Does ICT Investment Spur or Hamper Offshoring?

Empirical Evidence from Microdata*

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Abstract

In this paper we provide empirical evidence on the effect of ICT investment on the propensity to offshore for a large sample of Italian manufacturing firms. Contrary to previous literature which focuses on the service sector, after taking into account the endogeneity of ICT investment in the offshoring decision equation we find a negative and significant effect of ICT on the propensity to offshore some stages of the production process. Furthermore this effect turns out not to depend on the type of ICT investment and applies both to hardware and software/telecommunication expenditures. Our results seem therefore to suggest that negative exogenous shocks to ICT prices—possibly induced by targeted policy programs aimed at the diffusion of ICT technologies—do not favor offshoring of manufacturing activities.
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1 Introduction

As noted, among others, by Mankiw and Swagel (2006) the growth in offshoring activities in recent years has raised a lot of public concern in all advanced economies. In particular, a commonly perceived worry is that workers in previously sheltered service sectors of the economy will be more likely in the near future to suffer from competitive pressure from trade made possible by improved information and communication technologies (ICT thereafter). It is therefore hardly surprising (Grossman and Rossi-Hansberg (2006)) that both the academic and the media attention has progressively shifted towards the offshoring of a variety of services ranging from reading x-rays to developing softwares and from preparing tax forms to answering customer service calls.

Within this general framework a very recent empirical literature has started (Abramovsky and Griffith (2006), Bartel et al. (2005)) to provide econometric estimates of the effect of ICT investment on the outsourcing and offshoring of business services. Broadly speaking—but not without some cautionary remarks—the empirical evidence available so far confirms a positive causal link between ICT and the offshoring of business services. To the extent that the latter negatively affects labour market outcomes in advanced economies, ICT investment itself could be blamed for such undesirable results and, therefore, policy makers should take this unintended transmission mechanism into account when designing public policies aimed at the diffusion of ICT technologies.

It must be noted, however, that the scant international descriptive evidence points out that in many industrialized countries most of offshoring activities occurs in manufacturing and not in services. For instance, according to a very recent survey carried out by Eurostat for 13 EU countries over the 2001-06 period, 17.4% of manufacturing firms are found to offshore part of their production activity, whereas the percentage decreases to 5.2% in service industries. As for Italy, this difference

is even more striking, the percentages being, respectively, 15.9 and 1.3%.[1]

On theoretical ground there is no compelling reason why ICT investment in manufacturing should necessarily increase the propensity to offshore. This will crucially depend on the nature of the ICT investment. On the one hand, the reduction in communication and coordination costs is likely to favor offshoring. On the other hand, ICT also affects the composition of labor demand. Available empirical evidence (see Autor et al. (2003)) indeed suggests that ICT capital complements workers in performing non-routine problem solving and complex communication tasks but substitutes for workers in performing routine cognitive and manual tasks. ICT investment might therefore be associated with a downward shift in the labor demand for workers specialized in performing routine tasks and, ultimately, with a lower propensity to offshore to countries where the supply of such workers is high.

Our paper contributes to shed light on this issue by advancing the existing empirical literature on the effects of ICT on offshoring on several grounds. Firstly, we focus on manufacturing as opposed to business services. Secondly, as suggested by Bloom et al. (2008), we do not treat ICT investment as an homogenous capital good and therefore do not impose the unrealistic assumption common to most existing literature that all ICT components (i.e. hardware, software, and telecommunication) have the same effect on the propensity to offshore. Thirdly, we address the endogeneity problem of the ICT investment decision by specifying and estimating a non-linear equation system where identification of the effects of interest is obtained by relying both on functional form and on exclusion restrictions. This in turn allows us to test the validity of our exclusion restrictions.

What we find in this paper is that, after taking the endogeneity of the offshoring decision into account, the investment in ICT activities has a negative effect on the propensity to offshore

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[1]Further details on the survey *"Structural Business Statistics on International Sourcing"* can be found at http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/iss_base.htm.

in a large sample of Italian small-medium size manufacturing firms. Perhaps unexpectedly, this turns out to be the case both for the hardware and for the software/communication components. Furthermore, our findings are found to be robust to different criteria used for the construction of the relevant sample of firms as well as to alternative specifications of the econometric model. Taken at their face value, our overall results imply that—at least in manufacturing—public incentives to ICT investment are unlikely to promote offshoring and therefore this transmission channel should not be a reason of concern for policy makers when designing public policies aimed at the diffusion of ICT technologies.

The remaining of the paper is organized as follows. The next section motivates our paper by reviewing the theoretical literature and the empirical evidence on the relationship between ICT investment and offshoring. In section 3 we introduce our dataset and comment upon some relevant descriptive statistics. Section 4 presents our empirical model and discusses its identification assumptions. In Section 5 our main results are presented whereas section 6 concludes. An appendix reporting the relevant questions included in the Unicredit-Capitalia survey and describing the sample used in this paper is also included.

2   The Link between ICT Investment and Offshoring

ICT-induced organizational changes have an impact on several aspects of firms' decision-making and production activity. According to common wisdom, these changes are perceived to stimulate offshoring through a direct effect, induced by enhancements in communications abilities, and an indirect effect via increased firms' performances. It is a widely accepted fact that the introduction of new communication technology amplifies the information flows received and sent by the firm. This phenomenon should lead to higher fragmentation of production processes, irrespectively of whether

the transfer of authority occurs within or outside firms' boundaries (i.e. offshoring or outsourcing). On the one hand, a higher efficiency in monitoring information (Colombo and Delmastro (2004)) and controlling choices at all stages of the production process may induce a more frequent delegation of authority and decentralization of decision-making not only within the firm but also among different firms. On the other hand, ICT enhances firm ability to react to external information, to absorb new technologies and to considerably improve the quality of communication with external agents. As Grossman and Helpman (2002) show, the reduction of informational costs may lead to an increase in offshoring/outsourcing by improving the ability and chances of finding new suppliers. Moreover, ICT facilitates the codification of knowledge and the transfer of competencies outside the firm (Caroli (2003)).

