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BANK CROSS-SELLING AND THE PRODUCTION OF SOFT INFORMATION

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Bank cross-selling and the production of soft information

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Abstract

We model the effect of cross-selling on the quality of banks' loans and interest rates under alternative lending technologies when banks produce both hard and soft information. The main theoretical findings are: i) when banks adopt transaction lending technologies, where loan officers have only the task of screening loan applicants, cross-selling lowers banks' incentives of producing soft information and loans' quality, ii) when banks adopt relationship lending technologies, where loan officers have the task of both screening and cross-selling services, cross-selling may improve banks' incentives of producing soft information and loans' quality, iii) under relatively competitive market conditions, cross-selling reduces lending interest rates for both transaction- and relationship-lending banks. The econometric analysis, carried on a sample of European banks over the period 2001-2006, support these findings. The results suggest regulators should address cross-selling strategies to control for bank risk in different ways depending on the lending technology adopted by banks.

Keywords: Cross-selling; Hard and soft information; Relationship lending; Loans' quality; Interest margin
JEL Codes: G21, D82, C23, L15

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1. Introduction

Banks are considered by most economic theories like institutions whose current operations consist in granting loans and receiving deposits from the public (Freixas and Rochet, 2008). This view is incomplete since the propensity of banks to supply services other than loans and deposits, such as foreign services, trusts, annuities, mutual funds, insurance brokerage and transaction services, increased in a relevant way during the Nineties, first in the United States and then in Europe[1]. A bank may obtain significant economies in marketing and advertising by offering a set of related services to her borrowers. Some customers may be "trapped" by the bank because of the substantial implicit costs a given customer might face in switching to another provider and this offers substantial opportunities for companies to cross-sell other products and services to their existing customer base[2]. The relationship with a borrower may therefore have a "marketing value" for the bank.

Most of the literature on the transformation of banks has looked at complementarities between different kinds of services[3], or at the effect of cross-selling on interest rates[4], but these are not the only relevant aspects of banks' diversification: Cosci et al. (2012, 2009) theoretically demonstrated that, in a context in which the relationship with a borrower has a "marketing value" for the bank, cross-selling activity decreases the optimal screening effort (and therefore the quality of the pool of financed projects) whenever a bank is not able to exploit information synergies between screening and cross-selling activities. Once a loan applicant gets a loan she becomes a "warm" customer (i.e. it becomes easier to sell other services different from loans to that customer) and the larger is the range of services supplied by a bank the lower is her optimal screening effort (Cosci et al., 2009). Nevertheless, whenever banks are able to create and exploit information synergies between screening and cross-selling activities, cross-selling is less likely to reduce the role of banks as producers of "information-intensive" loans (Cosci et al., 2012). The effect of cross-selling on the bank's lending decisions therefore depends on the bank's information system and on the lending technology.

The aim of this study is to investigate theoretically and empirically the effect of cross-selling on the quality of banks' loans and on default risk pricing in a contest where banks adopting alternative lending technologies produce both hard and soft information about their loan applicants.

Product customisation requires banks to operationally support the whole process from the client-information gathering to the identification of products and services consistent with their needs. In this process banks acquire two types of information about their loan applicants: soft information, through bank-borrower relationship, and hard information, through public information (Petersen, 2004). Soft information, that is produced by banks through the direct contact between loan applicants and loan officers, is hard to quantify, verify and communicate through the normal transmission channels of a banking organisation. Hard information is less costly than soft information, since it is external and may be shared by credit bureaus and public credit registers.

The distinction between hard and soft information has been generally associated with the adoption of different lending technologies. The literature focuses on two classes of lending

[1] According to Allen and Santomero (2001) in the US non interest income increased from about 20% of bank earnings at the beginning of the Nineties to more than 50% at the end of the decade. In Europe non interest revenues increased from 33% of total revenues in 1997 to more than 40% in 2003 (ECB, 2004).

[2] See Li et al. (2005).

[3] See Mester (1987); Chiappori et al. (1995); Kashyap et al. (2002); Boot (2003); Kanatas and Qi (2003); Mester et al. (2007); Laux and Walz (2009).

