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EXPLAINING THE TERRITORIAL ADOPTION OF NEW TECHNOLOGIES - A SPATIAL ECONOMETRIC APPROACH

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Abstract

Several empirical studies highlight severe disparities among geographical areas in the adoption of ICT that affect not only developed vs. developing countries (*Global Digital Divide)* but also regions within the same country (*Local Digital Divide*). Economic scholars have investigated the determinants of these disparities but comprehensive conclusions are far to be reached. This paper contributes to the literature by modelling the level of ICT adoption at the Italian regional level (NUT3) using spatial econometric techniques. Namely, two main research questions are addressed: (i) do Italian regions exhibit significant differences in their patterns of ICT adoption? (ii) if so, how local structural specificities interact with spatial effects in explaining these disparities? According to recent approaches in the metrics of ICT, the empirical analysis uses domain name registrations by firms in 2001 as a proxy of ICT adoption at the local level. The results show that sectoral composition, technological endowment and absorptive capacity at the regional level, as well as firms' characteristics, do play a crucial role. In addition, pure spatial effects contribute to regional disparities.

JEL codes: O18, O33, C21

Keywords: Digital Divide, ICT adoption, spatial econometrics

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Understanding the interplay between innovation, technology and productivity growth is the foundation for projecting the future economic growth rate of a country, a region, or the world (Gordon, 2004).

1. Introduction

The notion that Information and Communication Technology (ICT) would have reduced the economic importance of geographic distance has been proposed with energy in the post-Internet literature (Cairncross, 2001). According to this view, the New Economy would work in a space rather than a place, cost of transport would be drastically reduced, distance would be less important, and peripheral regions would benefit from opportunities that were not available in the economy based on manufacturing industry (Negroponte, 1995; Kelly, 1998; Compaine, 2001). Since ICT are mostly based on immaterial and human capital investment, regions or areas that have historically suffered from isolation, large cost of transportation, or lack of physical private and public infrastructure might find new paths for growth. Consequently, according to this view, the concentration of income opportunities and wealth should decrease over time. Although other predictions were also present in the debate over the impact of the digital economy (e.g. Norris, 2002; UNDP, 2001), this view was largely dominant.

The reality is not so rosy. Not only there are huge disparities in the intensity with which ICT are adopted across countries, but also there are still large differences *within* industrialised countries. Indeed, differences in economic development still shape the rate of the adoption of these technologies, at the firm, regional and country level. The reasons behind these stylised facts have been investigated at length in recent times.

This paper contributes to the literature in several ways. First, it focuses on intra-national or regional differences, which is a much less explored dimension of the Digital Divide. Second, it uses a new metric for the adoption of ICT, namely the number of second level Internet domain names, registered under the ccTLD ".it". Finally, it explicitly combines the analysis of determinants with a spatial econometric approach.

The paper is organised as follows. Section 2 surveys the literature on the Digital Divide and the relation between local development and adoption of ICT. Section 3 describes data and

methodology. Section 4 contains the description of the model and the empirical results. Section 5 summarises the main conclusions of the paper.

2. Local Digital Divide: the relation between development and ICT adoption

The conceptual link between economic development and ICT adoption is a widely researched issue in the economic literature. It may be claimed that, given their nature ICT allow to overcome territorial peripherality. Differently from traditional heavy and light manufacturing investment, ICT may increase regional attractiveness as a strategic location factor, thus enhancing territorial competitiveness (Gillespie et al., 1989; Kraemer and Dedrick, 1996; Steinmuller, 2001; Camagni and Capello, 2004). The successful experiences of Ireland and India as emerging regions in the off-shore of software services, due to the availability of efficient communication infrastructures, is often quoted.

Contrary to most expectations, however, the overall empirical reality is one of large geographic differences in the rate of adoption of ICT, so that disparities and inequalities[1] seem to be reinforced, rather than reduced, by these technologies.