However, as Leamer and Storper (2001) and Leamer (2007) emphasise, the transfer of competencies depends critically on an important distinction between routine codifiable tasks and non-routine tasks. The completion of the former relies on a type of information that can be easily conveyed to an external agent. As in the case of standardized services, cognitive routine tasks may be easily transferred to other firms, virtually with zero transportation costs, and this is more profitable when the supplier enjoys economies of scale. On the other hand, non-routine tasks are more based on experience or are heavily dependent on creative skills. Some of these tasks are complementary to production stages performed within the firm and cannot be relocated away from firms' core activities. In this case, tacit—as opposed to codifiable—knowlesge plays a predominant role in production decisions, and the experience embodied in these specific tasks can not be easily conveyed within a buyer-seller relationship.

The decision to offshore (outsource) could not be optimal choice also when, as pointed out by Hempell and Zwick (2008) and Baccara (2007), the externalization of production processes is

associated with an unwelcome transfer of internal knowledge outside firm boundaries. This information leakage phenomenon might be especially harmful for highly specialized firms characterized by complex production processes and a high degree of labor specialization. It might indeed be argued that some of the components of ICT capital (e.g. production and management softwares) are characterized by high degrees of complexity and asset specificity and this in turn might make the offshoring of parts of the production process a less attractive option. Indeed, Hempell and Zwick (2008) provide convincing empirical evidence that ICT capital improves organizational flexibility and employee participation in decision making, whereas the impact on the probability to outsource and on the shares of intermediaries purchased appears to be far less strong.

As already mentioned above, an indirect effect of ICT on productivity can be implicitly derived by jointly considering the two separate strands of existing literature which analyze the relationship between ICT investment and productivity on the one hand (for a recent review see Draca et al. (2006)), and between productivity and the international fragmentation of production on the other hand (Antras and Helpman (2004)). The common framework in the first strand of literature is that ICT technologies may improve the flows of information within firms, reduce the distance between hierarchical levels and create opportunities for team-working and joint-decision making. As a consequence, the adoption of ICT, when accompanied by workplace reorganization and introduction of new human resources practices, may substantially increase firm productivity (Black and Lynch (2004), Brynjolfsson and Hitt (2000)). Since recent theoretical models on international fragmentation (Antras and Helpman (2004)) have shown that high productivity firms are more likely to offshore both components and services because they can spread the additional sunk costs from operating abroad on a larger amount of production, ICT investments may also indirectly affect offshoring decisions through productivity. Obviously, this second channel predicts a positive link

between ICT investment and offshoring.

The effect of ICT on efficiency does not uniquely depend on improvements on information flows and allocations of tasks. As thoroughly discussed in Autor et al. (2003), ICT investment is expected to reshape the task composition of the work force and ultimately the structure of labor demand, by fostering automatization and mechanization of the production processes. In particular, the complementarity (substitutability) between ICT capital and workers performing non-routine (routine) tasks increases the marginal productivity of non-routine inputs and therefore their relative demand. This in turn might make less attractive the standard offshoring option whenever this choice is driven by the abundance of routine-workers in less developed countries. This channel predicts therefore a negative relationship between ICT investment and the propensity to offshore.

Given this multiplicity of channels through which ICT capital can affect firms' offshoring decisions, it becomes ultimately an empirical issue to asses their relative importance. Although this issue has recently become harshly debated, existing econometric evidence is—to the best of our knowledge—confined to two recent papers: Abramovsky and Griffith (2006) and Bartel et al. (2005), both focussing on the outsourcing and offshoring of business services. In particular, Abramovsky and Griffith build on the idea that ICT investment helps to reduce transaction costs and show that ICT investment makes the acquisition of services from other firms (i.e. outsourcing) or the localization of production stages out of the national boundaries (i.e. offshoring) more convenient than in-house production. The authors implement an IV strategy to account for endogeneity in ICT adoption by future outsourcers and provide cross sectional evidence of the positive effect of ICT investments and internet usage on the probability to outsource and offshore services. Interestingly for the purpose of this paper, Bartel et al. provide a theoretical model where ICT innovation increases the compatibility between firm own technologies and the technology embedded in the services and

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products offered by other firms. ICT thus lowers firms adjustment costs and induces a higher level of outsourcing. The authors also analyze cross sectional data and show a positive relationship of ICT with the amount of services outsourced in communication, accounting, advertising, software, and legal assistance. However, a negative effect of ICT on the outsourcing of production related tasks including machine and building repairing is recorded. The authors motivate this negative effect with the low ICT content of these activities and the negligible role of ICT in reducing adjustment costs.

Finally, several studies have investigated the determinants of ICT adoption by Italian firms (Fabiani et al. (2005); Lucchetti and Sterlacchini (2004); Giunta and Trivieri (2007); Bugamelli and Pagano (2004)). The main factor which appears to hinder ICT adoption is the scarcity of qualified human capital in small and medium size Italian firms. More precisely, firms find it difficult to implement those organizational changes which are necessary to the creation of a favorable environment for ICT adoption. Moreover, the observed low level of ICT expenses is also explained by the national specialization in traditional industries. Finally, there is also evidence that geographical localization also matters. In particular, firms located in more developed local industrial systems are found to have higher incentives to adopting ICT because of tougher competitive pressure and positive network externalities (Fabiani et al. (2005)). A higher concentration of large firms in the local industrial system seems to force partners to adopt new internet technologies and to speed up the connection to internet, thus helping to reduce possible coordination problems in the adoption of new technologies.

3   Data and Descriptive Statistics

The variables we use are mainly retrieved from the 9th survey "Indagine sulle Imprese Manifat-turiere", a survey run by Unicredit-Capitalia (one of the largest Italian banks) covering the 2001-2003 period. This survey contains information on several quantitative and qualitative variables for more than 4,000 firms as well as their balance sheet data. The sample contains all Italian manufacturing firms with more than 500 employees whereas firms with less than 500 employees are selected on the basis of a stratified sample, so that small and medium sized firms are well represented.[2]

Very importantly for the purposes of the paper, several survey questions refer to firms' ICT investments and offshoring activity. Firms are asked to report the amount they invested in ICT over the three-year period, alongside with the breakdown by type (hardware, software, telecommunication) and area of application (administration, production, commercial activity, internet, and other applications).[3] Furthermore, firms also report their offshoring activity, i.e. whether they produce abroad part of their production previously performed at home.

The survey also provides very detailed information on firms' location at the municipal level. Given the likely importance of the local environment in shaping ICT and offshoring decisions, we merged the survey with data on geographic and demographic municipal characteristics, such as population, area, altitude, and geographical coordinates. Given our research strategy, we also collected—at the municipality level—information on the availability of Broad Band (BB, henceforth) infrastructures.[4]

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[2] For more details on the structure of the survey, sample selection, questions, and variables definition see the Data Appendix.

