The adoption of ICT among SMEs: evidence from an Italian survey

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Abstract

In this paper, we carry out an econometric analysis on the adoption and effective use of Information and Communication Technologies (ICTs) among a sample of Italian SMEs. An important result is that, in order to understand the main factors that drive SMEs to the adoption of ICTs, it is useful to divide the available technologies according to a taxonomy based on their typical function. Along with general-use ICTs (e-mail and Internet access), we identify two groups of technologies (labelled production-integrating and market-oriented ICTs) the use of which is associated with different firm characteristics. In both cases, however, the availability of highly educated workers turns out to be a key factor. Policy implications are also discussed.

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. On the contrary, 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.

One of the main arguments for explaining these different patterns has been an earlier, faster and more widespread adoption of Information and Communication Technologies (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 information technologies 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

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costs but also to enlarge the size of their potential markets and find new opportunities for growing. In short, efficiency gains 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, 2001a) with particular emphasis on the adoption of e-business practices and digital technologies among SMEs ((Commission of the European Communities, 2001b)). As the Commissions of the European Communities (2001a, p. 5) well summarises, there are different reasons for focussing on SMEs:

> 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. One of the objectives of this programme is to develop a comprehensive 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 sites);

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 econometric 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 built a taxonomy which enables one to classify technologies on the basis of their typical function.

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 2; 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[1] account for 95% of the sample while small firms for 80%.

Although not fully representative in a statistically rigorous sense, we believe that our study provides a good representation of the manufacturing and business services 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 access[2]; 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 — the influences of size and education vanish and only industry effects are relevant.

Production-integrating ICTs: include LAN, EDI and Intranet; these ICTs are linked to production processes either carried out within the firm or based on inter-firm relationships; they are more expensive than general-use ICTs and require relevant technological skills (often internal to the firms). A composite indicator of production-integrating 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 sites 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 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.

[1] According to the EU definition, firms with less than 50 employees are considered "small" while "medium-sized" firms span the range 50-249 employees.

[2] In this paper, we 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.

Although some of the above stressed relationships could be peculiar to our sample, 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 examines some of the firms' features that, in the rest of the paper, will be used as explanatory variables of ICT adoption. Section 4 is devoted to analysing the factors behind the use of e-mail and the Internet. In Section 5 a composite indicator of production-integrating ICTs is built and its determinants are examined by means of Tobit regressions. The same analysis is carried out in Section 6, 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 firms[3], the reference population amount to 514 firms: 456 in manufacturing and 58 in business services. The latter industry is composed by firms providing software, computing 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.

In spite of this, we believe that the qualitative findings of the survey are very likely to hold in a much broader setting since our sample has all the characteristics that make it an ideal candidate to represent Central and Northern Italy. First of all, as we shall see below, there are no size and industry peculiarities that would make it difficult to generalise our results. Moreover, the Ancona province shows a degree of economic development that is halfway between the most advanced and backward areas of Central and Northern Italy[4]. Firms belonging to high-tech industries are relatively rare (although not absent). This characteristic, in our opinion, makes our study particularly interesting when it comes to investigating ICT penetration and usage in the majority of Italian (and, to some extent, of EU) regions, and not only in the most advanced.

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

[3]The excluded enterprises either provide leisure, cleaning and transport services or produce artisan products, 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'.

[4]See, for instance, the 1999 data on per-capita value added by province provided in (Istituto Tagliacarne, 2001)

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.

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 mechanical[a]	3	12	4	4	23	13.7
Mechanical & Electrical equipment	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	

[a]Electronics and TLC, Electrical and mechanical machinery, Domestic appliances and Motor vehicles

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 by the EU, 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 (Mechanical & Electrical Equipment and Metal products). At the same time, consumer goods industries such as Food & Beverages, Wood & Furniture and Clothing & Footwear are well represented.

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 used. Thanks to the collaboration of the Employers Confederation' 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 allowed 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 firms[5].

