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FACTORS AFFECTING THE ADOPTION OF
ICTs AMONG SMEs: EVIDENCE FROM AN
ITALIAN SURVEY

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Abstract

The adoption of Information and Communication Technologies (ICTs) among small and medium sized enterprises (SMEs) is a phenomenon that has been the object of increasing interest by the academic literature and the policy makers. In this paper, we carry out an econometric analysis of a sample of 168 enterprises located in the Ancona Province (Central Italy). An important result is that, in order to understand the main factor that drive SMEs to the adoption of ICTs, it is useful to divide the available technologies according to a taxonomy based on their typical use. In all cases, however, the availability of highly educated workers turns out to be a key factor. Policy implications are also discussed.

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Factors affecting the adoption of ICTs among SMEs: evidence from an Italian survey^{*}

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1 Introduction

A number of empirical studies shows that a peculiar feature of the US economy during the 1990s was the presence of high growth rates both in productivity and employment. In fact, the productivity growth recorded by European countries in the same years was not matched by a comparable creation of jobs, both in manufacturing and services.

Along with the higher flexibility of the US labour market, one of the main arguments for explaining these different patterns has been an earlier, faster and more widespread adoption of ICTs in US business units and households and a greater propensity of consumers to use the Internet for buying goods and services.

The specific advantages for business units of recent ICT developments are hardly confined to the productivity gains given by the ITs applied in production (such as CAD-CAM, FMS) or the reduction of co-ordination and transaction costs allowed, for instance, by LANs and EDI. With the Internet boom of the 1990's it has been possible for the firms not only to attain similar efficiency gains at lower costs but also to enlarge the size of their potential markets and find new opportunities for growing. In short, efficiency gains

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can be attained also in conjunction with employment growth.

Also in the light of the previous arguments, in the policy agenda of the European Union the diffusion of ICTs has recently received the highest priority (see Commission of the European Communities, 1999, 2000, 2001b) with particular emphasis on the adoption of e-business practices and digital technologies among SMEs (ibidem, 2001a). As the Commission of the European Communities well summarises (2001a, p. 5), there are different reasons for focussing on SMEs (which, in Europe, are defined as firms with fewer than 250 employees):

In most EU Member States they make up over 99% of enterprises. SMEs generate a substantial share of GDP and are a key source of new jobs as well as a breeding ground for entrepreneurship and new business ideas. SMEs will also in particular benefit from the lowering of entry barriers to markets as a consequence of e-business. Hence, e-business is often described as the SMEs' gateway to global business and markets.

Therefore, the conclusion of the Commission, shared (among others) by the European Information Technology Observatory (cf. EITO, 2000), is that

Europe will only become a center of e-business if European SMEs are fully committed to using the Internet as a leading-edge business tool.

Thus, the Action Plan termed *e-Europe*, launched in 2000, includes a specific programme to help European SMEs to *Go-Digital* (the programme's name) to be implemented in the period 2001-2005. Among the actions of *Go-Digital*, the objective of Action 2 (*Measuring of take-up of ICT and e-business*) is to develop a comprehensive GoDigital scoreboard for measuring the take-up of ICT and e-business by SMEs in EU Member States and across business sectors.

In this context, the aim of the present paper is threefold:

- a. to provide statistical information on the 'raw' rates of ICT adoption for a sample of Italian SMEs (such as the percentage of firms with e-mail and Internet access or Web pages);
- b. to introduce some measures of the effective use of ICT and e-business (by looking, for instance, at the percentages of employees having access to these technologies and the content of the firms' Web sites) as well as composite indicators of ICTs (included LAN, EDI and Intranet);

- c. to identify, by means of empirical analyses, the main factors which affect the penetration of ICTs among SMEs; these determinants, already interesting *per se*, are also useful to discriminate between different ICTs and thus to build a taxonomy which enables one to classify technologies on the basis of their “natural” use.

There is a number of studies based on simple measures of ICT adoption, but only a few (see e.g. Bakker, 2000; Falk, 2001) have used comprehensive and sophisticated indicators such as those mentioned in point b; at the same time, the impact of ICTs on different variables (skilled employment, productivity, export performances) has been widely examined while little attention has been devoted to the issue of why some firms are more ICT-intensive than others.

Our empirical study is based on a stratified random sample of 168 enterprises located in the Ancona Province (Central Italy) to which a detailed questionnaire was submitted at the end of 2000. Most of them belong to the manufacturing sector while a minority provide business services. SMEs account for 95% of the sample while small firms (with fewer than 50 employees) account for 80%.

Our sample was extracted from the list of firms affiliated with the local Employers Confederation. Therefore, although we consider our results fully representative for the Employers Confederation affiliates, it can be legitimately put into question whether these results can be extended to the whole local economy. In this respect, we maintain that point estimates are probably unreliable when it comes to evaluating specific aspects, such as adoption rates or effectiveness of use for certain technologies; at the same time, the qualitative findings that emerge by putting the single results together are very likely to hold in a much broader setting. Our opinion is based on the fact that the Ancona province has all the characteristics that make it an ideal candidate to represent Italy’s Centre-North system of SMEs: the firms in the sample are not specialised in any particular industry producing consumer, intermediate or capital goods. Large firms are few, but SMEs abound. In short, there are no size and industry peculiarities that make the sample particularly suitable to record a high or low level of ICT diffusion. Moreover, the province itself shows a degree of economic development that is halfway between the most advanced and the most backward areas of Centre-North Italy¹.

Although not in a (statistically) rigorous sense, we believe that our study provides a good representation of the manufacturing and business services

¹According to the data recently issued by Istituto Tagliacarne (2001), in 1999 per-capita value added in the Ancona province was 19.7% higher than the national average.

activities located in Northern and Central Italy, which include the most developed regions of the country. The picture depicted by the present paper, instead, does not mirror the situation of Southern regions which record, along with lower per-capita income, employment rate and level of industrialization, a lower degree of ICT penetration (cf. Logica Consulting, 2000). Therefore, while it could be possible to extend our findings to the regions of the EU characterized by above-average economic performances (and a similar presence of SMEs), the backward regions classified by the EU as 'Objective 1' areas are not well represented and the policy considerations arising from our study cannot be applied to them.

The main findings of the empirical analysis can be summarised with the help of the following taxonomy:

General-use ICTs: include e-mail and Internet access²; simple rates of adoption are very high and do not depend on size (i.e. number of employees) and industry. When the rate of effective use is measured by the share of total employees with access to these ICTs, the percentages of educated workers exert a positive effect and, in the case of the Internet, a negative impact of size emerges. However, when the occupational structure of the firms is taken into account — by defining the rate of effective use as the percentage of nonproduction workers with access to e-mail and the Internet — both the size and education effects disappear and only the differences between industries are relevant.