[3] Unfortunately, data availability problems prevent us to compute the stock of ICT capital. For a limited number of firms we can however also observe ICT investment in the 1998-2000 period. For those firms, the correlation coefficient between ICT intensities in the two periods is equal to 0.29. This in turn suggests that our three-year ICT investment intensity is a sufficiently persistent variable and therefore can be legitimately used as proxy for ICT capital.

[4] Municipalities are the finest administrative unit in Italy. Our dataset provides information for all 8,106 municipalities.

Standard trimming procedures and exclusion of firms without information on the relevant variables reduced the original sample to the set of 3,205 firms we use in this paper.

— INSERT TABLE 1 ABOUT HERE —

— INSERT TABLE 2 ABOUT HERE —

Tables 1 and 2 report some descriptive statistics for the two crucial variables of our analysis: ICT investments and offshoring activity. Inspection of Table 1, where the statistics are presented separately by industry (at 2 digit level), reveals that the bulk of offshoring activities takes place in a limited number of traditional industries (textiles, clothing, leather). Notice also that offshoring activities are almost non-existent in a number of industries. For this reason we present our econometric results (see below) both for the full sample and for the sub-sample of industries where we observe non-trivial fragmentability in the data. Operationally we remove those firms operating in industries where the share of offshoring firms is below 4%. As expected, more ICT investment takes place in high-tech industries. Some of these industries also show moderate offshoring and—overall—high(low) ICT investment industries tend to present also high(low) percentage of offshoring activity.

Additional information on total ICT investment by type and area of application is reported in Table 2. As for the extensive margin, almost 78% of firms has invested in ICT in the three year period and the amount invested represent a fairly sizeable percentage of the turnover (0.3% for the whole sample, 0.4% for the sample of investing firms). Interesting insights also emerge from the breakdown of ICT investment by type. Most of the investment, in terms of both the number of investing firms and the amount spent, refers to hardware or software, whereas a much less important

role is played by the introduction of TLC devices. As for the area of application, production and administration/management are the areas mostly targeted by ICT investments, whereas commercial activities and internet are found to be far less important. Overall, ICT expenditures in our sample seem to be mostly concentrated in administration/management and production and involve the introduction of new hardware or software. Far more limited is instead the role played by those activities (communication, internet, and trade) which are commonly thought as being conducive to offshoring.

The unconditional correlation between offshoring and ICT detected by inspecting Table 1 calls for a deeper analysis. In fact, it might be driven by firm-level observable variables affecting both offshoring and ICT. To this end, Table 3 presents standard descriptive statistics for a number of additional firm-level variables highlighted by previous literature as important drivers of ICT adoption and offshoring activity: age, size (number of employees), and ISO 2002 certification. The vast majority of firms in the sample are relatively "old", as only 25% of them have been established less than 15 years before the first year of the survey. Note also that the median size is 49.33 employees. This provides an additional rationale—on top of the standard EU classification scheme for small firms—to use a size dummy for firms above or below the 50 employees threshold. Finally, 55% of the sampled firms have declared to comply with the ISO 2002 requirements. We interpret this variable as a proxy for observed quality. In fact, a common finding of previous literature is that ICT is mostly effective when it is associated with an high quality workforce and with an appropriate internal organizational structure. We use the compliance with the ISO 2002 standards as a general proxy for quality. The rationale here is that the ISO 2002 label is given only to those firms which have implemented the required organizational changes in terms of standardization and codification of most of the activities performed within firm boundaries.

A first answer to the crucial question of whether the unconditional positive correlation between ICT investments and offshoring activity we found in our data is robust to the introduction of firm-level variables and dummies capturing local (at regional or provincial level) and industry characteristics is provided in Table 4, where we report the results of several probit estimates of the relationship between ICT and offshoring conditionally on these additional variables.

— INSERT TABLE 3 ABOUT HERE —

— INSERT TABLE 4 ABOUT HERE —

We first control only for industry (2 digit) and regional effects (column (i)). Similarly to the scant previous empirical literature on this issue, the relationship between ICT and offshoring is positive and significant at the 1% level. The marginal effect (0.008) implies that increasing the investment intensity from the 25th to the 75th percentile of the distribution (from 0.020 to 0.314%) increases the offshoring probability of 0.2 base points. Although this effect might appear small at first glance, its real magnitude must be assessed by considering the low proportion (7.6%) of offshoring firms in the sample. Notice that industry dummies are very significant whereas regional ones are not. The positive correlation between ICT and offshoring is almost unaffected by the replacement of regional with provincial dummies (column (ii)) which prove to be jointly marginally significant. In column (iii), we include in the specification the additional firm-level variables presented above. As expected, size and observed quality are positively associated to the probability of offshoring, whereas age is also positive but not significantly different from zero at conventional statistical levels. More importantly for the purpose of this paper, the coefficient for ICT—although smaller in size than in columns (i) and (ii)— is still positive and significant. Finally, in the last two columns we

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focus separately on hardware and software/tlc expenditures.[5] Similar results emerge in terms of coefficients (both are positive) and estimated marginal effects (which turn out to be very similar: 0.009 for software/tlc and 0.008 for hardware). However, only the one for software is significantly different from zero.

Obviously, a causal interpretation of this set of results requires that ICT is exogenous in the offshoring equation, i.e. uncorrelated with shocks affecting offshoring. We believe this assumption is very unlikely to hold since one can well think of severable unobservable or imperfectly measured firm level variables—including managerial quality and technological/market opportunities—that affect both decisions.

4   Empirical Strategy

The econometric results presented in the last section support the widespread idea that ICT investment is positively associated to offshoring. However, as previously noted, we are interested in the causal effect of ICT on offshoring. This in turn implies that the issue of the likely endogeneity of ICT must be tackled in a convincing way. We therefore specify and estimate a recursive non-linear two-equation system for offshoring and ICT investment. Given the nature of our observables it is convenient to make the joint normal distribution for the two error terms. Within this estimation framework the offshoring and the ICT investment equations can be respectively interpreted as standard probit (equation 1) and Tobit type I (equation 2) models.[6] More specifically, we specify our

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[5] Both in Table 4 as well as in all the tables presented in section 5 we have aggregated software and tlc investments. We have also estimated all reported regressions separately for for the two types of investment. Estimated parameters turn out to be very similar even if those related to tlc investment are often not significantly different from zero. This might depend on the low share of of firms (31.09%) which have declared to have invested in tlc equipment in the sample period. All additional results are available upon request.