The questionnaire submitted to the firms (available from the authors upon request) was very detailed and comprehensive. It was composed of three sections. The first was

[5]Obviously, every statistic employed for inferential purposes was computed by using the true number of observations, appropriately weighted.

devoted to the firm's characteristics, i.e. affiliation with a group, sales due to subcontracting, number of plants, export status and presence in foreign markets. The second, after some questions on the adoption of information technologies in production (such as CAD-CAM), 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 ICT 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 the Web sites' presence and features (including the possibility of on-line ordering), the answers of the firms were checked ex-post by visiting their sites 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 procurement and production to IT services, marketing and sales).

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.

3 Characteristics of the firms

In this section, we will provide a descriptive analysis of a number of variables which shed light on the main characteristics of the firms included in our sample. Our aim is twofold: first, we will make it apparent that our sample covers a wide variety of SMEs not only as regards size and industry (see the previous section), but also with respect to their exporting behaviour, production technology, occupational structure and so forth. Second, these characteristics will be used as explanatory variables in the subsequent analyses on ICT adoption in which we shall follow a rank (or probit) model of technology diffusion (see (Karshenas and Stoneman, 1995); (Geroski, 2000)). Contrary to epidemic models, in rank models it is assumed that potential adopters differ from each other in many characteristics (such as size, skills, competitive environment, and so on), so that expected benefits from (and, thus, the probability of) adopting a new technology may significantly differ among firms.

In the rest of the paper, therefore, we will refer to these variables as the "control" variables. The complete list of the control variables, together with their description and basic statistics, is provided in table 2. All variables refer to the year 2000.

The size of firms is identified by the natural log of total employees, while nine dummy variables denote the industries; in the regressions reported in the next sections, 'Mechanical & Electrical equipment' will be treated as the reference industry. Apart from the remarks of the previous section (see table 1), these variables require no further comment.

The control variables that should capture the intensity of inter-firm (or inter-plant) relationships are: 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 controlling of other firms within the group (CONTROL)[6]. SUBCON, in particular, can

[6] As argued by (Baptista, 2000), the corporate status of the firm may influence adoption, although the sign

Table 2: Control variables

Variable name	Description	Mean	Std. dev.
LNEMP	Natural log of total employees	3.081	1.193
PLANTS	1 if the firm has more than 1 plant	0.160	0.367
SUBCON	1 if the firm's sales due to subcontracting exceeds 50%	0.168	0.375
GROUP	1 if the firm is part of a group	0.227	0.420
CONTROL	1 if the firm controls others among its group	0.125	0.332
EDU	percentage of employees with a university degree	0.124	0.222
EDS	percentage of employees with secondary education	0.518	0.258
NCM	1 if the firm uses Numerically Controlled Machines	0.363	0.482
CADCAM	1 if the firm uses CAD and/or CAD/CAM systems	0.428	0.496
FMSROBOT	1 if the firm uses FMS and/or robots	0.189	0.392
EXPORT	1 if a firm is an exporter	0.481	0.501
ABROAD	1 if a firm has commercial branches abroad	0.171	0.378
FOOD	Industry dummy: Food & beverages	0.067	0.250
WOOD	Industry dummy: Wood & furniture	0.083	0.276
PAPER	Industry dummy: Paper, printing & graphics	0.075	0.264
CHEMICAL	Industry dummy: Chemicals & plastic products	0.102	0.304
ADVMECH	Industry dummy: Advanced mechanical products	0.138	0.346
EQUIP	Industry dummy: Mechanical & electrical equipment	0.175	0.381
METPROD	Industry dummy: Metal products	0.170	0.377
CLOTHING	Industry dummy: Clothing & footwear	0.081	0.273
BUSISERV	Industry dummy: Business services	0.110	0.314

be viewed as a proxy for the extent of productive linkages with other firms.