Most studies have revealed astonishing differences in Internet and computer penetration between North America and Europe, on the one side, and African and Asian countries on the other (see Chinn and Fairlie, 2004 for a comprehensive survey of this literature). These large disparities have been explained referring mainly to differences in income, but also to human capital, telecommunication infrastructures (Dasgupta et al., 2001; Oyelaran-Oyeyinka and Lal, 2003; Pohjola, 2003; Wallsten, 2003), demographical variables and regulatory regimes (Wallsten, 2003)[2].

Although these explanations are rather convincing, it is puzzling why the evidence of a process of convergence of less developed countries in the adoption of these technologies is still scant.

Less investigation has been devoted to the local dimension of the phenomenon as indeed digital inequalities do not divide only developed from developing countries but also regions within the same country (*Local Digital Divide*, see for instance Gareis and Osimo, 2004; Ramsay, 2004). Both developed and developing countries suffer from severe regional disparities in ICT adoption. Evidence has been provided with reference to United States

[1] According to OECD (2001) Digital Divide refers to *the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities.*

[2] In Japan the cost of monthly connection to broadband services is estimated at 0,9% of the average income, while the same ratio is 1.207 % in Bielorussia and 9.116 % in Camerun (eEspana, 2004).

(NTIA, 2002; Mills and Whitacre, 2003), Canada (Dryburgh, 2001), Portugal (Nunes, 2004), Spain (Billon Curras and Lera Lopez, 2004), Italy (Bonaccorsi et al., 2002; Assinform, 2004), China (Qingxuan and Mingzhi, 2002; Wensheng, 2002).

A clear-cut stylised fact that emerges from this literature is that regional disparities are larger and more persistent when compared to cross country differences, at least within industrialised nations. For example, with respect to Italy, Bonaccorsi et al. (2002) found that geographic concentration of the adoption of Internet is much higher than concentration in population or income. Hence, it seems that ICT does not reduce regional disparities, but rather reinforces them.

Empirical works show that determinants of local inequalities relate to disparities in economic, social and demographic aspects. In particular, differences in the spatial diffusion of ICT have been explained in terms of differences in technological levels, infrastructural endowments (Marrocu et al., 2000; Iammarino et al., 2004) and local spillover effects (Jaffe et al., 1993; Audretsch and Feldman, 1996; Galliano and Roux, 2004). However, local inequalities might be influenced also by spatial factors. In a recent study, Nunes (2004), investigating the geography of top level domain names in Portugal (.pt), has proposed that Internet might contribute to reinforce the tendency to territorial disintegration, promoting geographic disparities in a more pronounced way than is the case in the real economy space. Specifically, he found that the role of ICT to overcome spatial inequalities in Portugal is less important than expected, since these technologies are deeply influenced by the existing spatial structure rather than changing it.

According to the most recent studies, mainly framed within the models of technology diffusion (Geroski, 2000), we distinguish several groups of factors which potentially influence the territorial adoption of ICT(for an excellent recent survey, see OECD, 2004).

A first category of factors, which are positively related to ICT adoption, concerns the local technological endowment and the relevant absorptive capacity. Specifically, absorptive capacity refers to both the firms' ability to assess technological opportunities (which depends on its endowment of human and knowledge capital, Cohen and Levinthal, 1989), and also to learning effects. The latter may arise from earlier use of ICT or a predecessor of a specific ICT element which already embodies constituent elements of later applied, more advanced vintages (McWilliams and Zilberman, 1996). Additionally, according to Hollenstein (2004: p.41) "these aspects of absorptive capacity refer to the standard epidemic model of technology diffusion and to the relevant information spillovers from users to non users of the technology. This model basically states that a firm's propensity to adopt a technology at a certain point in

time is positively influenced by the present (or lagged) degree of its diffusion in the economy as a whole or in the industry to which the firm is affiliated to".

A second category of variables refers to market characteristics. Specifically, the sectoral specialisation of the region has largely been shown to impact significantly upon the adoption of ICT (Pohjola, 2003).

Likewise, firms' characteristics have been traditionally employed as explanatory variables in most studies of adoption. In particular, firm's size captures the Schumpeterian hypothesis about the positive relation between innovativeness and dimensional scale. The same holds for firm age, although the theoretical arguments are not conclusive (positive experience effects vs. negative adjustment cost effects in case of older firms, see Lal, 2001; Hollenstein, 2004).