[6] In section 5.2 we relax the Tobit type I assumption for ICT investment by estimating separately the parameters of the extensive and the intensve decisions (Tobit type II).

model as

$$OFF^*_{ijmr} = \mathbf{x}'_i\boldsymbol{\lambda} + \rho ICT_{ijmr} + \mathbf{w}'_m\mu + f_j + g_r + \varepsilon_i \tag{1}$$

$$ICT^*_{ijmr} = \mathbf{x}'_i\boldsymbol{\beta} + \mathbf{z}'_m\boldsymbol{\gamma} + \mathbf{w}'_m\delta + c_j + d_r + \eta_i \tag{2}$$

$$OFF_{ijmr} = \begin{cases} 1 & \text{if } OFF^*_{ijmr} \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

$$ICT_{ijmr} = \max(ICT^*_{ijmr}, 0) \tag{4}$$

$$\varepsilon_i, \eta_i \sim iidN \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \sigma_\eta\rho_{\varepsilon,\eta} \\ \sigma_\eta\rho_{\varepsilon,\eta} & \sigma_\eta \end{pmatrix} \right] \tag{5}$$

where subscripts i, j, m, r respectively refer to firm, industry, municipality, and region. Therefore, $\mathbf{x}_i$ and $\mathbf{w}_m$ are vectors of firm- and municipal-level exogenous variables which enter both equations. $c_j(f_j)$ and $d_r(g_r)$ are industry and regional dummies which control for unobservable effects common within a region and an industry respectively. $\mathbf{z}_m$ is a vector of exogenous variables which enter the ICT equation but can be reasonably excluded from the offshoring equation. In this framework, endogeneity of the ICT variable stems from the non-zero correlation coefficient between the errors of the two equations, $\rho_{\varepsilon,\eta}$.

We estimate our model by maximum likelihood (ML). As opposed to (two step) control function methods, joint estimation by ML is more demanding in terms of assumptions (as it requires the full specification of the distributions), but offers the advantage of being more efficient than two-step type estimators if the distributional assumptions are correct.

Irrespective of the estimation method, the issue of identification of the model is crucial. The two equation system above is identified even with $\gamma = 0$ due to the non linear functional form.[7]

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[7]On the general condition for identification in parametric models see Bekker and Wansbeek (2001). As an indirect

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However, the availability of legitimate exclusion restrictions is likely to be useful since it increases the precision of the estimates in finite samples (see, for instance, Keane (1992)). Needless to say, however, finding such variables is—as usual in cross-sectional data—a very difficult task.

One potential candidate for this difficult role is the Broad Band (BB) provision at the local level. At the time of the survey (still nowadays, actually) the provision of BB connection was very heterogeneous across Italian municipalities as it requires the availability of both optical fiber infrastructures and Digital Subscriber Line Access Multiplexers (DSLAM) network devices.[8]

— INSERT GRAPH 1 ABOUT HERE —

Graph 1 plots the availability of BB across Italian municipalities at the end of our sample period.[9] It also displays regional borders. The heterogeneity between served (dark shaded) and non-served (light shaded) municipalities is striking not only at regional but even at a much finer geographical level. Even within much narrow geographical entities as provinces (whose borders are not shown for clarity sake) municipalities do differ in the availability of BB connections.

The availability of BB is expected to increase the productivity of ICT investments, since it reduces its cost per unit of information flow. Therefore, it enters the ICT equation. At the same time it can be reasonably assumed—and in our framework tested—not to affect offshoring decisions directly. Furthermore, this variable can be safely assumed to be exogenous in the ICT equation, although Graph 1 shows that the BB variable is not randomly distributed across municipalities.

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proof, the argument put forward by Wilde (2000) to verify identification in the context of a bivariate probit model also applies to our case of a Tobit-probit model. As an additional check, we also run a Montecarlo analysis that shows that the parameters of the models are consistently estimated under the restriction $\gamma = 0$.

[8]On the diffusion of Broad Band provision in Italy see Ciapanna and Sabbatini (2008).

[9]Information on BB provision at the beginning of our sample period would have obviously been preferable. Unfortunately, the first available data collected with a consistent methodology over the whole country refer to December 2003.

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What we argue here is that most of the non-random component of this observed heterogeneity can be accounted for by observable socio-geographical characteristics (density, latitude, longitude, altitude, proximity to the sea) which capture the differences in installation cost among municipalities. Indeed, Table 5 shows that BB provision is more likely in areas with a high population density as well as in coastal area but less likely in mountain areas. This in turn can be explained by the fact that most of the optical fibre infrastructures run parallel to main existing railways or electroduct lines.[10] Once we control for these factors we can reasonably defend the assumption that BB provision is uncorrelated with common shocks affecting firms' ICT investment decisions within a municipality. As a matter of fact, since not only ICT expenditures but also the offshoring decision might be driven by these geographical factors we include them in both equations.

— INSERT TABLE 5 ABOUT HERE —

5   Econometric Results

5.1   Basic Estimates

In this section we present our econometric results for the full sample of firms (Tables 6 and 7). In each table we report three sets of regressions which refer respectively to total ICT (columns (i) and (ii)), hardware (columns (iii) and (iv)) and software/tlc (columns (v) and (vi)) investments. Following a sort of general-to-specific approach the equation estimates reported in Table 7 omit those municipal-level variables which have turned out to be insignificant in the equations of the more general systems reported in Table 6. Marginal effects for all probit models for offshoring are

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[10]See Ciapanna and Sabbatini (2008).

summarized in Table 8.[11] Since results reported in the two tables are very similar we focus here mostly on the unrestricted estimates of Table 6.[12]

— INSERT TABLES 6, 7, AND 8 ABOUT HERE —

In the specification where total ICT investment enters the two equations (columns (i) and (ii) of Table 6), results for the Tobit model are similar to those found by previous literature: age, size, and observed quality (ISO 2002 compliance) positively affect the amount spent in ICT. Among municipal-level variables, the only significant variable is the dummy for firms located in large municipalities (those with a population above 4,000 inhabitants), whose sign is negative.[13] At first sight this result might sound a little bit counterintuitive. One, admittingly ad hoc, potential explanation is that firms located in small towns might find it more difficult to externalize ICT intensive activities due to the lack of partners located nearby and therefore are left with the only option to develop them in house. A complementary explanation might also be that these firms have to invest more in ICT to be able to connect to more distant suppliers or customers. Finally, as expected, the BB provision variable turns out to positively affect ICT adoption and to be marginally significant.[14]

As for the offshoring equation, size and observed quality are the most significant variables. Both positively affect the probability of offshoring. Instead, municipal-level variables turn out to

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[11]Estimation of the system has been carried out in Stata with the *cmp* command available at http://ideas.repec.org/c/boc/bocode/s456882.html. As standard errors for the marginal effects are not provided by Stata mfx command, we computed them by bootstrapping.