The average shares of workers with university (EDU) and secondary education (EDS) are 12.4% and 52.0% respectively[7]. These variables can be viewed as rough measures of the amount of human capital. Comparing these figures with those for the year 1997 (not reported in the table), the structure of labour force by educational level appears to be extremely stable[8].

It could be argued that these variables, however interesting, cannot be used as explanatory variables of ICT adoption: for a firm, investment in human capital could be akin to other forms of investment in technology, and therefore should be considered endogenous; to be more specific, ICT and human capital are widely regarded as complementary. In our sample, however, the labour force distribution by educational levels is mainly determined by its own inertia, so that there seems to be little influence by ICT investment; the use of these variables in the regressions carried out in the rest of the paper can thus be justified, because it allows us to evaluate the impact of the other explanatory variables on ICT adoption for a given level of human capital. Moreover, a factor distinct from ICT investment that accounts for the educational distribution of the workforce is its functional composition: in our sample, a strong association emerges between the distributions of employees by firm function and level of education (see table 3); workers with primary education prevail only in production activities and those with university education only in marketing and advertising. In all the other functions

of the relationship is ambiguous; in fact, on the one hand, independent firms decide more quickly whether to adopt a new technology or not, but, on the other, firms affliliated with a group experience less financial constraints and thus tend to be less risk-averse in the adoption decision.

[7]Note that these figures (contrary to those reported below in table 3) are not weighted by the size of firms.

[8]The correlation coefficient between EDU in 1997 and 2000 is equal to 0.96; for EDS one gets 0.93.

— including IT services and R&D and design — the majority of workers have a secondary educational level, followed by those with university education.

Table 3: Employees by level of education and firm function (row percentages)

	University	Secondary	Primary	Total (absolute values)[a]
Procurement and Storage	8.4	73.2	18.4	1432
Production	1.7	36.1	62.2	29119
Admistration	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

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

The next set of control variables refers to the adoption of different types of information technologies (ITs) that the firms can use in their production processes, ranked according to an increasing degree of complexity and connectivity capabilities: that is, from numerically controlled machines (NCM), to CAD and/or CAD-CAM systems (CADCAM) and, then, to flexible manufacturing systems and robots (FMSROBOT). It is worth noting that the first two technologies appear to be in far more widespread use than FMS and robots, which are employed by only 19% of the sampled firms. As (Santarelli and Sterlacchini, 1994) have shown, even for Italian SMEs producing traditional consumer goods and located in the same area of our sample, most of the above 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 ICTs.

Finally, we also considered as controls two dummy variables: one if the firm is an exporter (EXPORT) and another if it owns commercial branches abroad (ABROAD). The aim is to ascertain whether the attitude of the firms towards foreign markets influences the penetration of ICTs. Since nearly half of the sampled firms are exporters, the inclusion of these control variables seems particularly important.

With respect to the possible endogeneity of the EXPORT variable, considerations similar to those made for the educational variables apply: in our sample, there is a very little mobility between exporting and non-exporting firms over the period 1997-2000[9]; moreover, and most importantly, the use of up-to-date technologies should affect primarily a firm's 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.

4 E-mail and Internet as general-use ICTs

At the turn of the millennium, it is hard to find business units, located in one of 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

[9]Only 7.1% of firms that were not exporters in 1997 were exporters in 2000; the percentage of exporters who stopped exporting between 1997 and 2000 is just 2.6%.

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 4 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.

Table 4: Use of e-mail and the Internet: international and national comparisons

	% 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
Total manufacturing				
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
Italy - Ancona Province (2000)	94.8	92.2	30.7	20.4
Manufacturing firms with more than 9 employees				
Italy - Emilia Romagna Region (1999)	73.1	74.6		
Italy - Ancona Province (1999)	78.7	75.8		

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

It must be pointed out that the better performances of Italian manufacturing firms 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. It should also be stressed that 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 92% for the Internet[10].

