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INFORMATION TECHNOLOGY AND BANKING ORGANIZATION

by Sauro Mocetti*, Marcello Pagnini* and Enrico Sette**

Abstract

We investigate the impact of information and communication technologies (ICT) on local loan officers' autonomy in small business lending. We derive a simple agency model of the interaction between a local branch manager and the headquarters, which yields an estimable equation for the optimal delegation of authority. Using a unique and specifically tailored dataset including about 300 Italian banks, we show that banks equipped with more ICT capital and resorting to credit scoring delegate more decision-making power to their local branch managers. These results are robust to many additional controls, including instrumental variable estimation. The effects on decentralization are strengthened for those banks that jointly hold higher ICT capital endowments and adopt credit scoring.

JEL Classification: L22, M54, O33.
Keywords: ICT, credit scoring, delegation, banking organization, local branch manager, small business lending.

Contents

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** Bank of Italy, Economics, Research and International Relations.

1. Introduction*

Most banks organize their lending activity through a network of geographically dispersed branches, operating in different local credit markets. They are normally run by a local branch manager (henceforth LBM) who plays a critical role in collecting information about potential borrowers, in particular small and medium-sized firms. Through face to face interactions with the firms' managers and the local community, the LBM gains access to the relevant information about firms' creditworthiness, builds relationships with the most promising potential borrowers in the market, and screens applicants. Since the efficiency of the decision-making process requires the person responsible for decisions to have access to the knowledge which is valuable to those decisions, and since information transmission can be costly, some decision-making rights should be delegated to the LBMs, especially concerning small business lending. However, as stressed by principal-agent models, delegation raises agency costs since the LBM might pursue private benefits that could be in conflict with the maximization of the bank's profits. Naturally, the optimal degree of delegation is the result of the trade-off between agency costs and the costs of transferring information within the organization.

The rapid diffusion of the Information and communication technologies (henceforth ICT) in credit markets during recent decades affected this trade-off in several ways. On the one hand, they brought about a substantial improvement in the CEO's ability to measure and observe the output of the LBM thereby reducing agency costs and favouring decentralization. On the other hand, they also contributed to reducing bottom-up communication costs and to tackling the CEO's information overload, widening the possibilities for moving decisions further up in the hierarchy.

Moving on from these opposing effects, the aim of this paper is to examine whether the introduction of ICT affects the allocation of decision-making rights inside the bank hierarchy. The issue is particularly relevant since it is usually held that an autonomous and active LBM may facilitate credit access for small firms that are more opaque and difficult to evaluate.

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We derive a simple model of organizational design where the contrasting effects of ICT on the delegation of authority are represented. The model confirms the ambiguous effects of ICT on decentralization and also yields an equation for the optimal level of delegation which is estimated on a unique dataset reporting information on the internal organization of a representative sample of Italian banks.[1] The survey concerns the role of LBMs in small business lending. The focus on lending to small and medium-sized enterprises is motivated by the fact that typically LBMs have some authority on lending to small business, while decision-making powers for loans to large corporations are usually granted to managers at a higher hierarchical level.

Our main econometric findings indicate that banks equipped with more ICT capital and resorting to credit scoring delegate more decision-making power to their LBMs in small business lending activity. These results are robust to several additional controls and robustness checks, including instrumental variable estimation. Moreover, we find that the impact on decentralization is strengthened for banks with a greater orientation towards small business lending and for those that jointly hold higher ICT capital endowments and adopt credit scoring.

In light of our model, the interpretation of this evidence is that the impact of new technologies on agency costs more than offset their impact on the costs of transmitting information (from local branches to the headquarters) and on the improvement in the central manager's decision-making ability. Information technology helps banks to improve their internal monitoring activity, thanks to timely information about lending practices and the possibility of controlling the LBMs' activity and the performance of local branches. Finally, credit scoring models, intranet infrastructures and more cost-effective voice and internet communication have made it easier to analyse credit applications at the branch level, to share documentation and to combine information stored in different databases. All these factors lessen agency problems and favour delegation toward the peripheral units within the banking organization.[2]

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[1] Data was gathered through a specially designed survey conducted by the Bank of Italy in 2007 reporting, among other variables, the distribution of power delegation across hierarchical levels and the adoption of credit scoring for small business lending. The sample includes all medium and large banks and a representative sample of small banks and credit cooperative banks. See Albareto *et al.* (2008) for an illustration of the survey and for some related evidence.

[2] Obviously, there can be other channels through which new technologies are enabling greater decentralization. For example, they can facilitate information transmission from the centre to the periphery, the coordination of local branches and/or reduce the costs of acquiring information locally. Following Autor *et al.* (2003), new technologies can also substitute the LBM in carrying out a limited and well-defined set of standardized and manual activities – say "routine tasks" – increasing the

The present paper is at the crossing point of three strands of literature. One is related to the LBM's role in the banking industry. Despite the primacy of this role in small business lending, research in this field is relatively scant. Previous contributions focus on the impact of organizational form – decentralization or hierarchy – on information production and transmission inside an organization (Stein, 2002), and on how a bank actually disseminates hard and soft information through different hierarchical layers (Liberti, 2005).[3] Though interesting from our point of view, most of the empirical findings in this literature rely on clinical studies of a single organization and are therefore difficult to extend to the entire banking sector. The second strand of literature concerns the effects of new technologies in the banking industry. Berger (2003) assesses the impact of technological progress on productivity growth and on the structure of the banking industry.[4] Berger, Frame and Miller (2005) examine the effect of adoption of credit scoring on credit availability and price conditions for small business lending. Felici and Pagnini (2008) investigate how the ability of banks to open branches in distant markets changed following the advent of ICT. None of these papers analysed the impact of the new technologies on banks' organizational structure. This topic is at the core of a third strand of literature. In particular, Brynjolfsson and Hitt (1998) and Bresnahan *et al.* (2002), using firm-level data, find evidence of complementarities between information technology and workplace organization.[5] Bloom *et al.* (2009) distinguish between "information" and "communication" technologies and find that information technologies are associated with more autonomy and a wider span of control while communication technologies, by contrast, reduce autonomy for both workers and plant managers. These studies employ data from firms belonging to diverse industries, whereas our paper is the first to examine the impact of the new technologies on the internal organization of banks. Focusing on a single industry, with relatively homogenous inputs and outputs, may

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efficiency of cognitive and interactive tasks. These further channels are omitted in our model for sake of simplicity. However, their effects are discussed in the following section.

[3] Stein (2002) argues that decentralization is more attractive when information is soft whereas large hierarchical firms with multiple layers of management have a comparative advantage when information is hard and can be costlessly passed along within the hierarchy. Liberti (2005) and Liberti and Mian (2009) empirically show that loans that go to higher levels (that are more distant from the source of information) rely more on hard information and less on soft information. Uchida *et al.* (2008) analyze whether loan officer attributes affect the production of soft information. The role of the loan officer has also been investigated in Udell (1989), Ferri (1997), Scott (2006), and Hertzberg *et al.* (2009) and, for Italy, in Benvenuti *et al.* (2010) and Micucci and Rossi (2010). For a more general analysis of the importance of bank organization on lending activity see Berger and Udell (2002) and Berger, Miller, Petersen, Rajan and Stein (2005).

[4] See also Casolaro and Gobbi (2007) for evidence on the Italian banking industry.

[5] See also Gurbaxani and Whang (1991), Christie *et al.* (2003), Colombo and Delmastro (2004) and Rajan and Wulf (2006).

help mitigate problems of combining data from heterogeneous industries. Besides, factors like asymmetries of information and agency costs underlined by the theories on the internal organization of firms are likely to have special relevance in the banking sector.

The rest of the paper is organized as follows. Section 2 outlines a theoretical framework describing the trade-off between centralization and decentralization and investigates the impact of ICT on the elements of this trade-off. Sections 3 and 4 illustrate, respectively, the empirical strategy and the data used in the paper. Section 5 presents the results and a set of robustness checks. Section 6 concludes.

2. The impact of ICT on banks' internal organization

As explained in the introduction, the expected impact of ICT on decentralization is theoretically ambiguous. In order to clarify this intuition and to obtain some guidance in setting-up an estimable equation we derive a simple model of decision-making in banking, trying to capture the main trade-offs highlighted by the theoretical literature on delegation.[6] First, delegation provides incentives to the agent (the LBM); second, delegation determines a loss of control for the principal (the CEO) and may lead to bad decisions being made if the incentives of the agent are not fully aligned to those of the principal; third, centralization entails additional costs for the principal related to collecting information and making a decision; fourth, the principal may wish to monitor agents when they are delegated power, and this activity generates some extra costs as well.[7] The new technologies affect the costs for transmitting and processing information as well as those for monitoring the

[6] Our model blends elements from the literature on delegation as a response to agency problems with elements from the literature on delegation as a way to minimize the costs of transmitting information within the organization.