Production-oriented ICTs: include LAN, EDI and Intranet; these ICTs are linked to production processes either carried out within the firm or based on inter-firms productive relationships; they are more expensive than general-use ICTs and require relevant technological skills (often internal to the firms). A composite indicator of production-oriented ICTs turns out to be significantly and positively associated with firm size, the use of CAD and CAD-CAM technologies, the nature of the firm as subcontractor and the share of employees with secondary and, especially, university education.

Market-oriented ICTs: they are jointly identified by the presence and the content of a firm's Web site; analysis of the content show that Web pages are mainly used to improve the firms' visibility and to provide detailed information on their products, with a view to enlarge potential customers; on the other hand, e-commerce in a strict sense (identified

²In this paper, we will adopt the convention of labelling as "Internet access" all kinds of Internet services other than e-mail exchange. In this sense, the phrase "Internet access" is practically a synonymous for "Web browsing", although it need not be necessarily so.

by the possibility of on-line ordering) is extremely rare. The use of market-oriented ICTs does not depend on a firm's size or its productive or technological features, but raises when the firm is an exporter, is present in foreign markets with commercial branches and employs a relevant share of workers with university education.

Although some of the above stressed relationships could be peculiar to our sample of Italian SMEs, we think that this taxonomy is useful to depict the attitude of European SMEs towards ICTs and e-business and then to identify specific policy measures for each group of technologies.

The paper is organised as follows. Section 2 describes the sample's characteristics and the structure of the questionnaire. Section 3 is devoted to analysing the factors behind the use of e-mail and the Internet. In Section 4 a composite indicator of production-oriented ICTs is built and its determinants are examined by means of Tobit regressions. The same analysis is carried out in Section 5, after constructing a variable which identifies both the presence and content of Web sites. A concluding section summarises the empirical findings and briefly reflects upon policy implications and further research directions.

2 The survey: methodological issues

Our survey refers to the firms located in the Ancona Province (Central Italy, Marche Region) and affiliated, at the end of 1999, with the local Employers Confederation. After excluding some enterprises that cannot be strictly classified as industrial or producer services firms³, the reference population amount to 514 firms: 456 in manufacturing and 58 in business services. The latter industry is composed by firms providing software or computing services and other consulting services (engineering, accountancy, and so on), mainly to industrial enterprises.

These firms cannot be considered statistically representative of the whole business sector located in the Ancona Province, especially because, in Italy, very small artisan enterprises are affiliated with their own local associations rather than the Employers Confederation. As a consequence, the population under-represents micro firms with less than 10 employees, that, in the Ancona

³The excluded enterprises either provide leisure, cleaning and transport services or produce religious articles, toys and musical instruments. For each of the latter industries the number of observations is very low; given the different characteristics of artisan goods and high-tech instruments, we preferred to neglect these industries rather than aggregate them into the miscellaneous (and, thus, ambiguous) category labelled 'Other manufacturing industries'.

Province, account for a large part in the Food & Beverages and Clothing & Footwear industries.

In order to minimise the survey's cost and duration, a stratified random sample of the firms with less than 250 employees was extracted (by using size and industry as stratification variables and with the purpose of interviewing one third of the population); large firms were oversampled (compared to other firms) because they are relatively few and it was our aim to reduce sampling variability on certain key aspects, such as the incidence of e-commerce, that are more likely to be found in larger enterprises. The final sample, composed of 168 firms, is shown in Table 1.

Firms with less than 50 employees account for 80% of the sample; for the reasons explained before, among them small firms (having between 10 and 49 employees) strongly prevail over micro-businesses. According to the definition of SMEs adopted in the European Union, medium-sized firms should be added to the small ones, which leaves us with a share of large firms in the sample of just 5%.

As far as the industry distribution is concerned, it emerges that these SMEs are not particularly concentrated in any manufacturing industry. There is a prevalence of mechanical firms but they are equally distributed between, so to speak, 'high-tech' branches (such as those included in the industry labelled 'Advanced mechanical') and 'medium' or 'low-tech' ones (installation and repairing of Mechanical & Electrical Equipment and Metal products). Consumer goods industries such as Food & Beverages, Wood & Furniture and Clothing & Footwear are well represented, although the Italian specialisation in these industries⁴ (especially within Central and North-Eastern regions) is much stronger.

As stressed in the introduction, it can be said, on the one hand, that the sample provides a good representation of the manufacturing and business services industries located in Northern and Central Italy and, on the other, that there are not peculiar features in terms of size and industry distribution that bias the sample towards a high or low propensity to adopt new technologies, such as the ICTs under investigation.

From October to December 2000 a questionnaire on the adoption of ICTs was firstly mailed to the sampled firms and then, in order to obtain complete answers, telephone calls, faxes, e-mail messages and, often, a mix of them was used⁵. Thanks to the collaboration of the Employers Confederation'

⁴Often labelled 'traditional' or, according to Pavitt's taxonomy, 'supplier dominated' industries.

⁵For the more demanding and, thus, time-consuming sections of the questionnaire firms preferred to answer via fax rather than e-mail. Albeit suggesting a low effective use of e-mail, we did not exploit this information.

Table 1: Sample distribution by firm size and industry

	Micro firms (1-9 empl.)	Small firms (10-49 empl.)	Medium- sized firms (50- 249 empl.)	Large firms (more than 249 empl.)	Total	%
Food & Beverages	0	10	1	0	11	6.5
Wood & Furniture	2	7	3	0	12	7.1
Paper, Printing & Graphics	4	10	3	1	18	10.7
Chemicals and Plastic products	3	7	4	0	14	8.3
Advanced me- chanical ^a	3	12	4	4	23	13.7
Mechanical & Electrical equip- ment	2	25	2	0	29	17.3
Metal products	7	15	5	1	28	16.7
Clothing & Footwear	1	8	4	2	15	8.9
Business services	10	8	0	0	18	10.7
TOTAL	32	102	26	8	168	100.0
Percentages	19.0	60.7	15.5	4.8	100.0	

^aElectronics, Electrical and mechanical machinery, Domestic appliances and Motor vehicles

staff, the number of non-respondents was rather low so that we were able to substitute them with the firms belonging to the same size-industry stratum and thus obtain the 168 observations distributed as in Table 1.

It should be added that the sampling procedure allows us to ascribe to each interviewed firm a weight according to its size and industry, so that the descriptive statistics presented in the paper usually refer to the entire population of 514 firms⁶.