The adoption of ICT may also be affected by market conditions under which firms are operating, particularly the competitive pressure they are exposed to. In markets where competition is stronger firms are expected to be more inclined to innovative activities or rapid technology adoption (Porter, 1990; Majumdar and Venkataraman, 1993; Feldman and Audretsch, 1999; Hollenstein, 2004)

Finally, we explicitly take into account the role that spatial externalities play in the current thinking about innovative activity (see Audretsch, 2003).

3. Methodology and data

3.1. Domain names as a proxy for ICT adoption

The term ICT encompasses a wide range of technologies. According to the Canadian Statistic Bureau it *includes desktop and laptop computers, software, peripherals and connections to the Internet that are intended to fulfil information processing and communications functions*[3]. Such a variety poses severe methodological problems as measuring the level of territorial adoption of these assets? According to Pohjola (2003), two kinds of metrics reveal disparities in ICT adoption across countries: data on ICT equipment and its use, as well as indicators of ICT spending.

However, most of the studies that have analysed geographical inequalities at the international level have identified ICT with the Internet, referring to the number of Internet hosts (OECD, 2001; Kiinski and Pohjola, 2002) and of Internet users (Norris, 2002, NTIA, 2002)[4], although rendering the problem of differences in ICT adoption to the simple Internet access is misleading (Oden and Rock, 2004). As a matter of fact, data on Internet hosts are easily

[3] http://www.statcan.ca/english/freepub/81-004-XIE/def/ictdef.htm

available and highly reliable (Press, 1997; Wolcott et al., 2001) [5]. Anyway, this metric suffers from two main shortcoming: data are gathered only at the national level and they do not provide any information about the adopters.

Analyses at a regional level benefit from the availability of larger sets of indicators, ranging from the share of electronic productions to mobile phones; survey data are also available[6]. Recently, the use of domain names as a proxy of Internet diffusion has been proposed (Zook, 2000; Zook et al., 2004). Domains may be a valid proxy for ICT adoption, mainly because they operationalise the intention to actively supply contents through the Net. Specifically, those who register a domain name uses the Internet in a *more conscious manner* aiming not only at demanding but also at adding contents to it[7]. In general, the registration of a domain name by a firm is the first step towards the set up of a Web site through which presenting the offering or even undertaking electronic commerce activities. Therefore, domains provide an underestimation of the ICT adoption[8] as: (i) ICT adoption does not necessarily require registering a domain; and (ii) the Internet Service Providers often offer their users room (on their servers) for adding new contents. Thus, domains constitute a lower bound as any registrant is unquestionably an ICT adopter. Additionally, every domain name is uniquely associated to a registrant whose geographical location and nature are unambiguously recorded in the databases of the organisations that manage the different ccTLD (Mueller, 1998; Grubesic, 2002). The availability of information at the sub-national level makes domains a valid metric to explore the territorial dimension of ICT adoption while data on the nature of the registrants allow to take into account different adoption determinants for different population of potential adopters.

This paper makes use of domain name registrations by Italian firms as a proxy for ICT adoption at the NUTS3 level (103 provinces). During years 2002-2003, the Institute of

[4] An analysis of cross-country diffusion of personal computers is in Caselli and Coleman (2001).

[5] For instance every six months Network Wizard publishes the results about all the TLD on its web site, whereas the RIPE (http://www.ripe.net) publishes the data about the ccTLD in its area (Europe, North Africa, Middle East) monthly. Hosts belong to the so called endogenous metrics that are obtained in an automatic or semiautomatic way from the Internet itself (Diaz-Picazo, 1999). The organisations that manage the different ccTLD and gTLD perform the hostcount under their TLD on a regular basis and provide these data on the Web or by ftp.

[6] The bi-annual survey *A Nation on line*, conducted on more than 3,000 US citizens (NTIA, 2002), collects data on the number of PC purchased by families and on the activities they carry on through the Internet.

[7] Domain grabbing must to be taken into account. However, this phenomenon does not affect our data, as the unit of analysis is the registrant, rather than the domain: multiple registrations have been discarded from the database.