These 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. Nevertheless, 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

[10]Lower 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 Québéc and (Scally et al., 2001) for Lanarkshire in Scotland.

Table 5: Use of the Internet: survey results

	% of firms	% of employees	% of nonproduction employees
Food & Beverages	87.6	25.1	43.6
Wood & Furniture	100.0	29.2	79.3
Paper & Printing	100.0	20.2	67.5
Chemicals and Plastic products	100.0	8.4	15.2
Advanced mechanical	100.0	25.1	121.1
Mechanical & Electrical equipment	90.0	15.0	46.3
Metal products	83.0	17.3	67.3
Clothing & Footwear	86.3	5.3	31.2
Business services	89.6	80.3	84.8
ANOVA F test	*1.325*	*2.684*	*6.772*
p-value	*0.235*	*0.009*	*0.000*
Micro firms (1-9 employees)	83.1	49.4	65.1
Small firms (10-49 empl.)	93.1	23.0	52.3
Medium-sized firms (50-249 empl.)	100.0	23.1	78.7
Large firms (more than 249 empl.)	94.8	19.1	82.8
ANOVA F test	*2.126*	*1.164*	*1.512*
p-value	*0.099*	*0.325*	*0.213*
Total	92.2	21.1	71.0

(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 4 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 survey[11]. 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 are characterised by a lower degree of penetration.

Table 5 reports the Internet usage in our sample broken down by industry and size (e-mail usage gives practically the same results). When the share of Internet-using firms is considered, there are small differences by size and industry; by applying an F test, these differences turn out to be not statistically significant. On the contrary, there appear to be significant differences between industries in terms of within-firm penetration rates; employment-based indicators of ICT use are higher for micro firms than for their larger counterparts, although not significantly so.

However, in our opinion, these 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 consid-

[11] From 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 4.

erations 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 contend that the number of employees with e-mail and Internet access should be normalised by the number of nonproduction workers only[12]; for manufacturing firms they can be computed as the workers employed in nonproduction functions plus the graduates employed in production[13], while for business services firms they should amount to total employees (see above).

Adoption rates measured on nonproduction workers are shown in the rightmost column of table 5[14]. As can be seen, the apparent tendency towards lower usage of the Internet by larger firms is no longer supported by the data.

In order to carry out a more thorough investigation on the effective use of the Internet (both in terms of total and nonproduction employees), we ran some OLS regressions using the control variables described in section 3.

As the first column of table 6 show, the indicator based on total employees is positively related to the educational level of the workforce and, in the case of Internet access, there is a negative impact of size. However, the positive correlation between the percentage of employees having Internet access and the shares of workers with university and secondary education could be simply a by-product of the functional distribution of employees (see table 3 in the previous section).

Actually, once the functional distribution of the employees is taken into account by considering the variables based on nonproduction workers, 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 6) whose null hypothesis is that all coefficients except the constant and the industry dummies are zero. The null is rejected for the indicator based on total employees, but it is accepted when the nonproduction workers are used[15].

In conclusion, the within-firm penetration of e-mail and the Internet, when adjusted for the functional distribution of the labour force, is only affected by industry dummies while it does not appear significantly associated with any other firm characteristic. As a consequence, the definition of these technologies as general-use ICTs appears to be both appropriate and robust.

[12] As 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".

[13] They 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 ITs applied to production (such as CAD-CAM) but this does not imply that they should have access to e-mail and the Internet.

[14] In computing these values, one obvious outlier was excluded from the sample.

[15] Some coefficients in column 2 of table 6 are in fact significant when taken individually, especially the dummy variable for exporting firms. Although probably meaningful, these effects are marginal when considered in a bigger picture, and therefore can be considered negligible.