The questionnaire submitted to the firms was very detailed and comprehensive. It was composed of three sections. The first was devoted to the firm's structural characteristics, i.e. affiliation with a group, sales due to sub-contracting, number of plants, export status and presence in foreign markets. The second, after some questions on the adoption of IT in production (such as CAD-CAM technologies), refers specifically to the use of different ICTs; in writing this section we followed very closely the questionnaire on *Information and Communication Technologies and Electronic Commerce* predisposed by Statistics Canada (1999) which, to our knowledge, has carried out the first comprehensive survey on the ICTs' penetration across all the private and public sectors of the national economy (see Bakker, 2000). From this section, different indicators of ICT adoption and effective use can be drawn as well as information on the main obstacles or motivations for using them; in order to have a realistic picture of Web sites' presence and features (including the possibility of on-line ordering), the answers of the firms were checked ex-post by visiting their sites⁷ and searching if they could be found with the most common Internet engines. Finally, the third section was concerned with the occupational structure of the firms; in the questionnaire, data on employees was broken down not only by level of education but also by firm function (from purchases and production to IT services, marketing and sales) and the same information was required for the workers hired in the most recent years.

Thanks to the richness of the questionnaire, we will be able to provide in the next sections, along with detailed pictures of ICTs diffusion among SMEs, an analysis of the main determinants of their adoption and effective use by recurring to a wide range of structural, technological and occupational features of the firms.

⁶Obviously, every statistic used for inferential purposes was computed by using the true number of observations, appropriately weighted.

⁷In some cases, we discover that the responding person – who was not necessarily the responsible of web design – attributed to the firm' site more characteristics than it actually had.

3 E-mail and Internet as general-use ICTs

At the turn of the millennium, it is hard to find business units, located in one the most industrialised countries and not created for self-employment purposes, without access to e-mail and the Internet. The absence of these facilities almost implies that these firm did not buy even one PC during the second half of the 1990s. In fact, this would have meant, in the overwhelming majority of cases, to use an Intel-compatible operating system in which Microsoft owned almost 90% of the market (cf. US District Court for the District of Columbia, 1999). Starting from 1997-98, Microsoft bound a web browser and an e-mail programme to its operating system and, thus, for a firm acquiring a new PC it was highly probable to find user-friendly connectivity facilities already installed. Hence, the availability of e-mail and the Internet only required, at most, the modest additional fixed cost of a modem.

Although the above does not amount to an exhaustive explanation of the connectivity boom, it cannot be denied that this represents an important part of the story. For instance, almost all the firms included in our sample possess at least one PC at the end of 2000 but 20% of them made the first purchase only after 1996. Needless to say, even for early and more sophisticated adopters of IT the acquisition of connectivity facilities (also thanks to the purchases of new PCs) was not a difficult or expensive task.

As a consequence, to record nowadays a very high percentage of firms with e-mail and Internet access would not be surprising. However, as Table 2 shows, just at the end of 1999 the situation was quite different. Only 64% of Canadian and 60% of Australian manufacturing firms were connected to the Web, while our survey shows that around 73% of them had access to both connectivity facilities.

It must be pointed out that the better performances of Italian manufacturing firm are not peculiar of our sample since similar adoption rates arise, for instance, for those of the Emilia-Romagna, a border Region between Central and Northern Italy. What should be stressed from the bottom part of Table 2 is that

- a. in only one year, that is at the end of 2000, the percentages of adopters in our sample raised to about 95% for e-mail and 93% for Internet⁸;
- b. there are small differences across firms of different sizes and industries and, by applying an F test, they turn out to be not statistically sig-

⁸Lower percentages obviously emerge from analyses based on samples with higher shares of very small (artisan or self-employment) firms and a broader presence of industries (such as construction, retail, repair and wholesale). See the studies carried out by Poussart (2001) for Québec and Scally *et. al.* (2001) for Lanarkshire in Scotland.

Table 2: Use of e-mail and the Internet: international comparisons and survey results

	% of firms that use e-mail	% of firms that use the Internet	% of employees with access to e-mail	% of employees with access to the Internet
<i>Total manufacturing</i>				
Canada (1999)	63.4	63.7	28.2	20.4
Australia (1999-2000)		60.0		
Italy - Ancona Province (1999)	75.9	72.4	29.7	19.3
<i>Manufacturing firms with more than 9 employees</i>				
Italy - Emilia Romagna Region (1999)	73.1	74.6		
Italy - Ancona Province (1999)	78.7	75.8		
<i>Ancona Province (2000)</i>				
Food & Beverages	88.2	88.2	22.8	25.1
Wood & Furniture	100.0	100.0	39.2	29.2
Paper & Printing	100.0	100.0	21.7	20.2
Chemicals and Plastic products	100.0	100.0	30.0	9.0
Advanced mechanical ^a	100.0	100.0	37.7	25.1
Mechanical & Electrical equipment	90.0	90.0	18.0	15.2
Metal products	88.6	83.0	23.8	17.3
Clothing & Footwear	97.6	85.7	7.8	5.3
Business services	94.7	89.5	77.4	80.3
Micro firms (1-9 employees)	87.4	85.8	50.5	49.9
Small firms (10-49 empl.)	95.7	93.1	26.3	23.0
Medium-sized firms (50-249 empl.)	100.0	100.0	28.4	23.1
Large firms (more than 249 empl.)	94.8	94.8	33.2	19.1
Total manufacturing	94.7	92.6	30.7	20.4
Total manufacturing & business services	94.7	92.8	31.3	21.1

Sources: Bakker (2000), Australian Bureau of Statistics (2000) and Unioncamere Emilia-Romagna (2000).

^aElectronics, Electrical and mechanical machinery, Domestic appliances and Motor vehicles

nificant; moreover, the same differences are not associated with other firms' characteristics.

Both findings (and the easy-access arguments previously introduced) confirm the idea that, at present, e-mail and the Internet can be viewed as general-use ICTs. However, having access to these technologies does not imply using them effectively. In this connection, indicators of within-firm penetration of ICT have been introduced by Statistics Canada (1999) by collecting information on the percentage of total employees who have access to e-mail and the Internet.

The last columns of Table 2 show, in the first place, that in Canadian manufacturing firms the above percentages (28 and 20% respectively) are much lower than the 'raw' adoption rates and are very similar to those arising, always at the end of 1999, from our survey⁹. Second, in both cases the percentage of employees with access to e-mail is higher than that of employees with Internet access. Third, from 1999 to 2000, the increase of e-mail and Internet use in terms of employees was not relevant in our sample while, as we have seen before, the share of Italian SMEs having access to these ICTs raised significantly; thus, late adopters appear to be characterised by a lower degree of penetration. Finally, between industries and size classes the performances are quite different and employment-based indicators of ICT use are particularly high for micro firms as opposed to their larger counterparts.