[8] It is worth observing that hosts suffer from the same drawback. Indeed, the hostcount programs do not reach machines protected by firewalls and private networks (Intranets). The use of dynamic IP addresses by ISPs should be also taken into account. In addition, they are also prone to overestimation due to several factors such as the association of multiple IP addresses to the same computer.

Informatics and Telematics (IIT) of the National Research Council (CNR), Sant'Anna School of Advanced Studies and the University of Pisa have built a database that contains, at a sub regional level, the registrations of domain names by different categories of actors (individuals, business firms, universities and research centres, third sector associations and public administration bodies). Data were extracted from the databases of the registrations under the ccTLD ".it" that are managed by the Italian Registration Authority (RA) hosted by IIT. A total number of 500,000 domain names have been inspected for classification, multiple names registered by the same registrant have been carefully checked and eliminated.

3.2. The empirical evidence on ICT adoption from the Italian case

In order to use domain name registrations as a proxy for the level of ICT adoption, penetration rate in each province has been calculated as the percentage of firms in the province that have at least a domain name registered in the Registration Authority databases as in July 2001. Table 1 summarises the descriptive statistics of the variable.

Table 1-ICT adoption: descriptive statistics

ICT Adoption	*No.*	*Min*	*Max*	*Mean*	*Std. Dev.*	*Skewness*	*Kurtosis*
	103	1.2	9.1	3.76	1.65	0.42	2.72

Data highlight that the level of ICT adoption in Italy is quite low with an average penetration rate less that 4%. Table 2 reveals severe geographical disparities that mirror inequalities in the economic development emerging both among and within geographical macro-areas. No Southern province ranks in the top fifty, the best performing province in the South ranks 55th, only eight Northern provinces rank below that position. Conversely, all the twenty worst performing provinces are located in the South.

Table 2-ICT adoption in macro-areas

Area	*No.*	*Mean*	*Std. Dev.*	*Kruskal Wallis Test – p value*
North	46	4.76	1.31	0.000
Centre	21	4.40	1.29	
South	36	2.11	0.66	
Total	103	3.76	1.65	

Indeed, the penetration rate is positively correlated with per capita income and added value per employee (table 3). Nevertheless, registrants are more concentrated than firms and of income.

Table 3-ICT adoption and economic development: Pearson correlations and Gini's concentration indexes

Pearson correlations			*Gini's indexes*	
Added value per employee	0.45	***	Firms registering a domain	0.573
Income per inhabitant	0.78	***	Number of firms	0.421
			Income	0.458

Following the literature on spatial distribution of innovation (Audretsch and Feldman, 1996; Audretsch, 2003), we expect spatial dependence to exist between the observations. Specifically, "spatial dependence in a collection of sample data observations refers to the fact that one observation associated with a location which we might label i depends on other observations at locations j≠i" (Le Sage, 1998, p.3).

Table 4 reports results of tests normally used for detecting spatial dependence[9]. ICT Adoption is the percentage of firms that have registered at least a domain name in each province as in 2001.

All the three tests confirm the existence of spatial dependence so that we can conclude that the adoption of ICT by each province i is related to the adoption of other provinces j≠i, thus highlighting the existence of knowledge spillovers.

*Table 4-Spatial dependence tests for the dependent variable (ICT Adoption). Note: ° two-tail test; *** significant at p<.01*

Moran's I	*I*	*E(I)*	*Sd(I)*	*z°*	
ICT Adoption	0.589	-0.010	0.064	9.385	***
Geary's c	*c*	*E(c)*	*Sd(c)*	*z°*	
ICT Adoption	0.480	1.000	0.080	-6.494	***
Getis & Ord's G	*G*	*E(G)*	*Sd(G)*	*z°*	
ICT Adoption	0.053	0.044	0.002	6.001	***

4. Econometric models of territorial ICT adoption

We first run a model where the dependent variable, ICT Adoption, is regressed against a set of explanatory variables that are proxy for the absorptive capacity, the regional technological endowment, the competitive pressure, the firms' characteristics and the sectoral composition of the region (see Table 5). Table 6 reports their statistical properties and correlations.

