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Contribution of ICT to economic growth in Italy: Input Output analysis

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Index

Abstract

The spread of new information and communication technologies in enterprises has led to a profound transformation of the Italian production system, impacting efficiency and innovative capacity.
The aim of this work is to evaluate the impact on the national economy of investment in ICT by analysing production and demand multipliers calculated using input-output matrices released by ISTAT for the years 1995, 2000, 2005. The results show that ICT has a greater multiplicative effect on the productive system than non-ICT sectors and, thus, is a key sector for economic growth.

Introduction and aims of the work

Information and communication technologies (ICT) are an integral part of the social fabric of developed economies, to an extent that a modern society without ICT would be unthinkable.

ICT produces profound and rapid changes in advanced economies. ICT is changing types of goods and services, production methods and systems, production locations, infrastructure and business organization. ICT goods and services are used by citizens for daily life (work, study, communication), by government offices to provide prompt and inexpensive services (e.g. health services, registry services, etc.), and by enterprises in productive activities.

As regards these changes, economic studies mainly focus on ICT as a process of innovation and its impact on economic productivity. ICT makes production processes more efficient and also offers a wide range of product innovations. New ICT goods and services create new demands, new markets and new sectors of production. In particular, this new demand is driving change in the structure of modern economies. Suffice it to say that factories producing computers, mobile phones, ipods or Internet service providers did not exist 15 or 20 years ago.

According to the latest ISTAT data, the spread of basic information technology in industry and services is close to saturation. In 2009, 96.2% of enterprises with at least 10 employees used computers and 93.9% had an Internet connection. Approximately 86.3% of companies use the Internet to access online banking and financial services, about 60% have their own website (Istat 2009). In general, between 2004 and 2009 major core technologies were increasingly used by Italian companies: this spread of ICT in enterprises triggers a virtuous circle of economic growth.

Growth of demand in the ICT sector stimulates the growth of all other sectors of the economy. Since the production of ICT goods and services requires input from non-ICT sectors, greater ICT demand triggers increased production in non-ICT sectors. For example, the production of computer requires both ICT and non-ICT components, such as plastic, metal and glass. Moreover, the factories that make computers use financial and commercial services and need new offices and, in general, new locations. Similarly, the marketing of computers requires trade and transport services. Thus, the final demand for computers not only stimulates ICT sector production, directly involved in production, but also a wide range of traditional non-ICT sectors. There is another way which ICT stimulates the growth of non-ICT sectors. In fact, the ICT sector provides goods and services not only to consumers – there are electronic components in most domestic appliances (e.g. TVs, dishwashers, etc) - but also to companies, since ICT goods and services are used as intermediate inputs in the production of a variety of non-ICT goods and services. Consider, for example, electronically controlled manufacturing processes in industrial machinery or telecommunications services used for business transactions and exchanges.

The automotive industry is a clear example of the changes made possible by ICT in the productive system. Electronic components have replaced traditional mechanical components and built-in software offer modern functions such as entertainment, navigation and air conditioning. All this would not be possible without the new opportunities offered by ICT. Therefore it is clear that ICT is an economic multiplier triggering a virtuous circle which generates and fuels development and growth.

During the 1990s investments in ICT increased considerably (more than non-ICT investment) boosting the *new economy* within the framework of national investment (Iammarino et al. 2001). According to the latest Eurostat data, the percentage of GDP spending on information technology (IT) was 1.4% in 2009 and 1.5% in 2006. The analogous figure for telecommunications (TLC) was 2.7% in 2009 and 2.6% in 2006 (Eurostat 2010). In 4 years, total expenditure on ICT remained almost unchanged. According to the latest surveys conducted by ASSINFORM (National Association of Technology Producers and Services for Information and Communication - 2010), the Italian market declined in the first half of 2010 compared to the same period in 2009, -2.5% for IT and -2.3% for TLC, mostly because of the economic crisis. The decline, however, was lower than that of 2009 compared to 2008, indicating that many firms, despite the crisis, are starting to renew business technologies, with greater computerization and investment in new infrastructure (Assinform 2010). Although the evidence is not unequivocal, most studies show that ICT has not only been particularly strong as a sector of knowledge-intensive industry but also shown a remarkable capacity to contribute to the growth of other sectors, both technology intensive and traditional (Iammarino et al. 2001).