[7] Delegation of authority may increase the LBM's level of initiative and participation in the organization and propensity to acquire and use soft information (Aghion and Tirole, 1997; Stein, 2002; Zabojinik, 2002). Moreover, by delegating power to the agent who directly collects information, banks can fully exploit economies arising from local capabilities and task specialization (Geanakoplos and Milgrom, 1991), thereby saving on the costs of transferring information within the organization. However, principal agent models point to the fact that decentralization implies a loss of control, i.e. the agent is freer to pursue private benefits that could conflict with the principal or the CEO's interests. Typical agency costs in the banking industry consist of LBM incentives to grant loans to poor quality borrowers in order to increase the funds allocated to the branch, or because of a personal friendship with the owner, the prospect of a future job offer from the borrowing firm or illegal kickbacks. These agency costs may be alleviated through monitoring or incentive mechanisms that are however, in the presence of incomplete information, imperfect and costly to implement. For an analysis of organizational failures due to leaks and delays in information transmission between the top and the bottom of the hierarchy and vice versa, see also Radner (1993) and van Zandt (1999).

LBM's activity, thus influencing the choice between centralization and decentralization.[8]

Our model is as follows: two agents operate in a bank, the LBM and the CEO (or headquarters). The latter decides how much authority to delegate to the LBM. A bank receives several loan applications randomly varying in their amounts. Specifically, loan size L is distributed according to a uniform distribution with support $\left[0,\overline{L}\right]$. The LBM exerts an unobservable effort to improve the quality of loan origination, collecting information on the local credit market and on potential borrowers in order to build relations with firms which may apply for a loan. The more effort exerted in this loan generation activity, the higher the probability that potential borrowers are of good quality, and therefore that loans will generate a high payoff. We assume that neither the loan generating activity, nor the quality of borrowers is verifiable so that contracts to incentivate the LBM cannot be written. The LBM derives a private benefit from being delegated power and if the loan is granted. If decision-making powers are delegated, the CEO monitors the LBM's activity, learns the quality of the firm, and may decide to over-rule the LBM's decision.

In order to better illustrate our model, we sketch its timing:

1. The CEO designs the organization, by choosing the threshold loan size L^* above which decisions on the loan approval are centralized.
2. The LBM exerts effort in generating loans.
3. The bank receives a loan application of size L. The decision to grant the loan is centralized or decentralized according to whether L is above or below the threshold L^*.
4. The person in charge of the decision observes the quality of the firm and decides whether to grant the loan. The CEO monitors the LBM if the decision is decentralized, and possibly overturns it.
5. Payoffs are realized.

If the CEO centralizes loans above the threshold L^*, the expected payoff is

[8] ICT is likely to improve central management's monitoring ability, raising the chances to detect misbehaviour on the part of the LBM. This, in turn, would increase the scope for decentralization by reducing agency costs (Hubbard, 2000). On the other hand, ICT adoption lowers the costs of bottom-up communications and it improves the CEO's computation abilities thereby reducing the information overload (Bresnahan *et al.*, 2002). The result would be, in this case, greater centralization.

$$\frac{\bar{L}-L^*}{\bar{L}}\pi^C_{CEO}+\frac{L^*}{\bar{L}}\pi^D_{CEO}$$

where π^C_{CEO} is the payoff of the CEO from centralization while π^D_{CEO} is the payoff from delegation. Denote as x the probability the decision is delegated (that corresponds to $\frac{L}{\bar{L}}$, since loans are distributed uniformly).

We assume that the effort exerted by the LBM in generating loans increases the probability that the quality of the loan is high. Let e denote this probability and assume that it coincides with the effort exerted by the LBM. Our interpretation is that the more the LBM exerts effort in collecting soft information and building relationships with prospective borrowers, the higher the average quality of firms applying for credit.

The LBM's payoff is:

$$\Pi_{LBM}=x\cdot\Pi^D_{LBM}+(1-x)\cdot\Pi^C_{LBM}-\frac{1}{2}e^2$$

where:

$$\Pi^D_{LBM}=(1-m)\cdot 0+m[eB+(1-e)\cdot 0]$$

$$\Pi^C_{LBM}=0$$

B is the private benefit accruing to the LBM if the loan is granted (granting more loans increases the funds allocated to the branch, the connections with the debtor, etc.). Since the LBM derives private benefit B when loans are granted, the loan may be offered independently of a firm's quality. By monitoring the LBM's decision, the CEO learns the quality of the firm. In the case of delegation, if monitoring does not succeed (with probability *1-m*) we assume it is optimal not to grant the loan. If monitoring succeeds (with probability m) the loan is granted only if the borrower is of high quality (this is the case with probability e).[9] In the case of centralization, the payoff of the LBM is normalized to 0.

The LBM chooses effort to maximize the expected payoff. Hence optimal effort is:

$$e=xmB$$

which shows that effort increases provided the LBM is delegated more power with

[9] We could assume that when monitoring fails the loan is granted, and the results would be essentially unchanged.

higher probability (a similar relationship is represented in Aghion and Tirole, 1997), monitoring is more likely to succeed, and private benefit is larger.[10]

The CEO's payoff is:

$$\Pi_{CEO} = x \cdot \Pi^{D}_{CEO} + (1-x) \cdot \Pi^{C}_{CEO}$$

where:

$$\Pi^{D}_{CEO} = (1-m) \cdot 0 + m\left[eH + (1-e) \cdot 0\right] - c^{mon}$$

$$\Pi^{C}_{CEO} = eH + (1-e) \cdot 0 - c^{\inf} - c^{dec}$$

In the case of delegation, if monitoring does not succeed (with probability *1-m*) the loan is not granted and the CEO's payoff is normalized to 0. If monitoring succeeds (with probability *m*) the loan is granted only if it is of high quality (with probability *e*); if the quality of firms applying for credit is good the payoff is high and will be denoted by *H*. If the loan is bad instead, the CEO manages to over-rule the decision by the LBM, the loan is not granted and this yields a low payoff normalized to 0. Monitoring is beneficial, since it allows the CEO to provide incentives to the LBM.[11] Delegating decision-making power also entails costly monitoring activity (c^{mon}).

In the case of centralization, the screening activity and lending decisions by the CEO also benefit from the loan generating activity performed by the LBM: if the quality of firms applying for credit is good (with probability *e*) then the loan is granted and the CEO's expected payoff is *H*; if a firm's quality is not good (with probability *1-e*) the loan is not granted, and payoff is normalized to zero. Centralizing decision-making power also entails costs for transmitting information from the LBM ($c^{\inf}$) and for processing information and making a decision (c^{dec}).[12]

The optimization problem of the CEO is

$$\max_{x} \quad x \cdot \Pi^{D}_{CEO} + (1-x) \cdot \Pi^{C}_{CEO}$$

[10] Optimal effort must be such that $e \leq 1$, so that *e* is a well-defined probability.

[11] An alternative formulation posits that when monitoring succeeds and the firm is of bad quality, the CEO is able to earn a positive payoff by modifying the decision of the LBM. What matters for our results is the assumption that successful monitoring yields a larger payoff for the CEO than if monitoring fails.

[12] With no loss of generality, we are normalizing the cost of making a decision about the loan to zero for the LBM. This follows since we can assume that the LBM has better access to information about borrowers and also that given the incentives, not much effort is exerted to evaluate the quality of borrowers, since it is always more preferable to grant a loan than not.

or

$$\max_{x} \quad x \cdot \left(meH - c^{mon}\right) + (1-x) \cdot \left(eH - c^{\inf} - c^{dec}\right)$$

where $e = xmB$ and $0 \le x \le 1$.

It can be verified that this function is concave in *x* and optimal delegation is:

$$x^{*} = \frac{1}{2m(1-m)BH}\left[mHB + \left(c^{\inf} + c^{dec} - c^{mon}\right)\right]$$

which shows that the CEO delegates authority more, the higher the costs of transmitting information and of making a decision, and the lower the cost of monitoring.[13]

The effect of ICT endowment on delegation is ambiguous, since it affects the cost of transmitting information, the cost of deciding about the loan, and the cost of monitoring. According to the theory, and on the basis of available data, we assume that the cost of transmitting information within the bank depends upon the ICT endowments, the distance of the branch from the headquarters and the size of the bank, as follows:

$$c^{\inf} = \gamma_1 ICT + \gamma_2 dist + \gamma_3 size$$

where we assume that $\gamma_1 < 0$, as ICT reduces the cost of transmitting information within the organization, while it is assumed that $\gamma_2 > 0$, $\gamma_3 > 0$ since these costs are likely to increase in the case of wider geographical branch networks implying longer centre-periphery distances and of larger and more complex organizations. Finally, we assume that c^{dec} and c^{mon} depend on the same variables as those determining $c^{\inf}$:

$$c^{dec} = \theta_1 ICT + \theta_2 dist + \theta_3 size$$

$$c^{mon} = \lambda_1 ICT + \lambda_2 dist + \lambda_3 size$$

Moreover the effects of those variables are also assumed to be the same as before implying that $\theta_1 < 0$, $\theta_2 > 0$, $\theta_3 > 0$ and $\lambda_1 < 0$, $\lambda_2 > 0$, $\lambda_3 > 0$. By plugging the expressions for costs into the equation for optimal delegation, we obtain:

$$x^{*} = \frac{mBH}{2m(1-m)BH} + \frac{+(\gamma_1 + \theta_1 - \lambda_1)}{2m(1-m)BH} ICT + \frac{(\gamma_2 + \theta_2 - \lambda_2)}{2m(1-m)BH} dist + \frac{(\gamma_3 + \theta_3 - \lambda_3)}{2m(1-m)BH} size$$

and this yields an estimable equation for the optimal delegation by bank i:

[13] Notice that the non-negativity constraint may be binding, and $x^{*}=0$ if the numerator is negative. Similarly, if the optimal $x^{*}>1$, the constraint $x \le 1$ will be binding.

$$x_i^* = \frac{L}{\overline{L}_i} = \beta_0 + \beta_1 ICT + \beta_2 dist + \beta_3 size + \varepsilon_i \qquad (1)$$

This simple estimable model suggests that the effect of ICT on the delegation of authority is ambiguous, since it depends upon the sign of $(\gamma_1 + \theta_1 - \lambda_1)$, which is to say, that it depends upon whether ICT impacts more strongly on the cost of transmitting information, on the cost of decision-making, or on the cost of monitoring.