However, in our opinion, the above findings (and especially the negative effect of size) are strongly influenced by the functional distribution of the firms' employees. If, as is reasonable to assume, the probability (or convenience) of using connectivity facilities for production workers is much lower than that of the workers employed in nonproduction functions, the occupational structure of the firms can bias inter-industry and inter-firm comparisons. In particular, the negative relationship between size and the percentages of employees with access to these ICTs could depend on the fact that the share of nonproduction workers decreases with size. Obviously, the above considerations apply exclusively to manufacturing firms since it would make little sense to distinguish between production and nonproduction workers in firms that offer business services.

To attain an employment-based indicator free of this possible bias, we think that the number of employees with e-mail and Internet access should

⁹From a survey carried out in the second half of 2000 and concerned with a large sample of German firms (cf. Falk, 2001) it emerges that in manufacturing (excluding the ICT sector) 21% of workers have access to the Internet. This percentage is almost identical to those reported in Table 2.

be related to the number of nonproduction workers only¹⁰; for manufacturing firms they can be computed as the workers employed in nonproduction functions plus the graduates employed in production¹¹, while for business services firms they should amount to total employees (see above).

To analyse whether the effective use of e-mail and the Internet (both in terms of total and nonproduction employees) was related to some structural characteristics of the firms, we ran some OLS regressions with the variables reported in Table 3 as regressors; all the variables refer to the year 2000.

Table 3: Explanatory structural variables

Variable name	Description
LNEMP	Natural log of total employees
PLANTS	1 if the firm has more than 1 plant
SUBCON	1 if the firm's share of sales due to subcontracting exceeds 50%
GROUP	1 if the firm is part of a group
CONTROL	1 if the firm controls others among its group
EDU_H	percentage of employees with a university degree
EDU_M	percentage of employees with secondary education
NCM	1 if the firm uses Numerically Controlled Machines
CADCAM	1 if the firm uses CAD and/or CAD/CAM systems
FMSROBOT	1 if the firm uses FMS and/or robots
EXPORT	1 if a firm is an exporter
ABROAD	1 if a firm has commercial branches abroad
CLOTHING	Industry dummy: Clothing and footwear
PAPER	Industry dummy: Paper, printing and graphics
CHEMICAL	Industry dummy: Chemicals and plastic products
ADVMECH	Industry dummy: Advanced mechanical products
METPROD	Industry dummy: Metal products
WOOD	Industry dummy: Wood and furniture
BUSISERV	Industry dummy: Business services

The size of firms is identified by the natural log of total employees. The presence of two or more plants (PLANTS), the nature of the firm as a subcontractor (SUBCON), the affiliation with a business group (GROUP) and the

¹⁰As Berman *et al.* (1994, pp. 371-72) pointed out in a study concerned with US manufacturing industries "Both conceptually and empirically, the production/nonproduction worker distinction closely mirrors the distinction between blue- and white-collar occupations. [...] The blue-collar/white collar classification, in turn, closely reflects an educational classification of high school/college".

¹¹They usually act as production managers or supervisors and, in accomplishing their tasks, they may need of connectivity facilities. A similar argument does not apply to production workers with secondary education; they could be (and often are) strongly involved in IT applied to production (such as CAD-CAM) but this does not imply that they should have access to e-mail and the Internet.

controlling of other firms within the group (CONTROL) are the explanatory variables that should capture the intensity of inter-firm (or inter-plant) relationships; SUBCON, in particular, can be viewed as a proxy for the extent of productive linkages with other firms.

The shares of workers with university (EDU_H) and secondary education (EDU_M) are inserted as rough measures of the amount of human capital. For a firm, investment in human capital could be akin to other forms of investment in technology, and therefore should be considered endogenous. However, the structure of labour force by educational level cannot account for the dynamic nature of human capital investment; this is confirmed by the fact that, in our sample, such a structure is extremely stable¹², and changes in it can be regarded as marginal.

The next set of explanatory variables refers to the adoption of different types of information technologies (IT) that the firms can use in their production processes, ranked according to an increasing degree of technological complexity: that is, from numerically controlled machines (NCM), to CAD and/or CAD-CAM systems (CADCAM) and, then, to flexible manufacturing systems and robots (FMSROBOT). As Santarelli and Sterlacchini (1994) have shown, even for Italian SMEs producing traditional consumer goods and located in the same area of our sample, these ITs were largely available (and sufficiently diffused) since the mid-Eighties; thus it is interesting to investigate if their adoption has affected (and still affects) the use of e-mail and the Internet.

In order to ascertain whether the attitude of the firms towards foreign markets influences the penetration of these ICTs, we insert two dummy variables: one if the firm is an exporter (EXPORT) and another if it owns commercial branches abroad (ABROAD). With respect to the possible endogeneity of the EXPORT variable it must be stressed that, in our sample, there is a very little mobility between exporting and non-exporting firms over the period 1997-2000¹³; moreover, and most importantly, the use of up-to-date technologies should affect primarily a firm export intensity (the share of exports on sales) rather than its probability to export (see, among others, Sterlacchini, 1999; Lal, 1999; Zimmermann, 2000). Accordingly, the status of exporter can be safely treated as an exogenous variable.

Finally, industry fixed effects are taken into account by means of seven dummies (with the installation and repairing of ‘Mechanical and Electrical equipment’ as the reference industry).

As can be seen in the first two columns of table 4, both indicators based

¹²The correlation coefficient between EDU_H in 1997 and 2000 is equal to 0.96; for EDU_M one gets 0.93.

¹³Only 7.1% of firms that were not exporters in 1997 were exporters in 2000; the per-

Table 4: Employment-based indicators of general-use ICTs: OLS regressions

	Employees with e-mail access/Total employees	Employees with Internet access/Total employees	Employees with e-mail access/ Nonproduction workers	Employees with Internet access/ Non- production workers
Constant	...	0.242**	...	0.695**
LNEMP	...	-0.061**	...	...
PLANTS	...	...	...	...
SUBCON	...	...	...	...
GROUP	...	...	...	...
CONTROL	0.169*	...	...	...
EDU_H	0.420**	0.310*	...	-0.737*
EDU_M	0.281**	0.211**	...	...
NCM	...	...	...	...
CADCAM	...	...	...	...
FMSROBOT	...	...	...	...
EXPORT	...	...	-0.435**	-0.434**
ABROAD	...	...	...	...
CLOTHING	...	...	...	...
PAPER	...	...	1.438**	1.551**
CHEMICAL	...	...	...	...
ADVMECH	0.191**	0.193**	0.618**	0.577**
METPROD	...	...	...	...
WOOD	0.210**	0.190**	1.212*	1.174*
BUSISERV	0.323**	0.380**	0.616**	0.621**
$\bar{R}^2$	0.286	0.317	0.093	0.093
Wald test ^o (P value)	32.410** (0.001)	34.665** (0.000)	12.035 (0.361)	10.418 (0.493)