In this paper, we aim to assess the impact on the entire national economic system of increased investment in ICT in Italy. For this purpose, appropriate indicators are calculated using Input-Output tables (I-O tables) of the Italian economy for 1995, 2000, 2005 released by ISTAT.

Input Output matrix theory

An I-O table shows how the output and input of a single economic sector (branch) is distributed among the economic sectors of the economy. Each *row* of an I-O table shows the distribution of the output of a particular sector between intermediate demand and final demand. *Intermediate demand* means the demand that each sector receives from other sectors of the economy and from itself (intra-sectoral demand). *Final demand* means demand from consumers, government offices, foreign investment, or from other sectors such as capital goods.

Each *column* gives the distribution of the inputs of a particular economic sector between intermediate inputs and added value. Intermediate inputs are inputs from branches of the economic

system, while added value is the contribution of production factors (mainly *labour* and *capital*) to the output of that sector (Leontief 1941). In general, I-O matrices show that the balance of an economic system depends on the structure of the interdependencies between all sectors of the economy.

Table 1: Input-Output Matrix.

		ECONOMIC SECTORS – INPUT								FINAL DEMAND (Consumption + Investment +Exports)	TOTAL DEMAND
		1	2	…	…	j	…	…	N		$\sum_{j=1}^{n} x_{ij} + Zi$
ECONOMIC SECTOR – OUTPUT	1	x_{11}	x_{12}			x_{1j}			x_{1n}	Z_1	X_1
	2	x_{21}	x_{22}			x_{2j}			x_{2n}	Z_2	X_2
	…			…							
	…				…						
	i	x_{i1}	x_{i2}			x_{ij}			x_{in}	Z_i	X_i
	…							…			
	n	x_{n1}	x_{n2}			x_{nj}			x_{nn}	Z_n	X_n
ADDED VALUE		Y_1	Y_2			Yj			Y_n		
SUPPLY TOTAL		X_1	X_2			X_j			X_n		

Table 1 shows a standard I-O matrix (Guarini and Tassinari 1990). The generic element x_{ij} expresses the amount of goods and/or services traded between sectors *i* and *j*. In the rows, x_{ij} represents the output of sector *i* used by sector *j*. In the columns, x_{ij} expresses the input of sector *j* from sector *i*.

Final demand Z_i is the sum of the demand for non-productive sectors of the economy, namely households, government offices, foreign countries; added value Y_i is the sum of production factors (capital, labour, social security costs, depreciation, direct and indirect taxes). An economy imports exports) a part of the goods and services from abroad: they can be included in the I-O matrix (and usually are), but for the purposes of this work imports (exports) are not considered.

I-O matrices are characterized by a *balance equation* in which <u>total demand is equal to total supply</u>:

$$\sum_{j=1}^{n} x_{ij} + Zi = X_i$$

This relationship helps to analyze various branches of products according to their use, the first term being the part used by the branches of production and the second intended for final use.

In addition, in the balance equation an I-O table is based on an assumption of linearity, that is, any increase (decrease) in production causes an increase (decrease) proportionate to the intermediate inputs. The I-O tables are based on two additional assumptions: 1) the production of each sector is homogeneous (i.e. each industry sells homogeneous goods and services); 2) the final demand is exogenous. In the latter hypothesis, it is assumed that an increase in demand is caused by increased investment from abroad and from households, whose conduct is considered exogenous.

The prices of goods and services are determined by the following components: *producer prices*, i.e. costs for intermediate inputs and production factors; *indirect taxes* levied on production and trade; *distribution costs* consisting of trade margins and freight transport. In this study, we used I-O matrices expressed in producer prices.