There are a few assumptions of the model which are critical to obtain a simple linear estimable equation. First, the distribution of loans is assumed to be uniform. In a more general model, the dependent variable could be a complex function of the absolute loan size which is delegated to the LBM. Hence, as a robustness check, we also estimate the model using "absolute" delegation as a dependent variable, since this is just the maximum size of loans for which decision-making powers are granted to the LBM. Second, we are assuming that optimal effort *e* does not depend on ICT. Removing this assumption would generate a non-linear relationship between optimal delegation and ICT. Then, the first order condition for optimal delegation could still be brought to data and estimated by non-linear least squares, or it could be approximated by a linear equation. More generally, we could have written a more complex and richer model to capture the different channels through which ICT affect delegation of authority.[14] We believe our model captures the most important channels through which ICT affects delegation. Adding further channels would not change the main prediction that ICT has an ambiguous effect on delegation at the cost of yielding a complex non-linear model to estimate. Third, we are modelling the LBM's activity as one of loan generation. The LBM collects information and builds relationships with the most promising potential borrowers, in this way raising the average quality of firms that actually apply for a loan. However, the LBM, also collects information about borrowers when they actually apply for a loan (in our model, after a loan of size *L* arrives), in order to support the decision to grant the loan. This occurs both if the decision is delegated and if it is centralized. Hence, we can easily extend our model to include this further activity performed by the LBM and to allow ICT to have an impact on it, and little would change.

[14] Just to make a few examples, new technologies can affect the decision-making costs for the LBM in charge of the decision; they affect the LBM's ability to monitor the borrower after the loan is granted; they affect the cost of transmitting information from the headquarters to local branches (besides bottom-up communications) and diminish the coordination costs of peripheral units.

3. Empirical Strategy

In order to take equation (1) to data, it is necessary to think about the process through which banks invest in ICT, especially since organizational form and ICT adoption may be jointly determined. The scenario we have in mind starts from the recent waves of innovation in the telecommunication and computer sectors. These developments brought about a dramatic fall in the price of hardware and software and induce banks as well as firms in other industries to speed up ICT adoption. However, the intensity and speed of reaction to this largely exogenous price shock differ across banks depending on the quality of the management, the lending practices existing before the introduction of the new technologies and other organizational variables.

In particular, we assume that the introduction of the new technologies will take time to exert its effects because of the learning costs related to their use and the uncertainty surrounding their returns. Moreover, after some time, ICT will affect the more flexible components of the organizational structure, namely the ones featuring lower adjustment costs such as our proxy for the LBM's decision-making power (more on this below). This justifies our econometric strategy based on the idea that ICT adoption influences the degree of decision-making centralization in small business lending. In the long run it is likely that ICT adoption and organizational factors will be jointly determined as underlined by the literature (Breshnan *et al.*, 2002). But in the short and medium term, it is reasonable to assume that the causal link runs from ICT to the organizational variables.

The empirical analysis is carried out on a cross section of about 300 Italian banks and the empirical specification follows from equation (1):

$$PD_i = \alpha + \beta_1 ICT\_CAP_i + \beta_2 SCORING_i + \delta X_i + \mu_i$$

where PD_i represents the empirical counterparts of x^*, the optimal delegation identified in equation (1). More specifically, PD_i equals the ratio between the loan size that the LBM of bank i can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the bank's CEO. In our data, the power delegation of the CEO mirrors the upper bound of the loan distribution that arrives at the bank. The implicit assumption is that the maximum loan amount applied by a firm corresponds to the maximum sum of money that can be granted by the bank's top management. Therefore the ratio between the LBM's

and the CEO's power delegation identifies the threshold that discriminates between delegation and centralization. Among the explanatory variables, new technologies are represented through *ICT_CAP* and *SCORING*. ICT_CAP_i is the log of ICT capital stock per employee in bank i considered with a three-year lag; $SCORING_i$ is a discrete variable that distinguishes the following situations: no adoption of credit scoring for small business lending, adoption in the last two years and adoption at least 3 years ago. As explained above, the use of lagged values for these variables is consistent with a short run causal relationship in which power delegation is determined by the adoption of new technologies. Moreover, the use of lags for all the regressors may help in solving any simultaneity problems that might affect our econometric findings.

The use of *ICT_CAP* or some of its related proxies is relatively common in empirical studies on organization. It picks up the effects that the investment in computers and software might have on the relationship between the top management of the bank and the peripheral managers. The role of *SCORING* is relatively new and it is clearly specific to lending markets. These techniques provide a standardized screening procedure that allows banks to reduce the costs of recording and transmitting information and to speed up the loan approval process. Implementation of this kind of lending technology is very closely related to the use of the new technologies and consequently is considered here as part of that process. Credit scoring models, intranet infrastructures and communication technologies allow timely and frequent information about lending practices and local branches' performance. Other improvements include efficiency gains in accessing data, sharing documentation, in combining information stored in different databases, and in communicating between the headquarters and peripheral units. Finally, there can be positive spillovers between credit scoring and ICT endowments since scoring models affect how information is recorded and stored while software and other applications affect how information is processed. We also include a set of covariates (size, distance, etc.) varying across banks and that are also taken with a three year lag.[15] β_1 and β_2 are the key parameters to be estimated.

4. Data

The dataset is obtained by combining information on the internal organization

[15] In what follows, we will use lagged values for the explanatory variables whenever possible. For some regressors, we observe data for the year 2006 only (see Table A1 in the Appendix).

of banks taken from a specially designed survey and additional data derived from the Supervisory Reports (SR) of the Bank of Italy. The survey, conducted by the Bank of Italy in 2007, included questions about the organizational structure of the lending activity, the distribution of power delegation across hierarchical levels and the adoption of credit scoring for small business lending. The targeted sample consisted of more than 300 banks including the universe of medium and large banks and a representative sample of small and cooperative banks.[16] We excluded those intermediaries that do not lend to small firms (e.g. those specialized in lending to large firms) and foreign bank branches. The final sample consists of 297 observations. The SR contains balance sheet data, loan portfolio characteristics and other information disclosed by banks complying with prudential regulation requirements.

In the following subsections we will describe our key variables whereas Table A1 in the Appendix reports a complete list and description of the covariates included in vector X_i and that will be used in the empirical analysis.

4.1 Power delegation

One of the goals of the survey was to get a measure of the degree of delegation in the loan origination process. To this end, banks were asked to list all the levels within the organization involved in lending, ordered hierarchically from the local loan officer up to the board of directors (see Table A2 in the Appendix). In addition, banks were asked to indicate the maximum loan amount that each level can grant autonomously to a small firm applying for a loan at that bank for the first time.[17] The structure of this question was motivated by the need to avoid that the past characteristics of a bank's loan portfolio would not have too strong an impact on the decision to decentralize authority. Lastly, levels of delegation had to relate to those applicants with a risk level judged normal a priori by the bank. In other words, we wanted to observe banks' organizational strategies for the pool of applicants that are neither exceptionally good nor exceptionally bad because these kinds of borrowers are normally rare and, at the same time, they may induce an abnormally low or high level of delegation toward the LBM.

[16] The accuracy of the questionnaire was guaranteed through several checks before and after the realization of the survey. First, the questionnaire was tested with preliminary interviews with bank managers to detect potential ambiguities in the phrasing and improper question formulations. Second, several rounds of telephone interviews were conducted to ensure no data were missed and to correct inconsistent responses in the questionnaire. The response rate was nearly 100 per cent.

[17] This means that a specific applicant was not a customer of that bank at time *t-1*.