... : not significant

* : significant at 10%

** : significant at 5%

^o : H_0 : all coefficients except the constant and those for industry dummies are 0.
All the above tests were performed by using the heteroskedasticity-consistent estimator
of the parameters' covariance matrix.

on total employees are positively related to the educational level of the workforce and, in the case of Internet access, there is a negative impact of the firms' size. However, in our sample a strong association emerges between the distributions of employees by firm function and level of education (see table 5); workers with primary education prevail only in production activities and those with university education only in marketing and advertising. In all the other functions — including IT services and R&D and design — the majority of workers have a secondary educational level, followed by those with university education. As a consequence, the positive correlation between the percentage of employees having access to connectivity facilities and the shares of workers with tertiary and secondary education could be simply a by-product of the functional distribution of employees.

Table 5: Employees by level of education and firm function (row percentages)

	University	Secondary	Primary	Total (absolute values)*
Purchases and Storage	8.4	73.2	18.4	1432
Production	1.7	36.1	62.2	29119
Administration	25.0	68.9	6.1	2345
R&D and Design	33.8	61.3	4.9	1685
IT services	25.6	72.6	1.8	588
Marketing and Advertising	56.4	42.9	0.7	606
Sales	28.3	65.5	6.2	1751
Other (logistics, quality control)	15.0	65.6	19.4	581
Total	7.4	43.1	49.4	38107

*Data are re-proportioned to the firms' population by weighting the answers of all the sampled firms

As a consequence, when considering the variables based on nonproduction workers the education effects disappear (see table 4, columns 3 and 4); this leads us to think that the indicators we propose incorporate properly the composition effects of the workforce.

In fact, once the functional distribution of the employees is taken into account, all effects but the industry dummies bear little explanatory power, as made evident by the $\bar{R}^2$ index. This point was investigated more rigorously by means of a Wald test (reported in the last two rows of table 4) whose null hypothesis is that all coefficients except the constant and the industry

centage of exporters who stopped exporting between 1997 and 2000 is just 2.6%.

dummies are zero. The null is rejected for the indicator based on total employees, but it is accepted when the nonproduction workers are used¹⁴.

In conclusion, the within-firm penetration of e-mail and the Internet, when adjusted for the functional structure of the labour force, is not linked to any structural characteristic of the firms, with the only exception of industry effects. As a consequence, the definition of these technologies as *general-use ICTs* appears to be both appropriate and robust.

4 The use of production-oriented ICTs: LANs, Intranet and EDI

Having defined e-mail and the Internet as general-use ICTs the next step is to investigate if the other types of information and communication technologies can be grouped or classified and, then, to control that for each group specific determinants of adoption emerge.

A preliminary inspection of the data (based on correlation and principal component analyses) indicates that the presence and the content of a firm's Web site can be treated separately not only from the use of e-mail and the Internet but also from the adoption of a group of technologies composed of Local Area Networks (LANs), Intranet and Electronic Data Interchange (EDI) either on the Internet or not¹⁵.

In fact, contrary to general-use ICTs and Web pages, the latter technologies are specifically devoted to improve the communication system, either internal to the firm or to an already established network of firms involved in productive or commercial relationships. Moreover, there are at least two reasons for distinguishing them from the other two groups of technologies.

First, from a technological point of view, LANs and EDI had been available long before the 'Internet boom' of the mid-Nineties; in our sample, for

¹⁴Some coefficients in columns 3 and 4 of table 4 are in fact significant when taken individually, especially the dummy for exporting firms. Although probably meaningful, these effects are marginal when considered in a bigger picture, and therefore can be considered negligible.

¹⁵It must be said at this point that a complete analysis could not overlook the fact that decisions on the level of technical infrastructure made by a firm are likely to be interdependent, and therefore should be modelled jointly. However, it is not clear which identification restrictions should have been imposed to estimate the structural form. Instead, we focused on what can be considered reduced-form equations, and used as explanatory variables only those structural factors that can be considered exogenous with respect to the decisions on ICT investment. An initial joint estimate of the reduced form, in which the two disturbances were allowed to be correlated, showed (perhaps surprisingly) no significant correlation; therefore, the two equations were estimated separately.

instance, almost 42% of the firms that possess a LAN and 27% with an EDI (not on the Internet) had already introduced them by the end of 1995. Secondly, the adoption of these ICTs implies an investment on hardware, software and personnel training far higher than that required for having an Internet access or implementing a Web site. In other words, administering a medium-sized LAN (let alone a WAN – Wide Area Network) or an EDI infrastructure is by no means a trivial task, and it is more than likely that, in the firms that have been using these technologies, some form of technical staff (nearly useless if just web services are needed) is present.

According to the above arguments, it is reasonable to assume that the diffusion of these ICTs should be affected by the size of firms as well as the extent of inter-firm productive relationships and the quality (in terms of technology and skills) of the activities directly and indirectly linked to production. Although the evidence on this will be provided later, for the sake of brevity we label this group of technologies production-oriented ICTs.

Table 6: Production-oriented ICT variables

Variable name	Description	% on total
LAN	1 if a LAN (Local Area Network) is present	78.0%
INTRA	1 if an Intranet is present	21.4%
EDI.I	1 if the firm makes use of Internet-based EDI facilities (ie a FTP server)	37.8%
EDI.NI	1 if the firm makes use of non Internet-based EDI facilities	34.3%

Table 6 reports the percentages of firms in our sample that, at the end of 2000, had adopted these ICTs, which are identified by four dichotomous variables. Even a cursory comparison between the data for e-mail and Internet access of the previous section and those presented in Table 6 reveals that, due to the cost and technological factors just mentioned, the adoption rates of production-oriented ICTs (with the partial exception of LAN) are much lower¹⁶.

According to their common purpose (i.e the improvement of intra- and inter-firms communication systems) and in order to summarise the information contained in the basic variables, we aggregated them into a composite indicator termed PICT (which stands for production-oriented ICT). The composite indicator was built via a principal component analysis on the cor-

¹⁶With respect to the adoption of these ICTs it is difficult to find comparable data for other countries or regions.

relation matrix of the four original variables (shown in Table 7). Our PICT indicator is therefore defined as a linear combination of the original variables, where the weights are reported in the last column of Table 7, and are defined as the eigenvector associated with the highest eigenvalue of the correlation matrix.