[12]In principle we would have liked to estimate additional models with regional dummies being replaced by provincial dummies. Unfortunately convergence was never reached in all our experiments.

[13]At first sight the fact that most municipal-level variables are not significantly different from zero might seem to contraddict the empirical evidence reported in Table 5. Note however that in Tables 6 and 7 we also control for regional specific effects which pick up most of the variability in municipal characteristics that we observe in the data.

[14]Since the exclusion of the BB variable from the primary equation is not necessary for identification we can test the validity of this exclusion restriction by testing the significance of this variable when included in the probit equation. The null hypothesis is never rejected in all estimated models.

be insignificant. Very interestingly, the coefficient of ICT investment is now negative and very significant. This result must be read jointly with the very high and positive value (0.71) of the correlation coefficient between the two errors. This shows that the positive coefficients we found in Table 4 have to be explained by the positive correlation of the ICT variable with the error term, which biases the estimate upward. To assess the quantitative impact of the ICT variable, we repeated the experiment we performed in Table 4. By increasing the value of ICT from the 25th to the 75th percentile of its distribution the probability of offshoring decreases of 3.6 base points. In order to assess—as before—the magnitude of the impact we have to compare it with the percentage of offshoring firms in the sample (7.6%). This leads to the conclusion that the reduction in probability turns out to be quite large (almost 50%). Very similar results—both in terms of sign and significance of the coefficients—are obtained by dropping the insignificant variables (Table 7).

Additional insights can be gained by looking at the last four columns of the two tables where the two equation system is estimated by replacing total ICT investment with hardware (columns (iii) and (iv)) and software/tlc (columns (v) and (vi)) expenditures respectively. As to the Tobit equations two additional findings stand out. Firstly, the dummy for firms located in large municipalities is negative and significant only in the Tobit equation for software/tlc investment (column (vi)). This result is consistent with our previous explanation based on the lack of partners located nearby in small municipalities which is far more likely to apply to the software as opposed to the hardware component. Secondly, and much more importantly for the purpose of this paper, the broad band provision variable also enters positively and significantly only in the Tobit equation for software/tlc investment. This finding suggests that tlc infrastructures are complement only to firms' software/tlc investment and the likely candidate to explain this fact is that broad band provision has a productivity enhancing effect only for this type of ICT investment. Finally, in the

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offshoring equations, both types of ICT investment enters with a negative sign (columns (iii) and (v)). By increasing the value of the relevant ICT investment from the 25th to the 75th percentile of its distribution the probability of offshoring decreases of 1.7 base points for the hardware and of 1.3 base points for the software component. This finding therefore suggests that the negative effect of ICT investment on offshoring is general and it is not specifically related to a specific investment type, at least as captured by the hardware versus software/tlc dichotomy. Once again, very similar conclusions can be drawn by focussing on Table 7 where all non-significant municipal level variables have been omitted.

5.2   Robustness Checks

In this section we comment upon additional estimation results which provide evidence on the robustness of our main findings with respect to several departuters from our baseline specification. Firstly, it might be argued that there are some industries where the fragmentation of production is simply not a feasible option because of technological reasons. Therefore, we expect a null relationship between offshoring and ICT for these industries so that inclusion of firms operating in these industries in the estimation sample could bias the results. To address this legitimate concern we have rerun all reported equations only on the sub-sample of firms operating in industries with non-negligeable offshoring activities. To save on space, in Table 9 we report only the results for two parsimonious specifications, respectively for the hardware and the software/tlc component. As it can be easily seen, all our previous results are virtually unaltered with respect both to the sign and to the significance level of all estimated parameters.

— INSERT TABLE 9 ABOUT HERE —

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Secondly, it is well known that the Tobit type I model imposes strict—and sometimes implausible—restrictions on the relationship between the marginal effects for the two relevant economic dimensions of a variable characterized by a mixed distribution, namely the extensive and the intensive margin. In our setting, this set of restrictions can be in principle easily relaxed by estimating a three equation non-linear system composed by two probit equations modelling the binary decisions whether to invest or not in ICT and whether to offshore or not part of the production process and by one linear equation modelling the amount of ICT investment conditional on non-zero ICT expenditures. Differently from the first two, this third equation can obviously be only estimated on the sub-sample of ICT investing firms. Estimates of two parsimonious specifications are reported in Table 10, respectively for the hardware and the software/tlc component of total ICT expenditures. Before commenting upon the results, however, two cautionary remarks are necessary. Firstly, in order to achieve convergence we had to set the value of the correlation coefficient between the error in the probit equation for the ICT binary decision and the error in the linear model for the amount of ICT investment. Operationally, in all reported equations we have constrained this parameter to be equal to the correlation coefficient estimated from a standard Tobit type II model for ICT investment.[15] Secondly, the identification of the effects in the Tobit type II components of the system is based exclusively on the standard functional form assumption since finding reasonable exclusion restrictions simply proved to be an impossible task. Rather comfortingly most of our crucial results hold. In particular the effect of ICT investment on the offshoring decisions is found to be negative, and significantly so, both for the hardware (column (i)) and for the software component (column (iv)). By increasing the value of the relevant ICT investment from the 25th to the 75th percentile of its distribution the probability of offshoring decreases of 2 base points for the hardware

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[15] All Tobit type II models have been estimated with "full" maximum likelihood. Interestingly, estimated correlation coefficients are all very close to zero, thus suggesting that the errors in the two equations are not correlated.

and of 2.4 base points for the software component, the latter being substantially higher than the corresponding figure we obtained with the Tobit I model. Furthermore, the broad band provision variable is found to have no effect at conventional statistical levels both on the decision to invest (column (ii)) and on the amount spent on hardware (column (iii)). As to software/tlc the effect is positive and significant on the intensive margin (column (v)) but it does not significantly differ from 0 on the extensive margin (column (vi)).