Table 6: Employment-based indicators of Internet use: OLS regressions

	Total employees	Nonproduction workers
Constant	0.208**	0.577*
LNEMP	-0.061**	...
PLANTS	...	...
SUBCON	...	...
GROUP	...	...
CONTROL	...	...
EDU	0.308*	-0.744*
EDS	0.208**	...
NCM	...	...
CADCAM	...	...
FMSROBOT	...	...
EXPORT	...	-0.457**
ABROAD	...	...
FOOD	...	...
WOOD	0.221**	1.280*
PAPER	0.175*	1.699**
CHEMICAL	...	0.686*
ADVMECH	0.223**	0.680**
METPROD	...	...
CLOTHING	...	...
BUSISERV	0.417**	0.748**
$\bar{R}^2$	0.316	0.090
Wald test$^\circ$	37.199**	10.487
(P value)	(0.000)	(0.487)

... : not significant
* : significant at 10%
** : significant at 5%
$^\circ$: 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.

5 The use of production-integrating 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 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 not[16].

In fact, contrary to general-use ICTs and Web sites, 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 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- and intra-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-integrating ICTs.

Table 7: Production-integrating 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%

[16] It could be argued that decisions on the level of ICT infrastructure 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 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 of this and the next section were estimated separately.

Table 7 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 7 reveals that, due to the cost and technological factors just mentioned, the adoption rates of production-integrating ICTs (with the partial exception of LAN) are much lower[17].

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-integrating ICT). The composite indicator was built via a principal component analysis on the correlation matrix of the four original variables (shown in table 8). 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 8, and are defined as the eigenvector associated with the highest eigenvalue of the correlation matrix.

Table 8: Correlation matrix for the PICT variables and factor weights

	LAN	INTRA	EDI_I	EDI_NI	Weights
LAN	1.000	0.218	0.101	0.222	0.538
INTRA	0.218	1.000	0.332	0.276	0.740
EDI_I	0.101	0.332	1.000	0.222	0.643
EDI_NI	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 variables[18]. The main descriptive statistics for the PICT variable are reported in table 9.

Table 9: 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 control variables (see section 3) as regressors.

The chosen econometric specification was a Tobit regression with a truncation point at zero; 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.

As can be seen in table 10, the unrestricted model contains several non-significant coefficients, namely those associated with the the variables GROUP and CONTROL (affiliation with business groups and the firms' controlling function in these groups) and EXPORT and ABROAD (presence in foreign markets). We therefore considered a more restrictive specification, in which these variables were omitted; a likelihood-ratio

[17] Our results are consistent with those obtained by (Chiarvesio and Micelli, 2001) in a study on North-East Italian industrial districts, where only 13% of firms used EDI, while e-mail was used in 83% of cases.

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

Table 10: Tobit regressions for the PICT composite indicator

	Unrestricted		Restricted	
Variable	Coeff.	z-stat	Coeff.	z-stat
Constant	-0.597	-2.190	-0.532	-2.067
LNEMP	0.203	3.245	0.200	3.394
PLANTS	0.248	1.477	0.213	1.316
SUBCON	0.391	2.464	0.357	2.282
GROUP	-0.160	-0.843		
CONTROL	0.132	0.557		
EDU	1.328	3.770	1.296	3.735
EDS	0.709	2.968	0.667	2.865
NCM	-0.312	-2.302	-0.274	-2.077
CADCAM	0.561	3.950	0.557	3.920
FMSROBOT	-0.028	-0.189	-0.038	-0.255
EXPORT	0.102	0.775		
ABROAD	-0.086	-0.498		
FOOD	0.620	0.225	0.047	0.174
WOOD	0.600	0.248	0.072	0.302
PAPER	0.683	2.522	0.644	2.446
CHEMICAL	0.470	1.915	0.503	2.102
ADVMECH	0.339	1.594	0.329	1.591
METPROD	0.118	0.583	0.118	0.607
CLOTHING	-0.091	-0.370	-0.046	-0.193
BUSISERV	0.145	0.507	0.119	0.418
σ	0.670	16.601	0.674	16.602
Log-likelihood	-170.8806		-171.5988	
LR reduction test: 1.436, (df=4, p=0.838)				

test accepts the null hypothesis implicit in the reduction[19].