Table 7: Correlation matrix for the PICT variables and factor weights

	LAN	INTRA	EDLI	EDINI	Weights
LAN	1.000	0.218	0.101	0.222	0.538
INTRA	0.218	1.000	0.332	0.276	0.740
EDLI	0.101	0.332	1.000	0.222	0.643
EDINI	0.222	0.276	0.222	1.000	0.669

The composite indicator so defined accounts for the 42.4% of the total correlation between the original variables¹⁷. The main descriptive statistics for the PICT variable are reported in table 8.

Table 8: Descriptive statistics for the PICT composite indicator

N	168	Minimum	0
Maximum	2.590	Average	1.050
Std. Dev.	0.760	Variance	0.578
Skewness	0.519	Kurtosis	-0.706

To single out the main determinants of the PICT level of adoption, we carried out a regression analysis with the composite indicator as the dependent variable, and the structural variables already used in the previous section (see Table 3) as regressors.

The chosen econometric specification was a Tobit regression with a truncation point at 0; the motivation for this choice stems basically from the fact that a non-negligible number of firms exposed a zero value for the PICT variable. Truncation to the right was not considered because we believe that all the main available production-oriented ICTs were considered in the analysis, and therefore there is no scope for considering a possible propension higher than the one observed. Besides, limit observations to the right are fewer than the ones on the left.

The unrestricted model contains several non-significant coefficients, namely those associated with the variables GROUP and CONTROL (affiliation with business groups and the firms' controlling function in these groups) and

¹⁷The second principal component explained just 22.9% of the total correlation and was therefore not considered in the following analysis.

Table 9: Tobit estimation for the PICT composite indicator

Variable	Unrestricted		Restricted	
	Coeff.	z-stat	Coeff.	z-stat
Constant	-0.601	-2.343	-0.530	-2.175
LNEMP	0.214	3.356	0.204	3.476
PLANTS	0.244	1.455	0.204	1.266
SUBCON	0.383	2.522	0.343	2.311
GROUP	-0.169	-0.896		
CONTROL	0.149	0.628		
EDU_H	1.333	3.783	1.295	3.733
EDU_M	0.724	3.031	0.675	2.902
NCM	-0.317	-2.342	-0.277	-2.102
CADCAM	0.545	4.066	0.547	4.085
FMSROBOT	-0.033	-0.223	-0.044	-0.298
EXPORT	0.102	0.784		
ABROAD	-0.109	-0.628		
CLOTHING	-0.126	-0.550	-0.075	-0.339
PAPER	0.669	2.722	0.626	2.614
CHEMICAL	0.449	2.066	0.488	2.285
ADVMECH	0.334	1.690	0.322	1.664
METPROD	0.115	0.621	0.113	0.626
WOOD	0.056	0.247	0.068	0.298
BUSISERV	0.131	0.488	0.110	0.415
σ	0.670	16.603	0.674	16.604
Log-likelihood	-170.817		-171.633	

EXPORT and ABROAD (presence in foreign markets). We therefore considered a more restrictive specification, in which these variables were omitted. A likelihood-ratio test accepts the null hypothesis implicit in the reduction ($LR = 1.632$, $p = 0.803$). Another test that we performed (not reported in table 9) concerns the possibility of heteroskedastic disturbances. We considered a heteroskedastic version of the restricted model, in which the variance is an exponential function of LNOCC and the industry dummies. The log-likelihood for this model was -164.6369, leading to an LR test equal to 12.3602, which accepts the null hypothesis of homoskedasticity ($p = 0.136$).

Looking at the results of the restricted Tobit regressions, it emerges that the level of PICT raises with the firms' size, suggesting that the costs required to adopt these technologies are not negligible and, thus, must be spread over a large amount of output.

Strong productive linkages with other firms, identified by the SUBCON variable, positively affect the PICT penetration while the presence of more than one plant gets a positive but not significant coefficient.

The educational level of employees plays quite an important role in enhancing the use of PICT and it is interesting to note that both the shares of workers with university and secondary education are significant, and the coefficient of the former is higher. This result suggests that, among Italian SMEs, the technical skills needed to use effectively PICTs are found by employing not only engineers or IT graduates but also people with technical diplomas and it is consistent with the fact that, even within the more skill-demanding functions (such as IT services, R&D and design), the majority of workers has a secondary level of education (see Table 5 in the previous section).

Moving to the employment of the ITs applied to production processes, the use of CAD and/or CAD-CAM technologies is positively and significantly associated with a greater penetration of PICT; the sole employment of NCM exerts instead a negative impact while that of FMS and robots is not significant¹⁸. Thus, the presence of information technologies applied in production and characterised by a medium-high level of complexity and integration with other departments (especially that of design) appears to foster also the adoption of the ICTs aimed at increasing the efficiency of the communication system, both internal to the firms and to the networks of firms (especially those based on productive relationships, such as subcontracting and procurement of intermediate goods).

In conclusion, the above findings confirm that the diffusion of LAN, In-

¹⁸It must be stressed that only 19% of the firms included in our sample uses FMS and/or robots while the share of those with a CAD and/or a CAD-CAM system amounts to 59%.

tranet and EDI facilities is particularly associated with the size and the technology and skill content of all the activities that, directly and indirectly, are related to the production sphere. If the concept of production is used in its broadest sense — that is, including supporting activities (i.e. design and procurement) as well as productive linkages with other firms — it is possible to define the above technologies as production-oriented ICTs.

5 Market-oriented ICTs: Web sites' presence and content

From the surveys mentioned in section 3, it emerges that during the last 2 years (1999-2000) the proportion of firms with an Internet Web site is much lower than that of firms having access to e-mail and the Internet.

For instance, in 1999, the latter ICTs were used by more than 63% of Canadian manufacturing firms and more than 73% of Italian manufacturing enterprises located in the Ancona Province (see table 2 of Section 3) while, as Table 10 shows, the percentages concerned with Web sites decrease, respectively, to 32 and 37.5%. The same happens with the Australian survey and that carried out, in Italy, in the Emilia-Romagna Region. Thus, at the end of 1999 or 2000, there was still a large number of firms which had not enough competencies, resources or incentives to implement Web sites.

Table 10: Percentage of manufacturing firms with an Internet Web site
Total manufacturing

Canada (1999)	31.7
Australia (1999-2000)	23.0
Italy - Ancona Province (1999)	37.5
Italy - Ancona Province (2000)	53.6
<i>Manufacturing firms with more than 10 employees</i>	
Italy - Emilia-Romagna Region (1999)	48.2
Italy - Ancona Province (1999)	39.5

However, the adoption process it is still extremely dynamic and, for this reason, before making any comparison it is important to establish a common point in time. In effect, as the data for the Ancona Province show, in only one year the proportion of manufacturing firms with a Web site raised from 37.5 to 53.6 %.