I-O tables are important tools for economic analysis (Leontief 1967). Operationally, to analyse the production system they are transformed into technical coefficients tables (Guarini and Tassinari 1990). *Technical coefficients* indicate how many units of the goods from branch *i* are necessary to produce a physical unit of branch *j*. It is calculated by dividing the elements of each column by the output of the corresponding economic branch: $a_{ij} = x_{ij} / X_{ij}$. The coefficients can be expressed both in physical and monetary terms. If they are constant over time, we can calculate the amount of direct purchases required by each sector as a result of the increase (or decrease) in the output of all sectors. Table 2 shows a technical coefficients matrix.

Table 2: Technical coefficients matrix A

	1	…	J	…	N
1	a_{11}		a_{1j}		a_{1n}
…		…			
I	a_{i1}		a_{ij}		a_{in}
…				…	
N	a_{n1}		a_{nj}		a_{nn}

Table 2 should be read as follows: if the ICT sector output increases by € 1,000 (assuming that the technical coefficients are constant over time), the direct input of the ICT sector (i.e. ICT sector purchases) would increase by an amount equal to $a_{ICT,ICT}$ *€ 1,000, where $a_{ICT,ICT}$ is calculated by dividing the ICT branch input by its output. If the technical coefficients are relatively stable, the

usefulness of the technical coefficient table is obvious. In fact, using these coefficients, an ICT company manager could calculate in advance how much to buy from each branch in the event of increased demand for ICT goods and services.

However, the technical coefficients table in itself is of limited use, since it shows only the *direct effect* of a change in the output of a sector on the sectors from which it buys input for production. In fact, the technical coefficients indicate the direct purchases made by a particular production branch from all other branches for every euro of output, but they do not indicate the total contribution to production by the part of the branch for which demand increases. The increase in final demand in a particular sector (such as from investments) leads to both *direct* and *indirect* increases in the output of all sectors of the economy. In correspondence with the increased demand for ICT products, the ICT sector must purchase more products from non-ICT sectors (e.g. agriculture, manufacturing, etc). But when, for example, the manufacturing industry increases the sale of goods and services to the ICT sector, it also increases its demand for inputs from agriculture, textiles, etc, and these effects spread throughout the economy.

As a result, a substantial part of I-O analysis involves the construction of a table showing both the direct and indirect effects of these changes on overall economic growth. This table must show the total growth in output in all sectors of the economy as a result of an increase of € 1,000 in demand from households, government offices, investors and foreign buyers, etc.

In technical terms, direct and indirect effects can be obtained by calculating the inverse of a matrix obtained as the difference between the identity matrix and technical coefficient matrix A: $B = (I - A)^{-1}$. The matrix (I-A) is the *Leontief matrix*, and matrix B is called the *Leontief inverse matrix*. It shows the overall effects (direct + indirect) of an increase of 1,000 € in output for a generic sector of the economy. The Leontief inverse matrix can be seen in Table 3.

Table 3: Leontief inverse matrix B**.**

	1	…	J	…	N
1	b_{11}		b_{1j}		b_{1n}
…		…			
I	bi_1		b_{ij}		b_{in}
…				…	
N	b_{n1}		b_{nn}		b_{nn}

The main diagonal of the Leontief inverse matrix shows values greater than 1, while other values are all less than 1. The sum of the coefficients by column of the Leontief inverse matrix gives the

increase in production throughout the economy for every additional 1,000 € of demand for a particular sector. This figure, called *production multiplier*, can be decomposed into two components, direct and indirect. In fact, matrix B can be written as follows: $(I - A)^{-1} = (I + A) + (A2 + A3 + \ldots + An)$, where (I+A) is the direct effect matrix and (A2+A3+...+An) expresses the indirect effects. The sum of the coefficients by row of the Leontief inverse matrix indicates by how much the production of a branch of the economy increases as a result of increased overall demand throughout the economy. This gives us the *demand multiplier* (Miernyk 1965).

The aim of this study is to calculate the direct and indirect effects of an increase in demand for ICT goods and services on the Italian economy as a whole through the application of the above methodology to the I-O tables for Italy for the years 1995, 2000 and 2005. The results are shown in the following paragraph.