[4] See Degryse and Van Cayseele (2000); Drucker and Puri (2005); Lepetit et al. (2008b); Calomiris and Pornrojnangkool (2009); Zhao et al. (2013).

technologies: transaction-based lending technologies and relationship lending technologies. Transaction-based lending technologies are thought of as typically based (primarily but not exclusively) on hard information, relationship lending technologies as based (primarily but not exclusively) on soft information (Degryse and Van Cayseele, 2000; DeYoung and Hunter, 2003; DeYoung et al., 2004; Elsas, 2005). Rather we focus on the organisational aspects of the two lending technologies: we define as relationship lending technologies those tending to adopt a client (functional) approach, and as transaction lending technologies those tending to adopt a product (technical) approach. We model a relationship lending bank as a client-oriented bank in that the loan officer is in charge also of cross-selling other products to the borrower. In this case information synergies between the lending and cross-selling activities are relevant and can be exploited: the soft information produced by the loan officer in screening loan applicants can be used to increase the probability of selling services to borrowers and the information collected by the loan officer while offering services to loan applicants can improve the efficiency of the soft-information producing activity through screening. Small local banks tend to supply personalised services to borrowers and are more likely to adopt "relationship lending" strategies.

A transaction lending bank is modelled as a product-oriented bank in that the loan officer does not cross-sell services to borrowers: once the loan application is approved, other employees of the bank will offer services other than loans to borrowers. In this case information synergies cannot be exploited: the soft information produced by the loan officer cannot be transferred to the employees in charge of cross-selling ("cross-selling officers") nor the information collected by the cross-selling officer can be transferred to the loan officer. Large banks, taking advantage of economies of scale in the production, marketing, securitisation, and servicing of loans, tend to produce essentially standardised financial commodities sold in extremely competitive markets and are more likely to act as "transaction lending banks".

Our model results suggest that cross-selling reduces transaction-lending banks' incentives to produce soft information, while this may not be the case for relationship lending banks.

Furthermore the distinction between relationship lending banks and transaction lending banks allows to better investigate the effect of cross-selling on default risk pricing. Lepetit et al. (2008b) find that banks engaged in product diversification set a lower lending rate and that borrower default risk is underpriced in the lending rates charged by banks with higher fee-income shares. Their findings raise the issue of how cross-selling strategies should be addressed by regulators to control for bank risk. In our model an increase in cross-selling may reduce loan interest rates. If so, while in the case of transaction lending banks the decrease in interest rates is associated with lower quality of the pool of financed projects, in the case of relationship lending banks this decrease may be associated with higher quality of loans, i.e. relationship lending banks may end up with financing better projects at lower interest rates.

However, whether this is the case is an empirical issue that we test on a sample of European banks over the period 2001-2006. In particular we test econometrically whether the relationship between the share of revenues coming from commission and fees income (a proxy for the importance of services in banks' balance sheets) and the quality of banks' loans (the ratio of impaired loans to total loans) differs between relationship lending banks and transaction lending banks. We expect that a higher share of commission and fees income leads to a lower quality of banks' loans for transaction lending banks while this does not necessarily occur in the case of relationship lending banks. Furthermore we test whether an increase in cross-selling produces a decrease in the interest margin for both relationship lending banks and transaction lending banks.

This study extends the earlier work on bank diversification in two directions. First, to our knowledge, this is the first work investigating both theoretically and empirically the effect of

cross-selling on the quality of the loans granted by banks and on interest margins in a framework where banks use both hard and soft information for different lending technologies (relationship/transaction lending). Second it deepens the study of loan-pricing implications of cross-selling among traditional and non traditional activities finding that, although cross-selling induces banks to lower lending rates, the over-lending effect depends crucially on the lending technology adopted by the bank.

The study is organised as follows. Section 2 analyses banks' information system and lending technologies. Section 3 presents the set-up of the theoretical model, derives the equilibrium results and studies the impact of cross-selling on the quality of loans and on the optimal interest rate for transaction lending banks and relationship lending banks (technical details are in the Appendix). In Section 4 we carry out an empirical analysis aimed at testing the theoretical predictions. The final Section draws the main conclusions of the paper.

2. Bank's information system and lending technologies

Information is a crucial and costly input in the banking activity. Loan officers, by means of their direct contact with potential borrowers, generate "soft information" (judgement, opinions, notes...), that is difficult to summarise in a numeric score and hard to communicate (Petersen, 2004; Petersen and Rajan, 2002; Stein, 2002; Berger et al., 2005). This information remains tightly linked to the environment where it is produced, i.e. to the bank-borrower relationship which gives access to private and confidential information through multiple interactions in time (Boot, 2000; Berger and Udell, 2002). Since soft information is difficult to communicate within large banks, they may be induced to use almost exclusively "hard information" (credit history, balance sheet data, rating, scoring), that can be easily reduced to a numerical entry and transmitted credibly to superior hierarchical levels, where funds' allocation decisions are made. A large strand of the literature therefore suggests that more hierarchical banks are relatively less capable of processing and quantifying soft information and transmitting it through their complex organisations (Berger et al., 2005; Stein, 2002).