— INSERT TABLE 10 ABOUT HERE —

Finally, it might be argued that there are other firm-level determinants of the offshoring decision that we omit from our model. To address this issue we have re-estimated all our equations after adding a battery of additional firm level variables which control for business group and district membership as well as for the nationality of the ultimate owner. None of these variables turned out to be significant with the exception of business group membership which is positive and significant in some offshoring equations. More importantly for our purposes, however, all our results are virtually unaltered by the inclusion of these additional variables.[16]

6 Conclusions

Which conclusions can be drawn from the empirical evidence presented in this paper? Firstly, in many industrialized countries, including Italy, offshoring is more often related to the delocalization of manufacturing activities and not to the delocalization of business or personal services. Our conjecture is that this is the case in most, if not all, non-English speaking developed countries

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[16]All these additional results are available from the authors upon request.

where the delocalization of routine services is hampered by language barriers. Secondly, the ICT budget in manufacturing firms is mostly allocated to investment in software and hardware and not to investment in TLC. For instance, in our sample of Italian firms, only around 30% declare to have invested in TLC activities and, conditional on a total positive spending in ICT, the average share of TLC investment on total ICT investment is slightly less than one tenth.

Taken together, these two facts point out to the importance of investigating the role played by ICT investment on offshoring in the manufacturing sector. This is exactly what we have done in this paper. Our findings are striking: once we control for the endogeneity of ICT investment we find a negative effect which is both statistically significant and economically sizeable. On the aggregate the estimated marginal effect is equal to -0.137 in our preferred specification. This implies that moving from the first to the third quartile of the ICT distribution implies a reduction of the probability of offshoring of almost 50%. Furthermore, this negative relationship does not depend on a particular type of ITC expenditures but, for instance, equally applies both to hardware and to software/tlc investment.

What emerges quite clearly from this paper is that an exogenous reduction in the cost of ICT investment is unlikely to spur offshoring. Indeed, what we find is quite the opposite. One potential reason for this finding is that most ICT investment carried out within manufacturing firms does not serve the main purpose of enhancing those factors highlighted by the recent literature which underline the role of ICT as a monitoring and communication enhancing device.

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7 Data Appendix

The original dataset is composed of $4,289$ firms. We remove firms operating in non-manufacturing industries or with missing industry codes, so that we are left with $4,110$ firms. Subsequently we remove firms with missing (596 firms) or non-coherent information (297 firms) on ICT investment or with missing information on offshoring activities (12). This gives us our final sample of $3,205$ firms.

The BB provision data have been retrieved from the "Osservatorio banda larga"(*Between*), a private company appointed by the Italian government to monitor the digital divide in Italy.

Municipal-level characteristics are obtained from a database put together by the consulting company Metropolis from Istat sources.

7.1 Survey questions

The 9th wave of the Unicredit-Capitalia survey contains information on ICT expenditures, delocalization of production, and ISO_2002 compliance. The questions we use are listed below.

C1.3.1 In the three-year period 2001-2003 did the firm invest in hardware, software, internet and telecommunications?

  1. yes
  2. no

C1.3.2 Which is the amount of this investment in the three-year period 2001-2003? (Euro)

C1.3.3 Please indicate the specific percentage for each type of these investments (Total 100%)

  1. Hardware
  2. Software
  3. Telecommunication

C1.3.4 Please indicate the specific percentage for each type of these applications (Total 100%)

  1. Administrative/management systems
  2. Production systems
  3. Commercial systems (included customer databases)
  4. Internet (websites, intranet, extranet)
  5. Other applications

D3.1 At present the firm performs abroad part of his production previously performed at home?

E.6 Is the firm awarded ISO 9000 certification?

7.2 Variables definition

Size: number of employees averaged over the 2001-03 period.
Size dummy: dummy equal to 1 if **Size**$\geq$ 50, 0 otherwise.
Observed quality: dummy equal to 1 if the firm has been awarded the ISO 9000 quality certificate, 0 otherwise.
Age: measured as 2003 minus the establishment year.
ICT: 2001-03 ICT investment scaled by firm turnover.
Offshoring: dummy equal to 1 if the firm has declared to perform abroad part of his activities, 0 otherwise.
Broad Band provision: dummy equal to 1 if the proportion of broad band coverage in the municipality in December 2003 exceeds 50%, 0 otherwise.
Inhabitants: number of people resident in the municipality in 2003.
Density: number of people resident in the municipality per Kms.
Latitude and Longitude: municipality latitude and longitude converted to the decimal system
Altitude: municipality altitude in meters.
Costal Area: dummy equal to 1 if the municipality is along the coastline, 0 otherwise.
Industry dummies: 21 industry dummies have been included in all the equations (15 – food and beverages; 17 – textiles; 18 – clothing; 19 – leather; 20 – wood; 21 – paper products; 22 – printing and publishing; 23 – oil refining; 24 – chemicals; 25 – rubber and plastics; 26 – non-metal minerals; 27 – metals; 28 – metal products; 29 – non-electric machinery; 30 – office equipment and computers; 31 – electric machinery; 32 – electronic material, measuring and communication tools, TV and Radio; 33 – medical apparels and instruments; 34 – vehicles; 35 – other transportation; 36 – furniture). Each dummy equals 1 if firm's main activity is in that industry and 0 otherwise.
Regional dummies: 20 dummies corresponding to Italian administrative regions.
Provincial dummies: 95 dummies corresponding to Italian administrative provinces.