Results

This analysis is based on I-O tables of the national economy released by ISTAT on 26 January 2010 for the years 1995-2006. In particular, the tables for the years 1995, 2000 and 2005 are used, calculated at *producer prices* (Istat 2010).

The economic sector classification used by ISTAT in the I-O tables is ATECO 2002, which corresponds to the standard international classification of the European Community, NACE Rev. 1.1. Istat I-O tables are calculated for 30 and for 59 economic sectors. In this paper we use the tables calculated for 59 branches of the economy.

The aim of this study is to calculate the direct and indirect contributions of the ICT sector to Italian economic growth for the years 1995, 2000 and 2005, as described above.

According to Spiezia (2008), it is not necessary to know the intermediate inputs for each sector of the economy (as in Istat's tables), but: *1)* the supply of intermediate ICT inputs to the economy as a whole, and *2)* the demand for intermediate inputs from all economic sectors by the ICT sector. Then, we need an I-O matrix for 2 sectors: ICT and non ICT. To this end, the first phase of work involved grouping together the production branches that fall within the ICT sector, based on the ATECO 2002 classification, i.e. grouping all sectors considered to be ICT in one "ICT sector"; the remaining were placed in the "non-ICT sector". These groupings were made in accordance with the ISIC Rev.4 ICT sector classification used by the OECD (see OECD 2009 and Iammarino et al. 2001).

The ICT sector, therefore, includes the following branches (the code number refers to NACE Rev. 1.1):

22 - Publishing, printing and reproduction of recorded media

30 - Manufacture of office machinery, computers and computer systems

32 - Manufacture of radio, television and communication equipment and apparatus

33 - Manufacture of medical, precision and optical instruments, watches and clocks

64 - Post and telecommunications

72 - Computer and related activities

The grouping into a single sector was carried out by adding all intermediate inputs, added value, intermediate and final demand in each sector included in ICT industry. Then, an I-O Table was made for each year under consideration (one for 1995, one for 2000 and one for 2005), as follows:

Table 4: A standard I-O matrix with ICT and non ICT sectors.

	ICT	non ICT	Final Demand	Total Demand
ICT	$x_{ict,ict}$	$x_{ict,nict}$	Z_{ict}	X_{ict}
non ICT	$x_{nict,ict}$	$x_{nict,nict}$	Z_{nict}	X_{nict}
Total supply	X_{ict}	X_{nict}		

The total supply is the sum of the intersectoral supply ($x_{ict,ict} + x_{nict,ict}$), wages, social security charges, other income and indirect taxes (not shown in Table 4).

From this matrix we calculated the corresponding technical coefficient matrices and the Leontief inverse matrices. Below are the detailed results for 2005, while those for 2000 and 1995 are given in the appendix.

Table 5: Input Output Table for two sectors, Italy 2005 (millions of euro).

	ICT	non ICT	Final Demand	***Total Demand***
ICT	24,104	87,392	82,594	**194,090**
non ICT	62,203	1,292,064	1,599,997	**2,954,264**
Total supply	**194,090**	**2,954,264**		

Source: elaboration on Istat data 2005.

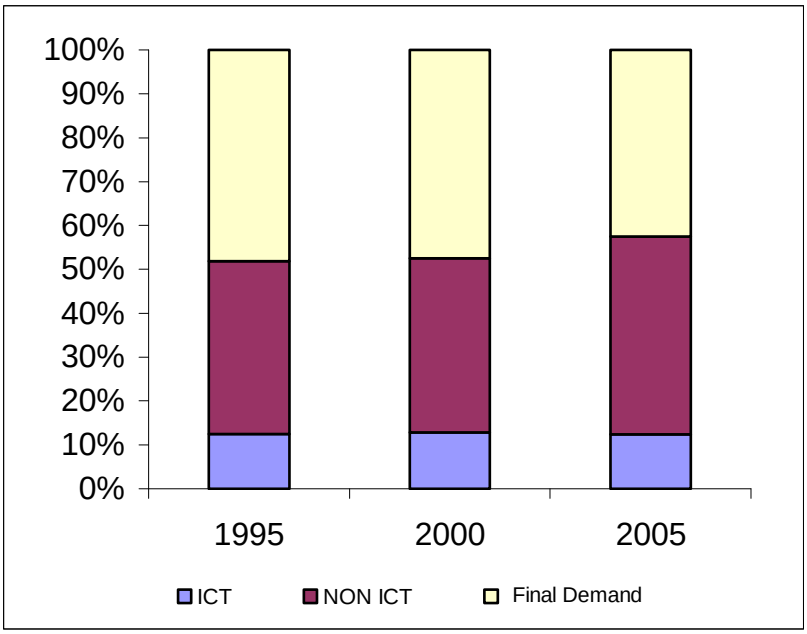
Table 5 shows the volume of trade between ICT and non ICT sectors in Italy in 2005, and the final demand of both sectors.

