Chapter 3), but, unfortunately, not enough analysed.

Conclusion

In a world where technology is spreading and evolving as fast as has never been done before, a research focusing on Information and Communication Technologies implementation, diffusion and efficiency within a country is extremely significant. In this specific research the starting point of the strongest diffusion of ICT in Italy (and the world) is analysed. One of the reasons it is significant to understand the trends of the beginning of ICT diffusion is because it allows examining the importance and the effects of such strong injection of innovation in the economy and subsequently to establish the best way of implementing such innovation. The diffusion of ICT was a very new subject for the beginning of the 21st century, even though economist experienced already some studies and examination about technology and human capital years before. The studies has never been of such a topicality as it happened between the end of the 90s and beginning of the current century, especially in the US, after the experience of the known Paradox of Productivity. This phenomena was the starting point of more accurate researches in the field and economists came out with interesting results and findings, which are still very innovative as focused on elements and variables which were new to economic history. From the research, the most favourable way to respond to the forces of innovations is to create and institutionalize the capacity to change. In the current competitive scenario, the secret of success does not consist only in the ability to predict the future, but in the ability to build an organization, which is able to ensure both survival and competitiveness. In recent years, we have experienced a massive introduction of computer technology in business management; what was previously considered an organization of human labour activities has gradually turned into a problem of adaptation of technology to the needs of the company. Initially, the technology did not present characteristics that made it easily adaptable to the business needs and it required the commitment of particular specialists who knew very well the functioning of computers to be able to be program and perform certain tasks. Over time, technology has made great strides forward and the dependence of the companies on this new management tool went gradually increasing. Entrepreneurs have improved their technology levels in enterprises, automatizing repetitive tasks, increasing their accuracy and speed of execution, and decreasing the number of employees. With years, technology becomes more sophisticated and reliable, and with it, grows the enthusiasm to apply it to many different business

sectors. However, in this way, attention has to be put not only on technology improvements itself, but also in the general application, organizational processes and management in which technology should be seen. In other words, for a technology implementation to be successful, it has to be equilibrated and harmonious with the corporate structure. In this context, the role of Information and Communication Technology appears to be rather ambiguous: on one hand, these technologies promote organizational innovation, on the other hand, generate new environmental complexity and new organizational and strategic challenges.

The limits represented by this research are many. The first limitation is the information accuracy. Most of information around the topic of ICT is recent and therefore still subject to investigation and analysis. Therefore, data and theories may not always be reliable. In addition, it is really challenging to find benchmarks valid to every economist about the way ICT is measured from a qualitative point of view, which, in this specific case study, has as much importance as the qualitative one. The last challenge this type of research offers is database availability at the Firm Level. Firm level investigations are usually conducted through questionnaires and even if quantitatively they are mostly reliable, qualitatively they might be subject to measurement errors by entrepreneurs or inappropriate answers to the questions proposed. The research could follow up in terms of research of the most effective country policy which could both stimulate ICT investments and offer support to company owners and ICT investors, for the most effective and efficient outcomes from their investments.

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