Table 1: Offshoring and ICT Investment

	N. of Firms	$Off.Firms$ (%)	ICT Inv. (mean)	ICT Inv. (median)
Full sample	3,205	7.36	0.308	0.121
Food, Bever. and Tobacco	371	0.54	0.170	0.066
Textiles	240	13.33	0.255	0.116
Clothing	92	42.39	0.268	0.156
Leather	117	20.51	0.197	0.063
Wood	97	9.28	0.218	0.153
Paper Products	90	1.11	0.265	0.102
Printing and Publishing	80	3.75	0.464	0.208
Oil Refining	17	0.00	0.245	0.033
Chemicals	178	5.06	0.245	0.083
Rubber and Plastics	169	5.42	0.233	0.098
Non-metal Minerals	201	1.00	0.235	0.076
Metals	121	1.65	0.306	0.084
Metal Products	463	4.32	0.381	0.150
Non-electric Machinery	429	8.16	0.317	0.182
Office Equip. and Comp.	12	8.33	0.413	0.264
Electric Machinery	129	10.85	0.362	0.157
Electronic Produts.	64	7.81	0.855	0.278
Medical App. and Instr.	58	12.07	0.608	0.375
Vehicles	45	11.11	0.731	0.107
Other Transportation	27	22.22	0.227	0.150
Furniture	205	4.88	0.330	0.122

Note: ICT investment is measured as the ratio of ICT expenditures over turnover, in %

Table 2: Descriptive statistics on ICT investments, by type and application

	Firms investing in ICT		mean (%)	
	Number	%	*unconditional*	*| > 0*
Total ICT	2,490	77.69	.31	.40
Hardware	2,309	72.95	.14	.19
Software	2,240	70.77	.15	.21
Telecommunications	984	31.09	.02	.06
Administrative/Management systems	2,080	64.90	.12	.18
Production systems	1,605	50.08	.12	.24
Commercial systems	1,033	32.23	.04	.11
Internet	915	28.55	.02	.07
Other applications	318	9.92	.01	.10

Note: Sample size is 3,205 for Total ICT, 3,165 for types, and 3,195 for applications

Table 3: Additional firm level variables

	Mean	Std. Dev	Median	1st Quart.	3rd Quart.
Age (Years)	27.94	19.44	24	15	36
Size (Employees)	112.21	266.70	49.33	24.00	102.00
Obs. Quality (ISO 2002).	0.55	..	..	..	..

Table 4: Preliminary Probit Estimates for Offshoring

	(i)	(ii)	(iii)	(iv)	(v)
N. of firms	3172	2817	2817	2782	2782
ICT Inv.	0.085 (0.032) [0.008]	0.089 (0.032) [0.010]	0.073 (0.034) [0.006]	..	..
Hardware Inv.	..	..	..	0.085 (0.080) [0.008]	..
Software/TLC Inv.	..	..	..	..	0.099 (0.044) [0.009]
Age	..	..	−0.000 (0.002) [−0.000]	−0.000 (0.002) [−0.000]	−0.000 (0.002) [−0.000]
Size Dummy	..	..	0.708 (0.094) [0.009]	0.712 (0.095) [0.065]	0.711 (0.095) [0.064]
Obs. Quality	..	..	0.207 (0.093) [0.008]	0.228 (0.094) [0.020]	0.219 (0.094) [0.019]
Constant	−2.759 (0.328)	−6.416 (0.846)	−7.105 (0.914)	−7.127 (0.913)	−7.142 (0.941)
Industry dummies.	Yes (0.00)	Yes (0.00)	Yes (0.00)	Yes (0.00)	Yes (0.00)
Regional dummies	Yes (0.25)	No	No	No	No
Provincial dummies	No	Yes (0.05)	Yes (0.19)	Yes (0.19)	Yes (0.21)
Log-likelihood	−715.86	−678.26	−637.61	−628.62	−627.07
Pseudo R^2	0.148	0.164	0.214	0.213	0.215

Note: Size dummy takes a value of 1 if the firm has more than 50 employees.

Standard errors in round brackets and marginal effects in square brackets.

Table 5: BBP, Geographic and Demographic Characteristics

	BBP Municipalities		Non-BBP Municipalities	
	Mean	Median	Mean	Median
Inhabitants	$31,121.64$	$12,192.00$	$4,142.17$	$3,124.00$
Density (Inhabitants per Kms)	735.49	421.37	306.40	155.79
Latitude (Decimal System)	44.22	45.04	44.43	45.24
Longitude (Decimal System)	11.25	11.02	11.05	10.98
Costal Area (%)	16.51		8.93	
Altitude (Meters)	164.17	128.00	257.02	227.00

Note: Unweighted statistics based on the 1,596 municipalities where firms headquarters are located

Table 6: Non-linear System Estimation (unrestricted model, full sample)

	ICT investments		Hardware		Software/TLC	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
N. of firms	3172	3205	3133	3165	3133	3165
Dep. Variable	Offshoring	ICT Inv.	Offshoring	ICT Inv.	Offshoring	ICT Inv
ICT Inv	−0.695(0.138)	..	..	..	..	..
Hardware Inv	..	..	−0.975(0.291)	..	..	..
Software Inv	..	..	..	..	−0.669(0.208)	..
Age	0.001(0.002)	0.002(0.000)	0.001(0.002)	0.001(0.001)	0.001(0.002)	0.002(0.001)
Size Dummy	0.575(0.096)	0.135(0.038)	0.638(0.091)	0.057(0.021)	0.667(0.087)	0.124(0.028)
Obs. Quality	0.238(0.070)	0.144(0.040)	0.227(0.080)	0.056(0.021)	0.248(0.081)	0.112(0.029)
Broad Band Prov.	..	0.075(0.049)	..	0.005(0.028)	..	0.078(0.038)
Inhabitants	−0.006(0.092)	−0.118(0.062)	0.030(0.103)	−0.004(0.034)	−0.011(0.106)	−0.128(0.046)
Density	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
Latitude	0.014(0.128)	0.084(0.072)	−0.018(0.147)	0.019(0.039)	0.017(0.149)	0.076(0.052)
Longitude	0.071(0.065)	−0.021(0.036)	0.093(0.073)	−0.005(0019)	0.101(0.073)	0.003(0.026)
Altitude	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
Costal Area	−0.045(0.137)	0.040(0.074)	−0.062(0.157)	..	−0.024(0.158)	0.034(0.054)
Constant	−4.126(0.663)	−3.536(3.19)	−3.620(6.526)	−0.873(1.723)	−5.337(6.594)	−3.564(2.332)
σ_η	0.971(0.014)	..	−0.515(0.008)	..	0.690(0.010)	..
$\rho_{\varepsilon,\eta}$	0.710(0.123)		0.516(0.138)		0.509(0.134)	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood	−4636.69		−2.990.34		−3624.15	

Note: standard errors in brackets.