In 2005, ICT output amounted to 194.091 million euros: ICT sector input amounted to € 24,104 billion (12.4% of total), non ICT sector input accounted for € 87.392 billion and the remaining 82.594 million euros (i.e. 42.5% of the total) corresponded to the final demand of government offices, households, investment and exports.

In 2005, ICT sector input was mainly provided by the non-ICT sector (€ 62,203 million) and € 24,104 million came from the ICT sector itself. The table also shows that the ICT sector meets the 6% of total demand, compared with 94% of non-ICT sector.

Figure 1 shows the percentage distribution of ICT use during the period 1995-2005. We can see that there has been no substantial change over the decade except for the fact that in 2005 there was a slight increase in use by the non ICT sector and a corresponding decrease in use by final consumers (government offices, households, exports and investments).

Figure 1: ICT sector use, percentage distribution - Italy 1995, 2000, 2005.



Source: elaboration on Istat data 2005.

The following table shows the technical coefficients for Italy in 2005.

Table 6: Technical coefficients matrix, Italy 2005.

	ICT	non ICT	***Total***
ICT	0.124	0.029	**0.153**
non ICT	0.320	0.436	**0.756**
Total	**0.444**	**0.465**	

Source: elaboration on Istat data 2005.

Table 6 is interpreted as follows: we assume an increase of 1,000 € in demand for ICT products. This will increase intra-sectoral input (i.e. ICT sector to itself) by € 124 (see row 1, column 1) and increase non ICT sector input by € 320 (row 2, column 1). This means that to produce € 1,000 the ICT sector mainly uses intermediate goods from the non-ICT sector. The total increase in the value of *direct* input due to an increase of € 1,000 in ICT output amounts to € 444 (i.e. €124 +320). Thus, total ICT output will increase by at least € 1,124 (€ 1,000 + € 124).

Moreover, an increase of 1,000 € in non-ICT demand produces an increase of only €29 in ICT sector input.

When ICT sector demand increases, ICT companies increase their demand for goods from non ICT sector companies, thus activating a chain of direct and indirect actions shown in Table 7.

Table 7: Leontief inverse matrix, Italy 2005.

	ICT	non ICT	***Total***
ICT	1.164	0.061	**1.225**
non ICT	0.662	1.810	**2.472**
Total	**1.826**	**1.871**	

Source: elaboration on Istat data 2005.

Table 7 shows that the direct + indirect transactions inside the ICT sector reached € 1,164, i.e. increased from € 1,124 to € 1,164. This happens because when ICT output increases, the ICT sector buys goods and services from the non-ICT sector. When the non ICT sector increases the sale of inputs to the ICT sector, it must, at the same time, buy goods and services from the ICT sector to increase production. In general, this process is initiated in all branches each time there is an increase in demand for goods and/or services. Table 7, therefore, shows the total *direct and indirect* demand from the sector in the column for each € 1,000 increase in final demand from the sector in the row.

Every time there is an increase of € 1,000 in the sale of ICT goods and/or services to households, government offices or other types of final demand, non-ICT sector output increases by € 662.

Table 7 shows that the multiplier effects are higher within the same sector, while intersectoral multipliers have lower values.