The rate of Web sites' adoption is much higher in Italy than in Australia while the distance from Canadian firms is less pronounced. It must

be stressed once more that the better performances of Italian firms do not depend on the choice of a sample of SMEs particularly advanced in the field of ICT; in effect, the proportion of manufacturing firms with a Web sites in the Ancona Province is significantly lower than that of the Emilia-Romagna Region, and the same happens when the most developed regions of Northern Italy, such as Lombardia, are considered (cf. Bonanno, 2001)¹⁹.

The main problem in using the above mentioned figures is that being present on the Web with a site does not imply that a firm is particularly engaged in e-commerce (i.e. in buying, selling or exchanging goods, services and information via computer networks and the Internet) or e-business (a broader concept which, along with e-commerce, include also servicing customers and collaborating with business partners by means of digital transactions). In order to ascertain the real attitudes of the firms towards e-business practices, it is necessary to see what is contained in their Web pages.

For this purpose, as has been stressed in section 2, we controlled the answers of the firms by visiting their sites and evaluated them according to their content. For this evaluation we focussed primarily on quantitative aspects (how much information the site provides) rather than qualitative features (how the site was designed) or aesthetics²⁰. The list of variables that we used to rate the Web sites' quality is shown in Table 11, which also reports the percentage of sites having a given characteristic.

Then, we found that almost 17% of sites consisted of one page with the name or logo of the firm, e-mail address and (sometimes) a poor description of what the firm produced. In these cases, we decided that the site had no contents. Furthermore, 37% of them were not linked to the most common Internet engines. The percentages of sites containing connectivity facilities needed to carry out e-business and e-commerce are rather low: 27.3% of the sites has feedback forms for customers, 6.6% allows the possibility of on-line ordering and only 2.2% contains on-line job offers. Thus, although Web sites are not the only available tools to sell products or services over the Internet (see Bakker, 2000), it can be said that the potential of digital technologies is far from being exploited by Italian SMEs²¹. It appears that the main aim that firms pursue when setting up a Web site is that of exposing their supply

¹⁹Different results emerge for the less-developed region of Southern Italy. For instance, in 1999 50% of the business Web sites registered in Italy refers to firms located in North-western regions, 35% in North-eastern and Central and only 14% in Southern regions (see Logica Consulting, 2000).

²⁰For a comprehensive classification of Web sites, see Huizingh (2000).

²¹The surveys carried out in other areas of Central and Northern Italy (see Unioncamere Emilia-Romagna, 2001; Bonanno, 2001) show that the percentage of firms involved in e-commerce through their Web site is slightly above that arising from our sample.

Table 11: Web sites' content variables

Variable name	Description	% on total
HOMEONLY	1 if the only page on the site is a home page with little information	16.9%
ML	Multi-language site (1 if the pages on the site are available in several languages)	55.5%
FEED	1 if the site provides some "feedback" forms other than e-mail addresses	27.3%
CAT	1 if a catalogue of the firm's product is available	65.5%
DETA	1 if detailed products' descriptions (complete with technical specifications) are available	39.3%
OLORD	1 if an on-line ordering facility is available	6.6%
OLJOB	1 if the site provides on-line job offers	2.2%
LINK	1 if the site can be found by searching on common Internet engines (Google, AltaVista and the Italian engine Virgilio)	63.0%

(possibly in the most effective and detailed fashion) and improving their visibility, rather than actively encouraging their customers to buy directly via the Web site.

In the same way adopted in the previous section, we built a composite indicator of Web sites' contents via a principal components analysis: therefore, we aggregated the variables shown in table 11 (with the exception of HOMEONLY) into a composite indicator termed SITECON. The weights are reported in the rightmost column in table 12. The percentage of the total correlation between the original variables explained by the variable SITECON is 34.3%²².

Table 12: Correlation matrix for the Web site contents variables and weights

	ML	FEED	CAT	DETA	OLORD	OLJOB	LINK	Weight
ML	1	-0.027	0.495	0.188	-0.01	-0.012	0.343	0.508
FEED	-0.027	1	0.171	0.196	0.335	0.158	0.233	0.457
CAT	0.495	0.171	1	0.584	0.193	0.109	0.32	0.781
DETA	0.188	0.196	0.584	1	0.331	0.186	0.239	0.735
OLORD	-0.01	0.335	0.193	0.331	1	0.252	0.204	0.538
OLJOB	-0.012	0.158	0.109	0.186	0.252	1	0.115	0.352
LINK	0.343	0.233	0.32	0.239	0.204	0.115	1	0.610

As a consequence, the variable SITECON takes the value 0 for those firms who do not have a Web site, or have a Web site that amounts to a single page with little or no information on (52.4% of the whole sample). Descriptive statistics for the composite indicator are provided in table 13 (note that the reported statistics refer only to the firms having a working Web site).

Table 13: Descriptive statistics for the composite indicator SITECON

N	80	Minimum	.457
Maximum	3.629	Average	1.865
Std. Dev.	.926	Variance	.858
Skewness	.038	Kurtosis	-1.073

The variable SITECON so constructed was further analysed by means of a Tobit regression, in the same fashion as we did with the variable PICT in the previous section, with the same explanatory variables (see table 3).

In this case, however, a distinct problem arises: in principle, the factors explaining the decision by a firm to have a Web site or not may be different

²²The second principal component explained a much lesser percentage of the total correlation (19.5%) and was not considered in the following analysis. Besides, the associated eigenvector was rather difficult to interpret.

from those accounting for the richness of the Web site. This would lead to estimating separate models, as in Cragg (1971): a probit model for the existence of the Web site, and a complementary truncated regression for its quality. The standard Tobit model is a special case in which the coefficients of the two models are proportional to each other²³. However, this turned out to be unnecessary in our case: the LR test reported in table 14 does not reject the null hypothesis, which compounds adequacy of the Tobit model and several zero-restrictions²⁴.