The distribution of power delegation across the hierarchical layers mirrors the allocation of formal authority within the organization. Following Aghion and Tirole (1997), formal authority refers to the right to make decisions, where the attribution of authority is based on a contractual relationship. In our framework, this kind of power is transferred from the CEO to subordinates by means of an act of delegation. When CEOs keep formal authority, they are in charge of the decision-making process for loan approval. If CEOs delegate decision-making power to the LBM, the latter is able to act autonomously within the limits set by the act of delegation. Starting from the distribution of power delegation across the hierarchical layers, we built a measure of decentralization for each bank, as suggested by our structural model. This is obtained by normalizing the amount of credit offered by the LBM with respect to that offered by the CEO.[18]

On average the LBM has a power delegation that is 15 per cent that of the CEO. This percentage is smaller for large banks (about 5 per cent) and higher for cooperative banks (nearly 20 per cent). Power delegation is zero for about 10 per cent of the banks whereas the maximum is 68 percent. The distribution of the variable is right-skewed with the mass concentrated around values not very distant from zero. However there is considerable variance across banks: the 25th and 75th percentiles are respectively equal to 3 and 22 per cent.[19]

The LBM's autonomy is clearly a multifaceted concept and is therefore very difficult to represent in a single index. In this respect, our proposed measure may clearly have some limitations. First, it does not pick up other aspects of the loan contract that may characterize the LBM's authority, such as the power to set interest rates and to ask for collateral. Second, being based on a concept of formal authority, our index could misrepresent the LBM's real authority that is seen in the effective control over decisions and that derives from the knowledge of crucial information (Aghion and Tirole, 1997). For instance, a high level of *PD* could not necessarily signal the LBM's real authority in those banks that do not allow their LBM to remain in the same branch for a sufficient time span to accumulate qualitative knowledge of the local credit applicants.

The first objection can be addressed by observing that the power to grant a loan is crucial within a bank-firm relationship and that power delegation is arguably

[18] In our sample there is a great variance across banks with respect to organizational structure and hierarchical layers. The LBM and the CEO are two figures that feature in the organization of almost all banks.

[19] The distribution of the LBMs' absolute power delegation across banks is reported in Figure A1 in the Appendix.

correlated with other aspects that characterize the LBM's authority in the lending process. The second objection can also be addressed by introducing a set of robustness checks aimed at controlling for other organizational variables that affect the LBM's capability to acquire information.

Finally, our index can also be evaluated through a comparison with alternative proxies for the decentralization of decision-making power used in the literature on organization. Bresnahan *et al.* (2002) propose an indicator based on the importance of self-managing teams among production workers. Colombo and Delmastro (2004) rank modes of allocating decision-making – centralization, partial delegation and full delegation – depending on the autonomy of plant managers in taking some strategic decisions related to the plant's activity. Christie *et al.* (2003) and Acemoglu *et al.* (2007) define an organizational unit of the firm as decentralized when it is designed as a profit centre. The basic assumption is that a profit-centre unit has a broader set of decision rights than a cost-centre unit.[20] Compared to the other indexes, our indicator is based on objective data and not on a subjective assessment about the importance of the peripheral manager. Second, it can be directly interpretable as a measure of how many decision-making rights are allocated to the local branch. Third, it is continuous and therefore it is not subject to the loss of information connected to a discrete measure.

4.2 ICT capital stock and credit scoring

As stated above, new technologies are represented through ICT capital stock and the adoption of credit scoring. The former was computed using the perpetual inventory method. Formally:

$$ICT\_CAP_{i,t} = \sum_j K_{i,j,t} = \sum_j \left[(1-\delta_j) K_{i,j,t-1} + I_{i,j,t} \right]$$

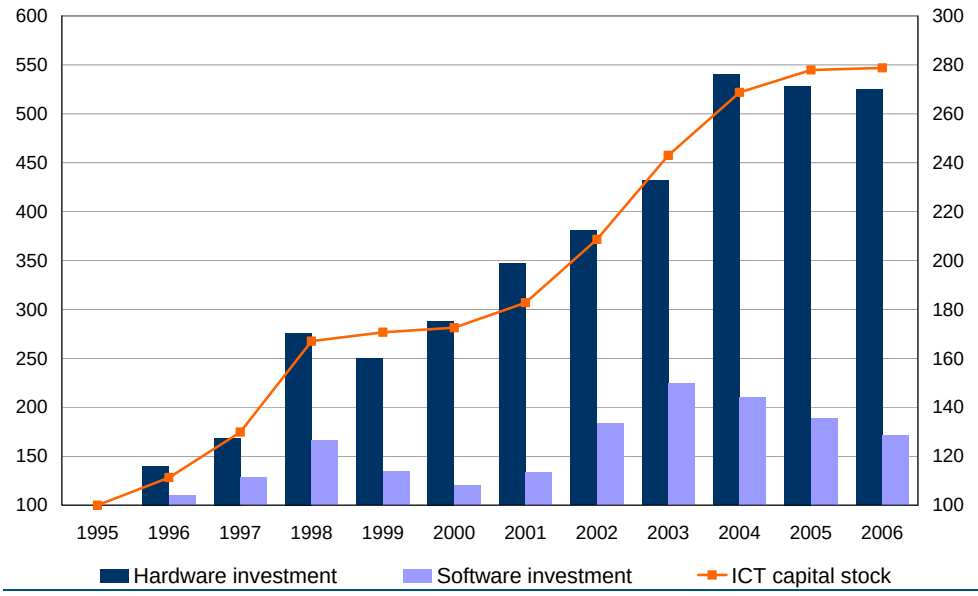
where $K_{i,j,t}$ is the capital stock of bank i for a particular asset type j at time t, δ_j is the constant rate of depreciation for asset j, and $I_{i,j,t}$ is the real investment by bank i for asset j at time t. Types of assets include hardware, software and premises for computing equipment. Banks' nominal investment flows are deflated using the hedonic price indexes developed by the Bureau of Economic Analysis and adjusted

[20] In Christie *et al.* (2003) the decentralization measure is obtained from a questionnaire, which asks the firm's management to identify the second level below the CEO and to indicate whether it is a profit centre, cost centre or a mixture of the two.

for the variation in the EU/USD exchange rate.[21] Then, capital stock is obtained as a weighted sum of past real investments, with weights given by the relative efficiency of capital goods. Depreciation rates are assumed to be constant over time and different across types of assets. Following Jorgenson and Stiroh (2000), software and hardware are assumed to depreciate at a yearly rate of 31.5 per cent, premises for computing equipment at a rate of 11.5 per cent.[22]

ICT capital steadily increased during the last decade: in 2006 its value in real terms was almost three times greater than in 1995 (Figure 1). Investment in hardware went up by more than 400 per cent, the software component by 70 per cent. This trend was mostly due to the exponential decline in the price/performance ratio of computers and related technology, reflected in the BEA price deflator.

Figure 1: Real ICT investments and capital stock *(1995 = 100)*



Source: Supervisory Reports of the Bank of Italy, Istat and BEA.

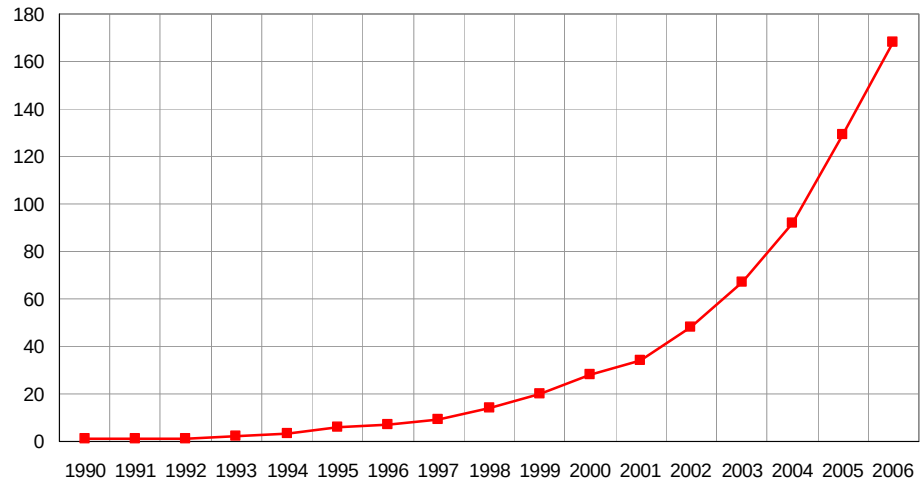
Credit scoring is the process of assigning a quantitative measure – the score – to a potential borrower (Feldman, 1997). The score represents an estimate of the

[21] We rely on hedonic prices to supplement traditional price index methods that do not properly account for the rapid technological progress in the ICT industry. Just to give an example, a new computer might have twice the memory of its predecessor with no change in its production cost. Therefore the data on ICT investments in current prices need to be deflated to arrive at constant-quality prices.