Table 7: Non-linear System Estimation (restricted model, full sample)

	ICT Investments		Hardware		Software/TLC	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
N. of firms	3172	3205	3133	3165	3133	3165
Dep. Variable	Offshoring	ICT Inv	Offshoring	ICT Inv	Offshoring	ICT Inv
ICT Inv	−0.710(0.134)	..	..	..	..	..
Hardware	..	..	−1.006(0.287)	..	..	..
Software	..	..	..	..	−0.691(0.206)	..
Age	0.001(0.002)	0.002(0.001)	0.001(0.002)	0.001(0.001)	0.001(0.002)	0.002(0.001)
Size Dummy	0.570(0.096)	0.132(0.038)	0.636(0.091)	0.057(0.021)	0.666(0.087)	0.123(0.028)
Obs. Quality	0.240(0.070)	0.144(0.040)	0.228(0.080)	0.057(0.021)	0.251(0.080)	0.112(0.029)
Broad Band Prov.	..	0.079(0.048)	..	0.004(0.028)	..	0.083(0.037)
Inhabitants	−0.027(0.086)	−0.125(0.061)	0.001(0.098)	−0.011(0.034)	−0.032(0.100)	−0.127(0.045)
Constant	−2.472(0.489)	−0.200(0.120)	−2.983(0.439)	−0.099(0.066)	−3.146(0.410)	−0.299(0.088)
σ_η	0.971(0.014)	..	0.515(0.008)	..	0.691(0.010)	..
$\rho_{\varepsilon,\eta}$	0.722(0.119)		0.530(0.136)		0.522(0.123)	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood	−4639.83		−2993.30		−3626.78	

Note: standard errors in brackets.

Table 8: Marginal effects for the offshoring equation

	ICT investments		Hardware		Software/TLC	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
ICT Inv	−0.113(0.068)	−0.119(0.069)	..	..	..	..
Hardware Inv	..	..	−0.110(0.060)	−0.116(0.062)	..	..
Software Inv	..	..	..	..	−0.072(0.053)	−0.077(0.057)
Size dummy	0.094(0.016)	0.096(0.015)	0.074(0.013)	0.075(0.014)	0.075(0.015)	0.077(0.016)
Inhabitants	−0.001(0.022)	−0.005(0.021)	0.003(0.011)	0.000(0.011)	−0.001(0.011)	−0.004(0.011)
Obs. Quality	0.038(0.018)	0.039(0.018)	0.025(0.009)	0.026(0.009)	0.027(0.010)	0.028(0.010)
Age	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
Costal area	−0.007(0.028)	..	−0.007(0.017)	..	−0.003(0.017)	..
Altitude	0.000(0.000)	..	0.000(0.000)	..	0.000(0.000)	..
Density	0.000(0.000)	..	0.000(0.000)	..	0.000(0.000)	..
Longitude	0.011(0.013)	..	0.010(0.007)	..	0.011(0.007)	..
Latitude	0.002(0.028)	..	−0.002(0.015)	..	0.002(0.014)	..

Note: Standard errors computed by bootstrapping (100 repetitions) in brackets. Columns (i), (iii), and (v) refer to the probit models of Table 6 whereas columns (ii), (iv), and (vi) refer to those of Table 7

Table 9: Non-linear System Estimation (restricted model, restricted sample)

	Hardware		Software/TLC	
N. of firms	2283	2293	2283	2293
Dep. Variable	*Offshoring*	*ICT Inv*	*Offshoring*	*ICT Inv*
Hardware	−1.228(0.313)	..	..	..
	[−0.217]	..	..	..
Software	..	..	−0.632(0.188)	..
	..	..	[−0.105]	..
Age	0.001(0.002)	0.001(0.001)	0.001(0.002)	0.002(0.001)
Size Dummy	0.578(0.094)	0.045(0.022)	0.611(0.091)	0.110(0.036)
Obs. Quality	0.258(0.083)	0.042(0.023)	0.301(0.085)	0.136(0.038)
Broad Band Prov.	..	0.025(0.029)	..	0.107(0.048)
Inhabitants	0.013(0.102)	−0.043(0.035)	−0.018(0.106)	−0.180(0.059)
Constant	−1.824(0.628)	0.097(0.160)	−2.070(0.606)	−0.001(0.253)
σ_η	0.463(0.008)	..	0.765(0.013)	..
$\rho_{\varepsilon,\eta}$	0.575(0.134)		0.529(0.133)	
Industry dummies	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes
Log-likelihood	−2135.92		−2970.70	

Note: standard errors in brackets. Marginal effects of ICT investment in square brackets.

Table 10: Non-linear System Estimation, 3 equations (restricted model, full sample)

	Hardware			Software/TLC		
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
N. of firms	3133	2309	3165	3133	2309	3165
Dep. Variable	Offshoring	ICT Inv	Probit Hard	Offshoring	ICT Inv	Probit Soft/TLC
Hardware	−1.049(0.424)	..	..	..	..	..
	[−0.127]	..	..	..	..	..
Software	..	..	..	−0.919(0.201)	..	..
	..	..	..	[−0.137]	..	..
Age	0.000(0.002)	0.000(0.001)	0.006(0.001)	0.001(0.002)	0.001(0.001)	0.006(0.001)
Size Dummy	0.621(0.109)	0.004(0.021)	0.257(0.052)	0.608(0.095)	0.041(0.029)	0.326(0.052)
Obs. Quality	0.223(0.079)	0.029(0.022)	0.139(0.054)	0.247(0.073)	0.080(0.031)	0.169(0.054)
Broad Band Prov.	..	0.036(0.029)	−0.136(0.073)	..	0.118(0.038)	−0.074(0.072)
Inhabitants	−0.006(0.097)	−0.056(0.035)	0.176(0.086)	−0.067(0.093)	−0.192(0.048)	0.118(0.085)
Constant	−2.871(0.582)	0.270(0.071)	−0.209(0.157)	−2.739(0.478)	0.068(0.094)	−0.092(0.159)
σ_η	..	0.483(0.007)	..	..	0.656(0.010)	..
$\rho_{1,2}$		0.520(0.201)			0.643(0.124)	
$\rho_{1,3}$		0.406(0.130)			0.466(0.103)	
$\rho_{2,3}$		−0.019[‡]			0.001[‡]	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood		−4005.34			−4685.85	

Notes: standard errors in brackets. [‡] Constrained to to be equal to the correlation coefficient from a standard
Tobit II model for ICT investments. Marginal effects evaluated at the mean of the covariates in square brackets.

Graph 1:Broad Band Provision (BBP) by municipality

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km   50   100   200