The sum of ICT column indicators – 1.826 - expresses the overall impact on the economy of the increase in ICT sector demand: this figure is the *production multiplier*. Specifically, 1.826 indicates that for each € 1,000 increase in ICT sector demand, overall economic output increases by € 1,826 (i.e. € 1,164 + € 662). The analogous figure for the non ICT sector is 1.871, i.e. for every increase of € 1,000 in non ICT demand there is an increase in production of € 1.871. This result indicates that ICT has a strong effect on economic growth, and that it can boost the national productive system substantially. In fact, the driving force of the ICT sector, which according to the classification consists of 6 branches, is almost equal to that of the rest of the economy, comprising 53 very diverse sectors. ICT, while meeting only 6% of total demand (see table 5) contributes to increased production almost as much as all other sectors put together.

The sum per row of the indicators in Table 7 gives us the *demand multiplier*, which tells us by how much the production of each sector increases when there is an increase in the final demand of the economy as a whole. The demand multiplier for the ICT sector is 1.22 and for the non-ICT sector 2.47, which means that the non ICT sector receives a greater boost than the ICT sector from the overall increase in economic output, i.e. the ICT sector is "less sensitive" than the non ICT sector to a global increase in production.

Conclusions

The results of this study of a simplified two-sector economy, ICT and non ICT, show that the ICT sector gives a big boost to the domestic production of goods and services. This indicates that investments in the ICT sector trigger a chain of actions and reactions that significantly increase the production of the national economic system.

This virtuous multiplier effect is mainly due to the pervasiveness of ICT and its ability to spread quickly in the economic fabric. The increasing use of ICT in companies is changing the value of production factors, production techniques, improving the production times and efficiency. In addition, the widespread use of ICT can open up new production lines, which in turn develop and distribute ICT applications.

The analysis shows that production and demand multipliers remained basically unchanged during the decade 1995-2005. Assuming production remains stable, it is reasonable to suppose that for 2010 roughly similar multiplier figures can be expected and, therefore, ICT will still be very an important driver for the economic system. This hypothesis can be tested as soon as we have I-O tables for 2010.

This work is a starting point for further research on the effects of technology on the country's economic growth. The next goal is to update the I-O analysis when the latest data available.

Appendix

Table 1A: Input Output Table, Italy 1995.

	ICT	non ICT	Final Demand	***Total Demand***
ICT	13,592	43,019	52,518	**109,129**
non ICT	35,473	797,339	1,028,786	**1,861,598**
Total Supply	**109,129**	**1,861,598**		

Source: elaboration on Istat data 1995.

Table 2A: Technical Coefficients Matrix, Italy 1995.

	ICT	non ICT	***Total***
ICT	0.125	0.023	**0.148**
non ICT	0.325	0.428	**0.753**
Total	**0.450**	**0.451**	

Source: elaboration on Istat data 1995.

Table 3A: Leontief inverse matrix, Italy 1995.

	ICT	non ICT	***Total***
ICT	1.159	0.046	**1.205**
non ICT	0.659	1.776	**2.435**
Total	**1.818**	**1.822**	

Source: elaboration on Istat data 1995.

Table 4A: Input Output, Italy 2000.

	ICT	non ICT	Final Demand	***Total Demand***
ICT	21,405	65,917	79,076	**166,398**
non ICT	53,161	1,076,650	1,318,811	**2,448,622**
Total	**166,398**	**2,448,622**		

Source: elaboration on Istat data 2000.

Table 5A: Technical Coefficients Matrix, Italy 2000.

	ICT	non ICT	***Total***
ICT	0.128	0.027	**0.155**
non ICT	0.319	0.440	**0.759**
Total	**0.447**	**0.467**	

Source: elaboration on Istat data 2000.

Table 6A: Leontief inverse matrix, Italy 2000.

	ICT	non ICT	***Total***
ICT	1.168	0.056	**1.224**
non ICT	0.666	1.816	**2.482**
Total	**1.834**	**1.872**	

Source: elaboration on Istat data 2000.

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