[22] Data on ICT investments are available starting from 1984. For 1983 the capital stock is set equal to zero. Although not fully satisfactory, this assumption does not affect our results because of the high capital stock depreciation rate.

borrower's future loan performance and is obtained combining information from firms' balance sheet data, the credit history of the loan applicant and, sometimes, qualitative information. Our survey documents the diffusion of this financial innovation across Italian banks (Albareto *et al.*, 2008). Banks were asked to report whether they adopted credit scoring for small business lending and (if so) the number of years since the adoption. In 2006 about 60 per cent of the banks in the sample adopted those techniques. The adoption rate has accelerated in recent years, probably because of the New Basel Capital Accord (Figure 2). Almost all the medium and large banks adopted credit scoring whereas about 65 per cent of small banks and 45 per cent of credit cooperative banks followed the same strategy.[23]

Figure 2: Adoption of small business credit scoring by year



Number of banks that adopted credit scoring per year. The whole sample consists of 297 observations. Source: Survey on Banking internal organization.

5. Results

5.1 Main findings

Correlations between the explanatory variables reported in Table A3 show that most of them are strongly correlated with bank size (*SIZE*). To cope with the potential collinearity problem, we start with a very parsimonious specification in which regressors include only our ICT variables and *SIZE* (see Table 1). *SIZE* is included to get rid of the differences across banks attributable to the heterogeneity in

[23] See also Akhavien *et al.* (2005).

terms of organizational complexity and institutional nature. Moreover our key explanatory variables, *ICT_CAP* and *SCORING*, are included separately in Columns I and II and simultaneously in Column III. Columns IV through VII add further controls stepwise to the basic specification.

SIZE has a negative and significant effect on the dependent variable. This finding is consistent with the idea that large banks face higher agency costs and therefore delegate less to the peripheral units within the organization. The other covariates are correlated with *SIZE* therefore it might not be possible to correctly and separately identify their effects. Since we are not interested in a structural interpretation of their parameters, these regressors are added to the specification as they can potentially affect the LBM's decision-making power and their omission could distort our econometric findings. We start by adding a set of dummies for the CEO's location. These regional dummies pick up all the influences that the local environment might have on the CEO's attitudes and strategies including propensity to delegate. Regional dummies are particularly important in the case of small banks since they also control for the characteristics of the local markets where these banks operate. *DISTANCE*, which is equal to the log of the average distance between the local branches and bank headquarters, is negatively and significantly associated to the degree of decentralization. This evidence is consistent with the fact that, other things being equal, agency costs increase with the CEO-LBM physical distance thereby increasing the need to centralize decision-making within the organization in response to a loss of control.[24] *LOAN SIZE* (the average size of loans that each bank extends to non-financial firms) is introduced since the LBM's role is enhanced when lending activity is focused on small business. However, *LOAN SIZE* does not significantly affect the degree of decentralization, probably because of the collinearity problems mentioned before. Last, we include *BRANCH SIZE* to control for the fact that an LBM running a larger branch could occupy a higher position within the bank hierarchy and because of that might also be given greater autonomy. The estimated parameter for this variable is positive, consistently with our expectations.

As far as our key explanatory variables are concerned, our findings clearly indicate that banks holding more ICT capital - and having adopted credit scoring techniques for at least 3 years - increase the LBM's decision-making power over small business lending. The estimated parameters for *ICT_CAP* and *SCORING 3+*

[24] Other papers analysing the effects of centre-periphery distance on bank strategies include Felici and Pagnini (2008) and Berger and De Young (2001).

are both positive and significantly different from zero. On the contrary, the impact of *SCORING 0-2* is not significant. It is likely that the learning costs associated to the introduction of scoring techniques do not enable them to have an immediate and/or a short-term impact on power delegation. Notably, these results are confirmed even when *ICT_CAP* and *SCORING 3+* are included in the same regression, showing that their effects can be separately identified. Moreover, the magnitude of the coefficients and their statistical significance is substantially similar in all the specifications proposed. Bresnahan et al. (2002) and Colombo and Delmastro (2004) find similar results on the relationship between ICT adoption and decentralization using firm level data.

Table 1: Baseline

	I	II	III	IV	V	VI	VII
ICT_CAP	0.013***		0.012**	0.012***	0.013***	0.013***	0.012***
	(0.004)		*(0.005)*	*(0.004)*	*(0.004)*	*(0.004)*	*(0.004)*
SCORING 0-2		-0.012	-0.018	-0.024	-0.020	-0.020	-0.022
		(0.017)	*(0.017)*	*(0.018)*	*(0.017)*	*(0.018)*	*(0.018)*
SCORING 3+		0.069***	0.060**	0.063**	0.071***	0.069***	0.070***
		(0.024)	*(0.024)*	*(0.024)*	*(0.025)*	*(0.025)*	*(0.024)*
SIZE	-0.035***	-0.031***	-0.033***	-0.032***	-0.013	-0.018*	-0.028***
	(0.005)	*(0.005)*	*(0.005)*	*(0.005)*	*(0.009)*	*(0.009)*	*(0.010)*
DISTANCE					-0.040***	-0.034**	-0.030*
					(0.015)	*(0.016)*	*(0.016)*
LOAN SIZE						0.026	0.009
						(0.021)	*(0.023)*
BRANCH SIZE							0.070**
							(0.030)
FE	-	-	-	YES	YES	YES	YES
Observations	291	296	291	291	291	289	289
R-squared	0.13	0.16	0.18	0.26	0.27	0.28	0.29

OLS estimates. The dependent variable is PD - that is, the ratio between the loan size that the LBM can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the CEO. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). Robust standard errors are reported in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

The role of ICT variables in shaping internal organization is also quantitatively important. According to our estimate, the adoption of credit scoring for more than 3 years increases our index of power delegation by 0.07, nearly one-half the mean value. Moving from the first to the third quartile in the distribution of the ICT stock per employee, would increase the index of power delegation by about 10 per cent. To compare the magnitudes of the effects associated with the two variables, we treat SCORING as if it were continuous. It turns out that an increase of one standard

deviation for *ICT_CAP* (*SCORING 3+*) would lead to an increase of 14 (20) per cent of the standard deviation for *PD,* thereby showing that the intensity of the two effects is not dissimilar.

Our findings suggest that the new technologies complement rather than substitute the role of the LBM in small business lending. By increasing its investment in computers and software and by adopting credit scoring, a bank improves the quality and frequency of reporting on the performance of the different local branches. Improvements in internal monitoring, in turn, favour more delegation exploiting LBMs' local capabilities and specialization in business lending. In the jargon of our model in Section 2, these savings on agency costs brought about by new technologies could overcome those generated through the fall in communication costs and the improvement in the CEO's decision-making process. In turn, these effects would modify the balance between centralization and decentralization favouring the latter.

A potential criticism that can be brought against our interpretation is the following. Suppose that banks adopting credit scoring organize their loan origination process in a hierarchical way. Namely, in the first stage of that process they screen loan applicants through the scoring system. In the second stage, they attribute loan power origination to the LBM if and only if the applicant obtained a sufficiently high score in the first stage of the evaluation process. Hence, under that organization mode, the positive correlation between *PD* and scoring would merely reflect the fact that the LBM could originate loans only for those applicants passing the test carried out in the first stage of the screening procedure. This argument however is not fully convincing in the context of our empirical analysis. In fact, the banks participating in the survey were asked to indicate delegation levels in reference to relatively good quality borrowers, i.e. presumably those credit applicants passing the test in the first stage screening procedure described above.[25]

5.2 An alternative measure of power delegation

In this subsection we control the robustness of our results using a different definition of power delegation, namely the (absolute) maximum loan amount that the LBM can grant in autonomy to a small firm. We start again with a very parsimonious specification and then we add the main covariates stepwise (Table 2). The absolute

[25] Furthermore, our findings continue to be interpretable as a positive relationship between the adoption of scoring and the decentralization of decision-making rights, since *PD* measures the amount of lending that can be granted at the branch level (i.e., without relying on the approval of higher hierarchical layers), independently from the chosen organizational mode.

amount of power delegation is positively and significantly associated with *SIZE*. Again, most of the bank variables are strongly correlated with size and therefore it might not be possible to correctly and separately identify their effects. For example, the coefficients on *SIZE* is reduced when we add *LOAN SIZE*. Larger banks typically focus their lending on larger firms which, in turn, borrow greater amounts of money. Therefore, the positive association between the loan officer's delegation and the size of the bank partly reflects the fact that larger banks need to delegate more in order to keep lending decisions at the local branch level.