Table 14: Tobit estimation for the SITECON indicator

Variable	Unr. Probit		Unr. Truncated		Restr. Tobit	
	Coeff.	z-stat	Coeff.	z-stat	Coeff.	z-stat
Constant	-0.659	-1.327	0.535	0.927	-1.291	-2.251
LNEMP	0.002	0.016	0.197	1.544	0.114	0.747
PLANTS	0.653	1.848	-0.120	-0.390		
SUBCON	-0.407	-1.327	-0.164	-0.451		
GROUP	-1.044	-2.601	0.281	0.634	-1.397	-3.216
CONTROL	0.098	0.200	-0.683	-1.239		
EDU_H	1.504	2.042	1.482	2.125	1.998	2.210
EDU_M	0.244	0.517	0.252	0.465		
NCM	0.144	0.544	0.328	1.245		
CADCAM	0.248	0.939	-0.195	-0.658		
FMSROBOT	-0.162	-0.549	0.368	1.321		
EXPORT	0.398	1.578	0.320	1.121	1.302	3.602
ABROAD	0.748	1.961	0.393	1.340	1.563	3.463
CLOTHING	0.329	0.734	0.038	0.082	-0.118	-0.184
PAPER	1.155	2.203	-0.066	-0.149	0.796	1.267
CHEMICAL	0.184	0.439	-0.567	-1.202	-0.282	-0.472
ADVMECH	0.119	0.304	-0.574	-1.344	-0.215	-0.396
METPROD	0.269	0.756	0.184	0.523	0.450	0.919
WOOD	0.282	0.621	0.217	0.517	0.765	1.282
BUSISERV	-0.008	-0.015	-0.105	-0.195	0.392	0.532
σ			0.827	10.637	1.680	11.257
Log-likelihood	-97.26015		-90.7928		-207.13	

LR reduction test: 38.1541 (df=27, p = 0.075)

Another factor that might lead to inconsistency of the Tobit estimators is

²³Details of this procedure can be found in Greene (1993).

²⁴In principle, other model reduction strategies could have been followed; the one adopted here has the virtue of conciseness.

the presence of heteroskedasticity in the data. An appropriate test accepted the null hypothesis of homoskedasticity²⁵.

From the unrestricted model, it emerges that both the probability of having a Web site and the ‘quality’ of the site are not significantly correlated with many explanatory variables, and especially those capturing the characteristics of production processes; this is the case of the SUBCON and PLANTS variables as well as those measuring the use of IT in production (NCM, CADCAM, FMSROBOT). The share of workers with secondary education (EDU_M) and the controlling function of the firm within business groups (CONTROL) do not play any significant role either.

Furthermore, looking at the restricted Tobit regression, it emerges that SITECON does not even depend on the firms’ size; thus, contrary to the results concerned with production-oriented ICTs, small firms, as opposed to their larger counterparts, do not show any significant disadvantage in the adoption of market-oriented ICTs²⁶.

The only variables that turn out to have a positive and significant impact on the effective use of Web pages are the share of employees with a university degree, the export status of the firm and the presence of commercial branches abroad. The affiliation with a business group has instead a negative influence, suggesting that, *ceteris paribus*, firms that do not operate under the umbrella of a group have a greater incentive to increase their visibility on the market through a Web site.

The finding concerned with the share of highly educated employees is consistent both with the features of Web sites and the firms’ occupational structure: as has been pointed out before, Web sites are mainly implemented for marketing and advertising purposes and, as we had shown in section 3 (cf. Table 4), more than 56% of the workers employed in marketing and advertising activities have a university degree.

The prevailing features and purposes of Web sites explain also the positive (and strong) correlation with the firms’ attitude towards foreign markets²⁷;

²⁵As done in the analysis of the variable PICT, we thought it appropriate to estimate a model in which the conditional variance σ^2 was a function of basic structural indicators such as size and industry. For such a model, a value of 202.9858 for the log-likelihood was obtained; therefore, it was possible to accept the null hypothesis of homoskedasticity by using a likelihood-ratio test ($LR = 8.288$, which for 8 degrees of freedom yields a significance level of 40.6%).

²⁶This confirms that the cost for implementing the latter ICT is far lower than that required for the former.

²⁷At first sight, this result could be considered an obvious consequence of the inclusion, among the original variables used for constructing SITECON, of the dummy for a multilingual site (ML). In fact, we have also built an alternative indicator omitting ML altogether; running the same procedure as in the text, the results were only marginally

here, it is interesting to note that being an exporter and having commercial affiliates abroad are both highly significant factors and therefore, in explaining the penetration of market-oriented ICTs, exert separate effects.

6 Concluding remarks

This paper has emphasised that the adoption and effective use of ICTs among SMEs depend, firstly, on the types of ICT — which, in fact, require different amounts of financial resources as well as technical skills internal to the firms — and, secondly, on different structural characteristics.

In terms of cost and technological requirements, these technologies range (in increasing order) from general-use (e-mail and Internet access) to market-oriented (presence and quality of Web sites) and, finally, production-oriented ICTs (LANs, Intranet and EDI).

The penetration of general-use ICTs does not appear to be linked to any specific feature of SMEs, apart from industry effects. Market-oriented ICTs are instead associated with the share of highly educated employees and, above all, with the firm's presence in foreign markets (either via exports or commercial branches). The adoption of production-oriented ICTs depends instead on the firms' size, the extent of productive linkages with other firms, the use of ITs in the production process and the educational level of the labour force.

In terms of policy implications, the above findings suggest that European actions aimed at increasing the use of ICTs among SMEs should be based on a well-aimed policy mix. If the objective is to help firms increase their productivity, then the development of production-oriented ICTs should be given priority; if, on the contrary, the policy is aimed to enhance market opportunities, then the focus should be on market-oriented ICTs.

In either case, a key factor is the improvement of the firms' level of human capital, which can be achieved by lowering, through different types of incentives, the hiring and training costs of educated workers, and especially university graduates.

Secondly, at a national and regional level, fiscal incentives should be provided to SMEs that invest in the most expensive ICTs (i.e. the production-oriented ones) with the aim of interfacing the internal communication system with the external one (particularly in presence of inter-firm productive relationships).

different from those reported in table 14. None of the conclusions was affected. This is hardly surprising, considering that the correlation coefficient between SITECON and the alternative indicator was 97%.

Finally, the main ‘institutional’ obstacles to the adoption of e-commerce practices (different standards and regulations, security of transactions and consumer protection), which are particularly harming for cross-borders’ transactions (and, therefore, for the exporting firms), should be removed, and this task pertains necessarily to the European Commission.

It must be stressed that the above findings and policy considerations mainly refer to the European SMEs located in well-developed areas; for the backward regions of the European Union, in which even general-use ICTs are not so generally diffused, a different (and probably wider) mix of policies is needed.

Being based on static, cross-sectional analyses, the nature of the present study is mainly descriptive or taxonomic. Further work is necessary to investigate, in particular, to what extent the investment on different types of ICT affects the skill composition of workers and improve, for instance, the export performances of SMEs. For this purposes, a dynamic (panel) analysis is needed and we plan to do so by replicating the survey used for this paper in the next years, possibly with the same sample of SMEs.

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