Looking at the results of the restricted Tobit regressions, it emerges that the level of PICT raises with firm 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 PICTs effectively are found by employing not only engineers or IT graduates but also people with technical diplomas; this 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 3 in section 3).

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 significant. The former result might be due to the fact that most NCMs in Central Italy SMEs are isolated devices, which do not need to be connected to a network. If these act as substitutes for more advanced technologies, the negative effect follows.

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 communication systems.

In conclusion, the above findings confirm that the diffusion of LAN, Intranet and EDI facilities is particularly associated with firm 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-integrating ICTs.

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

From the surveys already mentioned in section 4, it emerges that, during the 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, table 11 shows that the percentages of Canadian and Italian manufacturing firms with a Web site are 32 and 37.5%, respectively. Thus, at the end of 1999 or 2000, there was still a large number of firms which had not enough skills, resources or incentives to implement Web sites. However, the diffusion process is still extremely dynamic; as the data for our sample

[19] Another test that we performed (not reported in table 10) concerns the possibility of heteroskedastic disturbances. We considered a heteroskedastic version of the restricted model, in which the variance is an exponential function of LNEMP and the industry dummies. The log-likelihood for this model was -164.1304, leading to an LR test equal to 14.937, which accepts the null hypothesis of homoskedasticity ($p = 0.093$).

show, in only one year the proportion of manufacturing firms with a Web site increased up to 53.6 %.

Table 11: Percentage of manufacturing firms with an Internet Web site

Total manufacturing	
Canada (1999)	31.7
Italy - Ancona Province (1999)	37.5
Italy - Ancona Province (2000)	53.6
Manufacturing firms with more than 9 employees	
Italy - Emilia-Romagna Region (1999)	48.2
Italy - Ancona Province (1999)	39.5

It must be stressed once more that these results do not depend on the choice of a sample of SMEs particularly advanced in the field of ICT; in fact, in 1999 the proportion of manufacturing firms with a Web site in the Emilia-Romagna Region was higher than that of the Ancona Province; the same happens when the most developed regions of Northern Italy, such as Lombardia (cf. (Bonanno, 2001)) and Veneto and Friuli (cf. (Chiarvesio and Micelli, 2001)), are considered.

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 sites.

For this purpose, 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 provided) rather than qualitative features (how the site was designed) or aesthetics[20]. The list of variables that we used to rate the Web sites' quality is shown in table 12, which also reports the percentage of sites having a given characteristic.

Then, we found that almost 17% of sites consisted of one page with a summary description of the firm only. 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 SMEs[21]. It appears that the main aim that firms pursue when setting up a Web site is that of exposing their supply (possibly in the most effective and detailed fashion) and improving their visibility, rather than actively encouraging their customers to buy directly via the site.

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

[21] Surveys carried out in other areas of Central and Northern Italy ((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. On the other hand, the figure reported in (Chiarvesio and Micelli, 2001) for North-East Italy is lower. For an analysis of the diffusion of e-commerce among Italian firms, see also (Santarelli and D'Altri, 2002).

Table 12: 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	Multilingual 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%
DESCR	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%

In the same way adopted in the previous section, we built a composite indicator of Web sites' contents by means of a principal components analysis: therefore, we aggregated the variables shown in table 12 (with the exception of HOMEONLY) into a composite indicator termed SITECON. The weights are reported in the rightmost column of table 13. The percentage of the total correlation between the original variables explained by the variable SITECON is 34.3%[22].

Table 13: Correlation matrix for the Web sites' content variables and weights

	ML	FEED	CAT	DESCR	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
DESCR	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 zero for those firms that do not have a Web site, or have a 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 14 (note that the reported statistics refer only to the firms having a working Web site).

Table 14: 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

[22]The 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.