[9] The proximity matrix W has been constructed using the concept of Queen contiguity between provinces (i.e. they have borders that touch, see Le Sage, 1998, p. 10). Therefore, it is a 103x103 matrix that has zeros on the main diagonal, rows that contain zeros in positions associated with non contiguous observational units and ones in positions reflecting neighbouring units.

Table 5- Specification of dependent and independent variables

Variables	*Description*	*Source*
DEPENDENT VARIABLE		
ICT Adoption	Percentage of firms that have registered at least a domain name	Registration Authority for the ccTLD "it" - Elaboration
EXPLANATORY VARIABLES		
Absorptive capacity		
PATENTS	Ratio of the number of patents granted in each province in the period 1991-1999 by the USPTO and the number of firms in that province	USPTO - Elaboration
PUBLICATIONS	Ratio between the number of scientific publications by University researchers in each province and the number of firms in that province	ISI Citation Index databases - Elaboration
Competition		
DISTRICTS	Percentage of districtual local units	Infocamere - Elaboration
Firms' characteristics		
AGE	Percentage of firm aged less than 10 years	Unioncamere - Elaboration
Sectoral Composition		
STRUCTURE	Percentage of firms in Agriculture. It is a dummy variable that assumes value 0 if the province is below the national average, 1 otherwise.	Infocamere - Elaboration
Technological Endowment		
IT_EXPENDITURE	Ratio of IT expenditure in each province and the number of firms in that province	Assinform/NetConsulting - Elaboration
INFRASTRUCTURE	Facilities and networks for Telephony and Telematics (Index of endowment, Italy =100)	Istituto Tagliacarne

Table 6-Statistical properties of the explanatory variables and correlation matrix

Variable	AGE.	PATENTS	INFRASTRUCTURE	PUBLICATIONS	IT_EXPENDITURE	DISTRICTS
Min	33.60	0.00	17.30	0.00	1092.23	0.00
Max	55.90	2.43	345.20	4.17	266667.10	100.00
Mean	44.92	0.26	87.03	0.39	18147.52	27.96
Std. Dev.	3.93	0.36	51.17	0.74	33204.24	35.35
Obs.	103	103	103	103	103	103
AGE	1.000					
PATENTS	-.037**	1.000				
INFRASTRUCTURE	.276	.428***	1.000			
PUBLICATIONS	.084	.305**	.378***	1.000		
IT_EXPENDITURE	.173	.307**	.589***	0.229	1.000	
DISTRICTS	-.288**	.256*	.227**	0.001	0.016	1.000

Additionally, as we already identified the existence of spatial dependence for the dependent variable (see Table 4), the model must include the spatially lagged dependent variable among the explanatory variables. In other words, we estimate the following mixed regressive-spatial autoregressive model:

$$ICT\quad Adoption_i = \rho W_1 ICT\quad Adoption_i + X\beta + \varepsilon$$

The parameter ρ would reflect the spatial dependence inherent in our sample data, measuring the average influence of the adoption of neighbouring regions on the adoption of each region. The parameters β reflect instead the influence of the explanatory variables X.

The results from the mixed regressive-spatial autoregressive model are obtained again through maximum likelihood (using Stata) and are reported in Table 7. It emerges that the

dependent variable exhibits a strong spatial dependence as the estimate of ρ on the spatial lagged variable is large and significant.

Table 7-Results from the mixed regressive-spatial autoregressive model

		Coef.		z	P>|z|
Absorptive capacity					
	PATENTS	0.505	*	1.830	0.068
	PUBLICATIONS	0.270	**	2.230	0.026
Competition					
	DISTRICTS	0.008	***	2.870	0.004
Firms' characteristics					
	AGE	-0.095	***	-3.750	0.000
Sectoral Composition					
	STRUCTURE	-0.560	***	-2.900	0.004
Technological Endowment					
	IT_EXPENDITURE	0.000	**	2.370	0.018
	INFRASTRUCTURE	0.013	***	5.510	0.000
	_cons	6.005	***	4.920	0.000
	rho	0.032	***	2.970	0.003
No. obs.		103			
Wald test of rho=0:	chi2(1) = 8.834 (0.003)				
Likelihood ratio test of rho=0:	chi2(1) = 8.473 (0.004)				
Lagrange multiplier test of rho=0:	chi2(1) = 8.460 (0.004)				
Acceptable range for rho: -1.232 < rho < 1.000					
Log likelihood		-123.720			