Table 2: Baseline with absolute level of delegation

	I	II	III	IV	V	VI	VII
ICT_CAP	0.135**		0.119**	0.107*	0.109*	0.119*	0.110**
	(0.057)		*(0.060)*	*(0.061)*	*(0.061)*	*(0.058)*	*(0.056)*
SCORING 0-2		0.336	0.302	0.339	0.347	0.361*	0.324
		(0.213)	*(0.216)*	*(0.219)*	*(0.218)*	*(0.214)*	*(0.218)*
SCORING 3+		0.412*	0.352	0.398*	0.414*	0.390*	0.393*
		(0.212)	*(0.215)*	*(0.219)*	*(0.222)*	*(0.222)*	*(0.221)*
SIZE	0.646***	0.631***	0.620***	0.558***	0.601***	0.490***	0.427***
	(0.057)	*(0.060)*	*(0.061)*	*(0.064)*	*(0.119)*	*(0.105)*	*(0.118)*
DISTANCE					-0.092	0.035	0.083
					(0.198)	*(0.171)*	*(0.173)*
LOAN SIZE						0.544**	0.430*
						(0.248)	*(0.260)*
BRANCH SIZE							0.401
							(0.387)
FE	-	-	-	YES	YES	YES	YES
Observations	291	296	291	291	291	291	289
R-squared	0.33	0.32	0.34	0.43	0.43	0.45	0.45

OLS estimates. The dependent variable is the loan size that the LBM can autonomously grant to a small firm applying for credit. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). Robust standard errors are reported in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

As far as *ICT_CAP* and *SCORING 3+* are concerned, our results are fairly consistent with those presented in Table 1. The impact of the new technologies on the level of the LBM's power delegation is positive and significant in almost all the specifications. In particular, increasing the ICT capital stock per employee by 10 per cent leads to an increase of 1 per cent in the maximum amount of the loan that the LBM can autonomously grant to a small firm applying for credit. Having adopted credit scoring for more than 3 years increases the absolute level of power delegation by 10 per cent.

Although our empirical findings are qualitatively confirmed when we use the *absolute* level of the LBM's power delegation as a dependent variable, we will use the *relative* measure in the rest of the empirical analysis. Apart from the fact that the relative index is directly suggested by our structural model (see above), it is also much closer to what we are really interested in since establishing the degree of decentralization in an organization necessarily means measuring the autonomy of the local manager with respect to the pinnacle of the hierarchy. Moreover, a relative index enables us to exclude the huge differences between Italian banks in terms of size, business focus and institutional nature.

5.3 Robustness checks

In this subsection we provide several robustness checks.[26] In Table 3 we add further controls to our preferred empirical specifications. We start by adding bank profitability, approximated by the return on assets (*ROA*) that can be considered as a proxy for the CEO's managerial talent.[27] A talented CEO could have a stronger propensity to adopt new technologies *and* could also be better able to select good quality LBMs and therefore to delegate more power to them. In Column II we add *BAD LOANS* (the ratio of bad loans to total lending) that should capture the effects of the riskiness of the loan portfolio on delegation. In particular, a riskier loan portfolio could induce a lower degree of decentralization. Based on our findings, none of these variables plays a significant role.

Columns III through VII add variables referring to the internal bank organization and to the CEO's characteristics. *NUMLEV* is the log of the number of hierarchical levels between the LBM and the CEO and it should capture how the depth of the hierarchical structure affects the degree of decentralization. *NUMLEV* is negatively and significantly associated with the degree of power delegation. This evidence is consistent with the fact that in a deeper organization decision-making rights are distributed over a higher number of intermediate positions and therefore peripheral managers are likely to have less decision-making power. *TURNOVER* measures the average LBM's length of tenure at the same local branch. The introduction of *TURNOVER* is aimed at controlling for further variables that might

[26] In unreported evidence we also control the robustness of our results using different empirical specifications. Namely, we use a TOBIT model instead of OLS in order to take account of the fact that our measure of decentralization, PD, varies between 0 and 1. We also consider an alternative estimation method (Stata's `glm` procedure) enhanced to deal with fractional response data (see Papke and Wooldridge, 1996). The empirical findings are substantially unchanged.

[27] This variable could also signal a bank's market power.

affect the *real* authority of the LBM in small business lending. The latter might vary according to the bank's internal policy concerning LBMs' turnover across local branches since longer tenure at the same local branch can be associated with a better knowledge of the local credit market.

Table 3: Controlling for other banks' characteristics and organizational variables

	I	II	III	IV	V	VI	VII
ICT_CAP	0.012***	0.012***	0.014***	0.011***	0.014***	0.014***	0.014***
	(0.004)	*(0.004)*	*(0.004)*	*(0.004)*	*(0.004)*	*(0.004)*	*(0.004)*
SCORING 0-2	-0.020	-0.020	-0.015	-0.017	-0.034*	-0.034*	-0.026
	(0.018)	*(0.019)*	*(0.017)*	*(0.018)*	*(0.020)*	*(0.020)*	*(0.021)*
SCORING 3+	0.071***	0.072***	0.072***	0.081***	0.070***	0.070***	0.083***
	(0.024)	*(0.025)*	*(0.024)*	*(0.025)*	*(0.026)*	*(0.026)*	*(0.026)*
SIZE	-0.029***	-0.025**	-0.020*	-0.030***	-0.036***	-0.035***	-0.030**
	(0.011)	*(0.011)*	*(0.011)*	*(0.011)*	*(0.012)*	*(0.012)*	*(0.015)*
DISTANCE	-0.031*	-0.031*	-0.030*	-0.031*	-0.021	-0.023	-0.028
	(0.017)	*(0.018)*	*(0.016)*	*(0.017)*	*(0.018)*	*(0.019)*	*(0.021)*
LOAN SIZE	0.005	-0.013	0.013	0.005	0.028	0.029	-0.006
	(0.024)	*(0.027)*	*(0.023)*	*(0.029)*	*(0.027)*	*(0.027)*	*(0.034)*
BRANCH SIZE	0.074**	0.070**	0.066**	0.090***	0.077**	0.076**	0.112***
	(0.030)	*(0.030)*	*(0.029)*	*(0.033)*	*(0.032)*	*(0.032)*	*(0.037)*
ROA	0.224						0.837
	(0.848)						*(2.737)*
BAD LOANS		0.116					0.008
		(0.192)					*(0.331)*
NUMLEV			-0.067**				-0.045
			(0.029)				*(0.035)*
TURNOVER				0.017			-0.015
				(0.023)			*(0.027)*
CEO EDU					-0.014		-0.011
					(0.017)		*(0.020)*
CEO AGE						-0.001	0.000
						(0.002)	*(0.002)*
FE	YES	YES	YES	YES	YES	YES	YES
Observations	287	285	289	268	254	254	231
R-squared	0.30	0.29	0.31	0.32	0.31	0.31	0.34

OLS estimates. The dependent variable is PD - that is, the ratio between the loan size that the LBM can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the CEO. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). Robust standard errors are reported in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Finally, we control for the CEO's individual characteristics since they may affect both the adoption of new technologies and the internal organization of the bank. For instance, a younger and/or a more educated CEO may be more willing to adopt innovative organizational strategies and to introduce new technologies. Therefore we include *CEO EDU* – a dummy variable that is equal to 1 if the CEO is a graduate – and *CEO AGE* – the age of the bank's CEO. Most of the coefficients on

these additional controls are not significantly different from zero. On the contrary, the coefficients for *ICT_CAP* and *SCORING 3+* are unaffected by all these robustness checks, i.e. they remain stable and highly significant in all the specifications adopted.

Table 4: Sample splits

	By size:		By small business specialization:	
	Small banks	Large banks	Small fraction of small business	Large fraction of small business
ICT_CAP	0.017***	0.006	0.004	0.017**
	(0.006)	*(0.004)*	*(0.005)*	*(0.007)*
SCORING 0-2	-0.031	-0.000	0.003	-0.031
	(0.029)	*(0.018)*	*(0.026)*	*(0.023)*
SCORING 3+	0.082**	0.053**	0.059*	0.075**
	(0.040)	*(0.026)*	*(0.031)*	*(0.036)*
SIZE	-0.015	-0.033***	-0.031***	-0.027**
	(0.026)	*(0.006)*	*(0.008)*	*(0.011)*
Observations	145	146	146	145
R-squared	0.09	0.21	0.17	0.13

OLS estimates. The dependent variable is PD - that is, the ratio between the loan size that the LBM can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the CEO. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). Robust standard errors are reported in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

Banks in our sample are very heterogeneous in terms of their size which, in turn, is strongly correlated with other variables approximating lending practices and internal organization. Therefore, one might want to examine whether the empirical findings hold when considering samples of banks that are more similar in terms of size. We define small (large) banks as those with total assets below (above) the median and we run separate regressions for these subsamples (see Table 4). It is worth noticing that the results should be interpreted with caution given the limited number of observations available. Our key variables (*ICT_CAP* and *SCORING 3+*) have the expected positive sign in both subsamples, even though the impact seems to be somewhat stronger (and with a higher level of significance) for small banks. This effect might be driven by a higher degree of specialization in small business lending on the part of these banks, as emphasized by the second sample split. In fact, the magnitude and the statistical significance of the coefficients of our key variables are higher for banks with a larger fraction of small business in their portfolio. By exploiting the predictions of our model, a possible explanation for this evidence is that the reduction of monitoring costs due to ICT adoption was greater for banks with

smaller and more opaque customers. Alternatively (and perhaps more reasonably), new technologies have reduced the cost of transmitting and processing information (and thus pushed towards more centralization) especially for banks relying extensively on hard information.

Finally, we look for the existence of possible spillovers between ICT variables and the adoption of credit scoring techniques. In Table 5 we report our baseline specification and an additional column with the interaction term between ICT and credit scoring. The coefficients on *ICT_CAP* and *SCORING 3+* remain significant and with the expected sign. In addition, the coefficient on the interaction term is positively and significantly associated to the degree of decentralization. This means that the effects of ICT capital on decentralization are stronger for those banks adopting credit scoring; the other way round, the impact of credit scoring is enhanced when intermediaries have large ICT capital endowments. Therefore, there are multiple complementarities between decentralization strategy, ICT endowments and scoring techniques.