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. 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 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 other[23]. However, this turned out to be unnecessary in our case: the LR test reported in table 15 does not reject the null hypothesis, which compounds adequacy of the Tobit model and several zero-restrictions[24].

Table 15: Tobit estimation for the SITECON indicator

	Unr. Probit		Unr. Truncated		Restr. Tobit	
Variable	Coeff.	z-stat	Coeff.	z-stat	Coeff.	z-stat
Constant	-0.796	-1.500	0.577	0.924	-1.420	-2.220
LNEMP	0.005	0.036	0.202	1.583	0.126	0.812
PLANTS	0.643	1.826	-0.134	-0.436		
SUBCON	-0.339	-1.071	-0.293	-0.795		
GROUP	-1.098	-2.693	0.318	0.710	-1.426	-3.242
CONTROL	0.154	0.314	-0.716	-1.304		
EDU	1.507	2.048	1.493	2.150	1.996	2.207
EDS	0.249	0.529	0.290	0.537		
NCM	0.136	0.514	0.313	1.179		
CADCAM	0.303	1.067	-0.191	-0.636		
FMSROBOT	-0.160	-0.546	0.364	1.302		
EXPORT	0.380	1.495	0.336	1.168	1.273	3.480
ABROAD	0.710	1.870	0.389	1.343	1.543	3.407
FOOD	0.298	0.562	-0.146	-0.248	0.341	0.475
WOOD	0.394	0.817	0.135	0.285	0.887	1.362
PAPER	1.306	2.258	-0.148	-0.282	0.922	1.348
CHEMICAL	0.323	0.678	-0.646	-1.179	-0.160	-0.245
ADVMECH	0.226	0.534	-0.640	-1.346	-0.091	-0.151
METPROD	0.378	0.956	0.133	0.324	0.572	1.031
CLOTHING	0.427	0.879	-0.039	-0.076	0.003	0.004
BUSISERV	0.118	0.206	-0.163	-0.272	0.508	0.653
σ			0.825	10.650	1.680	11.258
Log-likelihood	-97.25646		-90.56321		-207.0182	
LR reduction test: 38.1541 (df=29, p = 0.091)						

Another factor that might lead to inconsistency of the Tobit estimators is the presence of heteroskedasticity in the data. An appropriate test accepted the null hypothesis of homoskedasticity[25].

From the unrestricted model, it emerges that both the probability of having a Web

[23]Details of this procedure can be found in (Greene, 1997).

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

[25]As 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 -202.3158 for the log-likelihood was obtained; therefore, it was possible to accept the null hypothesis of homoskedasticity by using a likelihood-ratio test ($LR = 9.405$, which for 9 degrees of freedom yields a significance level of 40.1%).

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 (EDS) 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 firm size; thus, contrary to the results concerned with production-integrating ICTs, small firms, as opposed to their larger counterparts, do not show any significant disadvantage in the adoption of market-oriented ICTs.

The only variables that turn out to have a positive and significant impact on the effective use of Web sites 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*, independent firms have a greater incentive to increase their visibility through a Web site and/or are more flexible in deciding to use such an instrument (see note 3).

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 3), 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 markets[26]; 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.

7 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 firm 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-integrating ICTs (LANs, Intraned and EDI).

Apart from industry effects, the penetration of general-use ICTs is not linked to any specific feature of SMEs. On the other hand, market-oriented ICTs are 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-integrating ICTs depends instead on the firms' size, the extent of productive linkages with other firms, the use of advanced information technologies in production and the educational level of the labour force.

[26] At 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 different from those reported in table 15. None of the conclusions was affected.

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-integrating ICTs should be given priority; if, on the contrary, the policy is aimed at enhancing market opportunities, then the focus should be on market-oriented ICTs. In either case, a key factor is the improvement of the human capital within SMEs, which can be achieved by lowering, through different types of policy instruments, the hiring and training costs of educated workers, and especially university graduates.

Moreover, 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 performance 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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