Moran's I	*I*	*E(I)*	*Sd(I)*	*z°*	
residuals	0.380	-0.010	0.064	6.131	***

*Notes: *** significant at p<..01, ** significant at p<.05, * significant at p<.10, ° two-tail test*

The results also indicate that all of the explanatory variables exhibit a significant effect on the dependent variable we wished to explain, that is the penetration rate of registered domain.

Finally, the Moran's I test on the residuals from the mixed regressive-spatial autoregressive model (which is reported at the bottom of Table 7) highlights that the inclusion of the spatial lag term (ρW_1ICT Adoption) does not eliminate spatial dependence in the residuals of the model. Therefore, the final model estimated is a general spatial model:

$$ICT\ \ Adoption_i = \rho W_1 ICT\ \ Adoption + X\beta + \varepsilon$$

$$u = \lambda W_2 u + \varepsilon$$

Such a model has been estimated using Matlab libraries for spatial econometrics, as indeed Stata did not allow us to run it[10]. The estimates confirm the high significance of all the explanatory variables, and the overall fit of the model (the adjusted R-squared is indeed

0.795, higher than that obtained from the OLS estimate, see Annex 1). Specifically, as expected, ICT adoption at the regional level is positively influenced by: absorptive capacity (PATENTS and PUBLICATIONS are both positive and significantly different from zero), technological endowment (both IT_EXPENDITURE and INFRASTRUCTURE are positive and significantly different from zero), competition level (DISTRICTS is positive and significant at p<.01), firms' characteristics (AGE is significant at p<.01, meaning that younger firms are more keen to register a domain), and sectoral composition (STRUCTURE is negative and significant at p<.01).

This model produces also estimates for ρ, which is positive and significantly different from zero, thus confirming the existence of spatial dependence for the dependent variable, while λ does not come out significant.

Table 8-Results from the general spatial model

		Coef.		Asymp. t	z-probab
Absorptive capacity		0.489	*	1.813	0.069
	PATENTS	0.288	***	2.690	0.007
	PUBLICATIONS				
Competition		0.006	**	2.270	0.023
	DISTRICTS				
Firms' characteristics		-0.061	***	-2.626	0.008
	AGE				
Sectoral Composition		-0.443	**	-2.508	0.012
	STRUCTURE				
Technological Endowment		0.000	***	3.801	0.000
	IT_EXPENDITURE	0.010	***	4.645	0.000
	_cons	3.944	***	3.287	0.001
	rho	0.342	***	3.313	0.000
	lambda	0.046		1.206	0.228
	No. obs	103			
	R-squared	0.809			
	Adj R-squared	0.795			
	Log likelihood	-19.774			

*Notes: *** significant at p<..01, ** significant at p<.05, * significant at p<.10*

[10] It is worth observing that we relied on the same W=W1=W2 for both the spatial lag and error correlation terms, and results are reported in Table 8.

5. Conclusions

This paper contributes to the literature on ICT adoption in several ways.

First, it corroborates some robust findings in the literature. We find that variables that describe the vitality of general economic activity are relevant. Economic environments with a low turnover of firms and traditional economic activities are less vibrant in ICT adoption, that is the larger the share of firms in the agriculture sector and the proportion of firms older than 10 years, the lower the intensity of Internet use at advanced level. This general effect is reinforced by a specific technological effect related to ICT. Indeed, the higher the expenditure in Information Technology at local level, the larger the probability to make advanced use of Internet. Also, an index of technological endowment measured with respect to the telecommunication network has a positive and significant effect.