Table 5: Complementarities between ICT and credit scoring

	Baseline	Interaction
ICT_CAP	0.012***	0.009***
	(0.004)	*(0.004)*
SCORING 0-2	-0.022	-0.019
	(0.018)	*(0.018)*
SCORING 3+	0.070***	0.176**
	(0.024)	*(0.068)*
ICT × SCORING 3+		0.020*
		(0.011)
SIZE	-0.028***	-0.028***
	(0.010)	*(0.010)*
DISTANCE	-0.030*	-0.031**
	(0.016)	*(0.016)*
LOAN SIZE	0.009	0.007
	(0.023)	*(0.023)*
BRANCH SIZE	0.070**	0.064**
	(0.030)	*(0.030)*
FE	YES	YES
Observations	289	289
R-squared	0.29	0.30

OLS estimates. The dependent variable is PD - that is, the ratio between the loan size that the LBM can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the CEO. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). Robust standard errors are reported in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.

5.4 IV estimation

So far, our results suggest that there is a strong correlation between ICT variables and the degree of power delegation to the LBM. Lagged values were used to avoid potential endogeneity of some explanatory variables. However, there might still be some omitted determinants of power delegation that are also correlated with the adoption of new technologies. Moreover, the direction of causality could be reversed with respect to that suggested by our empirical specification. To address these endogeneity issues, we instrument *ICT_CAP* and *SCORING*. Specifically, we use the lagged value of *ICT_CAP* as an instrument for the current ICT endowment, and the adoption of credit scoring for either consumption credit or mortgages as instruments for the adoption of credit scoring for small business lending. Let's discuss them in turn.

Our first instrument is *ICT_ 95*, the log of the ICT capital stock per employee in 1995. Using lags of the explanatory variables as instruments is frequently seen as controversial. In particular, instruments cannot be sufficiently correlated with the endogenous variable or there might be time invariant omitted variables driving both the dependent variable and the lagged values of the instruments. In our empirical framework, the first problem does not arise since our instrument is highly correlated with the current endowments of ICT capital. As for the existence of time invariant omitted factors, we are confident that this is not an issue in our case because of the length of the time span and the peculiarity of the period considered. The Italian banking system underwent deep restructuring in the 1990s including M&A that led to wide changes in the management of each bank. Also the external conditions changed profoundly and banks nowadays face an environment that was largely unpredictable in the 1990s.[28] Moreover, the ICT capital stock within a specific time span is strongly related to ICT investments in that period because of the high depreciation rate of this type of asset. ICT investments, in turn, are volatile and lumpy – i.e. they are concentrated in a relatively short period of time – and they are plausibly unrelated to the organizational structure observed ten years later. As an additional instrument we also introduce *ICT_00,* the log of the ICT capital stock per employee for the year 2000. We exploit the fact that many banks made significant investment in new software and hardware in that period because of the widespread concern that the information system would cease operating between December 31,

[28] In 1990s, there was an increase in the size and in the geographical reach of the banks, the competition in the local credit markets increased and the skill composition of the workforce changed, thus largely modifying the environment in which banks operate.

1999 and January 1, 2000 – because of the so-called *millennium bug*. Once again, the determinants of these investments are plausibly unrelated with the current allocation of decision-making power.

SCORE_CC is the instrument for the adoption of credit scoring for small business lending. This variable is built in the same way as *SCORING* with the further condition that the adoption of credit scoring for consumption credit must have occurred in the same year or earlier than that for small business lending. The correlation between *SCORE_CC* and *SCORING* is due to the fact that the adoption of a scoring system for consumer credit historically preceded and hence facilitated the introduction of these lending technologies in small business lending.[29] Data seem to support this hypothesis. Apart from the indirect effect through *SCORING*, *SCORE_CC* has no direct effect on *PD*. This assumption is based on the recognition that consumers and small firms have historically been approached with two different "lending technologies". In consumption credit, creditworthiness is quickly assessed through standardized procedures and in an impersonal way. In contrast, in small business lending, the emphasis is usually placed on the role of soft information and the primacy of the loan officer who personally interacts with the firm. This is why credit scoring has become the first criterion for consumer credit decisions (automobile, credit card, and mortgage loans) and it has taken longer to be adopted for business loans.[30] To sum up, we believe that the motivations driving the adoption of credit scoring for *consumer* credit are plausibly uncorrelated with the determinants of power delegation to the LBM in *business* lending. Using a similar argument, we use *SCORE_MO* – the adoption of credit scoring for mortgages – as a further instrumental variable.

The IV estimates are reported in Table 6. As mentioned before, the instruments proposed are strongly correlated with our potentially endogenous explanatory variables. The first stage F-statistics are above the rule-of-thumb of 10 traditionally used to assess the strength of instruments. The results clearly confirm previous findings that the adoption of ICT goes hand in hand with a larger decentralization in

[29] The experience accumulated with credit scoring in the local branches may favour the extension of these techniques to other activities. Prior adopters are also likely to have a more codified database that are necessary to implement a credit scoring mechanism.

[30] In the U.S., the first country where credit scoring was adopted during the 1950s, these techniques were mainly used for mortgage loans and credit for small amounts. Only in the 1990s were these procedures applied also to small business lending activity. The adoption of credit scoring in Italy started much later. However, in Italy as well, credit scoring was adopted first for mortgage loans and consumer credit and only later for small business lending – even though the time gap is much shorter. See Bofondi and Lotti (2005) for an analysis of the diffusion of credit scoring in Italy. See Albareto *et al.* (2008) for more recent evidence.

small business lending. The estimated parameter for *SCORING* is only marginally affected by the use of instrumental variables. As far as the estimated coefficient for *ICT_CAP* is concerned, it is revised upward (if at all) and it remains highly significant.

Table 6: IV estimates

	I	II	III	IV
ICT_CAP	0.029**	0.029**	0.011***	0.011***
	(0.012)	*(0.012)*	*(0.004)*	*(0.004)*
SCORING 0-2	-0.026	-0.026	-0.022	-0.023
	(0.025)	*(0.024)*	*(0.024)*	*(0.023)*
SCORING 3+	0.066*	0.064*	0.061	0.060*
	(0.039)	*(0.033)*	*(0.039)*	*(0.033)*
SIZE	-0.028**	-0.028**	-0.030***	-0.030***
	(0.012)	*(0.012)*	*(0.011)*	*(0.011)*
DISTANCE	-0.035*	-0.034*	-0.027	-0.027
	(0.019)	*(0.018)*	*(0.018)*	*(0.018)*
LOAN SIZE	0.001	0.001	0.010	0.010
	(0.028)	*(0.028)*	*(0.030)*	*(0.030)*
BRANCH SIZE	0.060*	0.061*	0.066**	0.066**
	(0.033)	*(0.033)*	*(0.029)*	*(0.029)*
FE	YES	YES	YES	YES
Instrumental variables	*ICT_ 95 SCORE_CC*	*ICT_ 95 SCORE_MO*	*ICT_ 00 SCORE_CC*	*ICT_ 00 SCORE_MO*
Observations	263	263	278	278
R-squared	0.09	0.21	0.17	0.13

IV estimates. The dependent variable is PD - that is, the ratio between the loan size that the LBM can autonomously grant to a small firm applying for credit and the corresponding amount that can be extended by the CEO. The key explanatory variables are ICT (log of ICT capital stock per employee) and SCORING (dummies equal to 1 if the bank has adopted small business credit scoring in the last 2 years or for more than 3 years, respectively). The lagged values of ICT (ICT_95 and ICT_00) are used as an instrument for the current ICT endowment; the adoption of credit scoring for either credit consumption or mortgages (SCORE_CC and SCORE_MO, respectively) are used as the instrument for the adoption of credit scoring for small business lending. * significant at 10%; ** significant at 5%; *** significant at 1%.

6. Conclusions

Over the past decades, advances in information technology have transformed the production process and the organization of the workplace. As far as we know, this paper represents the first attempt to examine the impact of the new technologies on internal organization in the banking industry.

The issue is important for two main reasons. First, the allocation of decision-making power across hierarchical layers is one of the distinctive features of an organization. Specifically, the degree of autonomy of the LBM is the key variable as far as small firms' access to credit is concerned. Second, the banking industry is

particularly interesting since nowadays it is one of the most intensive adopters of ICT. Moreover, factors like asymmetries of information and agency costs underlined by the theories on firms' internal organization are likely to have a special relevance to the banking sector.

We derive a simple model of organization design that yields an estimable equation about the relation between technology adoption and the degree of delegation in lending activity. This relationship has been empirically investigated using a unique and specifically tailored dataset including about 300 Italian banks. We find that banks equipped with more ICT capital and resorting to credit scoring delegate more decision-making power to their LBMs. These results are robust to many additional controls, including instrumental variable estimation.

Hence, worries about the introduction of the new technologies and the negative effects on small business credit access seem to be exaggerated. Indeed, ICT adoption has favoured delegation of decision-making rights to LBMs. Our interpretation is that the lessening of agency problems (leading to more delegation) due to the adoption of new technologies more than offsets the efficiency gains in transmitting and processing information (that, in turn, would push towards more centralization). It also likely that computers and related technologies have substituted the LBM in carrying out standardized and manual activities, leaving more time to focus on "border" lending practices. Decentralization may imply that, de facto, a larger number of lending practices are decided at the branch level, where the important information resides. Granting more responsibilities to LBMs can promote their initiative and effort in collecting and acting on soft information. This may be important for small firms' access to credit, especially those with a limited operating history or that are more opaque. It is also reasonable to expect, in the near future, an increase in the degree of decentralization due to the wide adoption of credit scoring in recent years and continuing progress in the ICT industry. Quite clearly, all these considerations hold true in those circumstances in which the LBM has better access to proprietary information about borrowers' quality than the CEO and so is also better able to act on that information.

As a task for the future research agenda, it could be interesting to elaborate an empirical strategy aimed at identifying the different channels through which ICT may affect decentralization. Moreover, it could also be of interest to attempt to analyse the heterogeneity of the strategies followed by the banks in the adoption of credit scoring methods and how these reflect on credit allocation.

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Appendix

Table A1: Descriptive statistics

Variable	Description (1)	Mean	St. dev.
Dependent variable			
PD	Ratio between the loan size that the LBM can autonomously grant to small firm applying for credit and the corresponding amount that can be extended by the CEO (2006).	0.15	(0.144)
PD (absolute level)	Log of the loan size that the LBM can autonomously grant to small firm applying for credit (2006).	3.90	(1.775)
Main explanatory variables			
ICT_CAP	Log of ICT capital stock per employee.	-5.54	(1.616)
SCORING 0-2	Dummy equal to 1 if the bank adopted small business credit scoring in the last 2 years.	0.35	(0.477)
SCORING 3+	Dummy equal to 1 if the bank adopted small business credit scoring more than 3 years ago.	0.23	(0.419)
Instrumental variables:			
ICT_ 95	Log of ICT capital stock per employee (1995).	-5.67	(1.309)
ICT_ 00	Log of ICT capital stock per employee (2000).	-5.43	(1.435)
SCORE CC 0-2	Dummy equal to 1 if the bank adopted credit scoring for credit consumption in the last 2 years and before or in the same year as the adoption of credit scoring for small business lending.	0.15	(0.356)
SCORE CC 3+	Dummy equal to 1 if the bank adopted credit scoring for credit consumption more than 3 years ago or in the same year as the adoption of credit scoring for small business lending.	0.22	(0.412)
SCORE MO 0-2	Dummy equal to 1 if the bank adopted credit scoring for mortgages in the last 2 years and before, or in the same year as the adoption of credit scoring for small business lending.	0.18	(0.381)
SCORE MO 3+	Dummy equal to 1 if the bank adopted credit scoring for mortgages more than 3 years ago or in the same year as the adoption of credit scoring for small business lending.	0.23	(0.421)
Dimensional features of the bank			
SIZE	Log of total assets.	20.69	(1.476)
DISTANCE	Log of average distance (in kilometres) between the headquarters of the bank and the local markets where the bank has at least one branch. The distance is weighted by the amount of loans borrowed in the market where the local branches are situated.	3.10	(0.895)
LOAN SIZE	Log of the average loan size in the bank's portfolio.	11.57	(0.548)
BRANCH SIZE	Log of the number of employees per branch.	1.66	(0.350)
Other bank characteristics			
ROA	Returns on assets.	0.01	(0.008)
BAD LOANS	Ratio of bad loans to total lending.	0.04	(0.044)
Organizational features of the bank			
NUMLEV	(Log of the) number of hierarchical levels between the LBM and the CEO (2006).	1.19	(0.355)
TURNOVER	(Log of the) average permanence (in months) of the LBM within the same branch (2006).	3.71	(0.430)
CEO EDU	Dummy equal to 1 if the CEO has a university degree.	0.38	(0.487)
CEO AGE	Age of the CEO.	53.48	(6.123)

(1) Data refer to 2003 if not otherwise specified. Source: Supervisory Report of the Bank of Italy, Survey on Banking internal organization.

Table A2: Survey on Banking internal organisation

Question 1: Hierarchical levels

Consider the lending activity to small business. This activity may involve several levels of the bank's internal organization. Please list all these levels starting from the bottom of the hierarchy (e.g. loan officer) up to the board of the directors. If the bank belongs to a group, list also the figures of the group who may participate at the lending process.

Description of the hierarchical levels:

1) _____
2) _____
3) _____
4) _____
5) _____
6) _____
7) _____
8) _____
9) _____
10) _____
11) _____
12) _____

Question 2: Power delegation

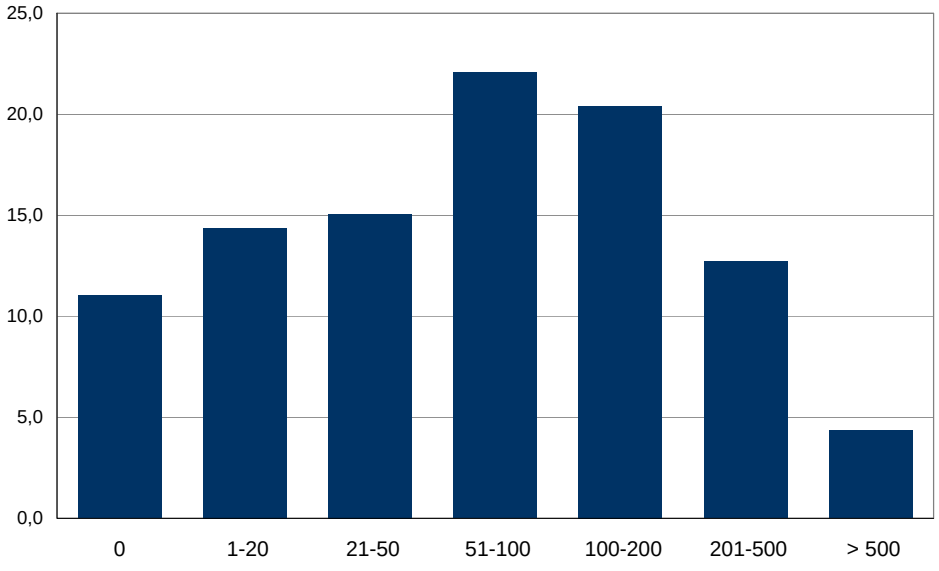
Consider the lending practice for a firm applying for credit for the first time. Please write down the maximum amount of loan that can be granted in autonomy by each of the figure indicated. Levels of delegation had to be referred to applicants exhibiting a risk level that a bank judge a priori as normal.

Maximum amount (in thousands of euros):

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Source: Survey on Banking internal organization.

Figure A1: The distribution of absolute power delegation of LBMs



The x-axis reports classes of absolute power delegation of LBMs (in thousands of euro); the y-axis gives the frequencies. Source: Survey on Banking internal organization

Table A3: Matrix of correlations between the explanatory variables

	ICT_CAP	SCORING 3+	SIZE	DISTANCE	LOAN SIZE	BRANCH SIZE	ROA	BAD LOANS	NUMLEV	TURNOVER
ICT_CAP										
SCORING 3+	0.118 *(0.044)*									
SIZE	0.159 *(0.007)*	-0.018 *(0.754)*								
DISTANCE	0.146 *(0.013)*	0.055 *(0.349)*	0.787 *(0.000)*							
LOAN SIZE	-0.054 *(0.363)*	-0.032 *(0.582)*	0.208 *(0.000)*	-0.084 *(0.152)*						
BRANCH SIZE	0.171 *(0.004)*	-0.050 *(0.392)*	0.595 *(0.000)*	0.407 *(0.000)*	0.268 *(0.000)*					
ROA	-0.037 *(0.531)*	0.020 *(0.729)*	0.235 *(0.000)*	-0.025 *(0.665)*	0.301 *(0.000)*	0.272 *(0.000)*				
BAD LOANS	0.097 *(0.102)*	0.012 *(0.843)*	0.016 *(0.788)*	0.169 *(0.004)*	0.301 *(0.000)*	0.049 *(0.407)*	-0.114 *(0.054)*			
NUMLEV	0.170 *(0.004)*	-0.021 *(0.725)*	0.622 *(0.000)*	0.503 *(0.000)*	0.086 *(0.137)*	0.360 *(0.000)*	0.194 *(0.001)*	-0.024 *(0.684)*		
TURNOVER	0.032 *(0.598)*	0.058 *(0.337)*	-0.293 *(0.000)*	-0.318 *(0.000)*	0.004 *(0.950)*	-0.143 *(0.019)*	0.150 *(0.013)*	0.073 *(0.231)*	-0.336 *(0.000)*	

The p-values are reported in brackets.

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