These findings corroborate the notion that very traditional, highly "material" investments do play a great role in explaining the Local Digital Divide. As it was anticipated in the literature on telecommunication investment (Biehl, 1982; Gillespie et al. 1989; Kraemer and Dedrick, 1996), regional development may be adversely affected by disparity in the level of infrastructure. Contrary to the expectations, the spatial diffusion seems to *follow* the existing geography of development, rather than dramatically changing it. Our results are also consistent with existing evidence on the geographic concentration of ICT production and differences in the adoption of ICT by firms in Italy. Iuzzolino (2003) examined the geographic concentration of all sectors related to products and services in ICT using Ellison and Glaeser (1997) indexes and found evidence of strong agglomeration effects (see also Pagnini, 2002). Fabiani et al. (2003) found extremely large differences between firms in the South of Italy and in the North and Centre in the rate of adoption of almost all ICTs, while Iammarino et al. (2004) highlight the same divide as the production of ICT is concerned. It is true that our data do not capture the structure of *supply* of ICT, but rather the structure of *demand* or utilisation. Firms are only part of the adoption process as described by our data on domain names. At the same time, it is clear that general economic factors and the localisation and activity of firms in these industries strongly influence the utilisation in the business sector, in households and in society at large.

Second, the adoption of ICT is strongly influenced by the level of knowledge available at the province level, as measured by the flow of patent registrations and scientific publications. We relate this effect to the notion of absorptive capacity, drawing a clear analogy with the idea that only firms that invest into in-house R&D are able to capture externally created knowledge. According to our results, areas that are poor in general technological activity and

in research are less likely to make active use of Internet, thus suggesting that ICT benefits from local effects of accumulation of human capital. While this effect may be intuitive for *production* activities, due to input pooling and knowledge spillovers (Ellison and Glaeser, 1997; Pagnini 2002), it is interesting to observe how important it is also for the adoption of new technologies. Additionally, the larger the proportion of firms in a province that is part of an industrial district, the more intense the adoption of ICT, thus confirming the positive impact of competitive pressure. This adds to the debate about the ability of industrial districts (mainly based on small and medium-sized firms in traditional industries) to absorb new Internet technologies.

Third, the paper explicitly introduces a spatial econometric approach in the analysis of the relationship between Digital Divide and diffusion of new technologies. Spatial contiguity is very important as spillovers flow across provinces (at least at the lag 1 level). However, as benefits from spillovers do actually decline with distance (Jaffe et al., 1993; Keller, 2000) we expect peripherality to be still an obstacle to ICT adoption. As a matter of fact, our empirical evidence from the Italian case show that areas far from the centres suffer from severe difficulties in adjusting to the new technology. Consequently, models that include contiguity matrices at further levels of spatial lags are required.

Finally, the crucial role of complementarities is nicely reflected in our data. The literature on the impact of ICT on productivity and economic growth has strongly emphasised the crucial importance of the coexistence and co-evolution of investment into physical infrastructure and equipment, investment into human capital, and deep changes in organisational structures and procedures in both private and public sector (Brynjolfsson, 1993, Brynjolfsson and Hitt, 1996; Bresnahan et al. 1999; Black and Lynch, 2001; OECD, 2004).

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ANNEX 1: RESULTS FROM THE OLS MODEL

		Coef.		T	P>|t|
Absorptive capacity					
	PATENTS	0.786	***	2.79	0.006
	PUBLICATIONS	0.322	**	2.48	0.015
Competition					
	DISTRICTS	0.011	***	3.99	0.000
Firms' characteristics					
	AGE	-0.113	***	-4.27	0.000
Sectoral Composition					
	STRUCTURE	-0.588	***	-2.81	0.006
Technological Endowment					
	IT_EXPENDITURE	0.000	***	2.67	0.009
	INFRASTRUCTURE	0.130	***	5.06	0.000
	_cons	7.217	***	5.78	0.000
	No. obs	103			
	R-squared	0.741			
	Adj R-squared	0.722			

Moran's I	*I*	*E(I)*	*Sd(I)*	*Z°*	
residuals	0.235	-0.010	0.064	3.862	***

*Notes: *** significant at p<..01, ** significant at p<.05, * significant at p<.10, ° two-tail test.*