Boot (2000) defines "relationship lending" as the provision of financial services by a financial intermediary that invests in obtaining customer-specific information, often proprietary in nature, and evaluates the profitability of these investments through multiple interactions with the same customer over time and/or across products. "Interactions across products", by producing customer-specific information, originate what we name "information synergies". Information like entrepreneur's competence, honesty and diligent approach to management cannot be unambiguously documented in a report that the loan officer can pass on to his superiors (Berger and Udell, 2002)[5]. Since hard information, on the opposite, is not tightly linked to the environment and context where it is produced, it is easy to separate collection, production and treatment functions and to automate its treatment by banks adopting "transaction lending" technologies. Berger and Udell (2006) briefly define and describe the distinct transaction technologies used by financial intermediaries, such as financial statement lending, small business credit scoring, asset-based lending, factoring, fixed-asset lending, and leasing.

Petersen (2004) outlines critically that the reason why hard information is less costly to communicate is that it is less information. The replacement of soft with hard information inevitably results in a loss of information. He compares two methods of making a loan approval decision: in a credit scoring decision, a finite number of quantitative variables are

[5] Uchida et al. (2012) suggest that loan officers at large banks appear to be capable of producing as much soft information as they do at small banks. Petersen (2004) conjectures that transactional lenders might be able to "harden" soft information. For an investigation about lender practices aimed at changing the nature of information, see Bartoli et al. (2013), who find that substitutability between transaction lending and relationship lending by means of soft-information hardening might be rather unfeasible.

weighted and summed to obtain a credit score. Based on that score, a decision is made to approve or deny the loan. In the traditional lending relationship decision, after spending several hours discussing the borrowers investment plans and using the loan officers years of experience with the borrower, a decision is render. Both lending technologies lead to a loan decision, but the first requires less information as an input to the decision.

Most of theoretical and empirical literature analyses separately transaction-based and relationship-based lending technologies. Berger and Frame (2007), using a survey conducted by the Federal Reserve Bank of Atlanta in 1998, show that banks tend to use the credit scoring technology in very different ways to achieve quite different objectives. While some banks use rules to automatically screen loan applicants and to price loans based on purchased credit scores, other institutions add credit scores to information gathered also through relationship lending.

We argue that it is likely that most of banks use hard information and soft information jointly[6], which makes interesting to deepen the understanding of bank's incentives to increase the amount of soft information produced in the presence of cross-selling.

3. The theoretical model

3.1. The set-up of the model

As in Cosci et al. (2012) we consider a Salop spatial competition model (Salop, 1979) where a continuum of borrowers is located uniformly (with density 1) around a unit circle and *n* banks are located symmetrically around the unit circle. All agents are risk-neutral. Each borrower has to finance an investment project with one unit of loanable funds. Since borrowers have no private funds, they borrow from a bank. Each borrower, when granted a loan, incurs a transportation cost $\gamma>0$ for unit of length.

There are two types of borrowers (projects). Good borrowers represent a proportion θ in the overall population, and they have a probability p_G of producing z and a probability $1-p_G$ of producing zero. Bad borrowers represent a proportion $1-\theta$ in the overall population, and they have a probability p_B ($p_B<p_G$) of producing z and a probability $1-p_B$ of producing zero. The proportions of borrowers and the success probabilities are common knowledge. Borrowers are informed about their types but banks are uninformed, and the return z cannot be observed on the basis of ex ante screening[7]. We assume that the return z is large enough so that both good and bad borrowers will always apply for loans at the prevailing interest rate[8]. We also assume that $p_B z<r_f<p_G z$, where r_f denotes the risk-free interest rate, so that it is efficient to finance good borrowers but not the bad ones, and that $pz>r_f$, where $p\equiv\theta p_G+(1-\theta)p_B$ denotes the average success probability in the population, so that it is ex ante efficient to grant a loan.

Since borrowers are protected by limited liability, demand for credit occurs if borrowers' net expected outcome from borrowing and investing is non-negative. Each bank's demand for loans is given by:

$$L_i = \frac{1}{n} - \frac{p}{\gamma}(r_i - r_0) \qquad (1)$$

where r_i and r_0 denote the interest rates offered, respectively, by bank i and by bank i's neighbour competitors (banks $i+1$ and $i-1$).

[6] Also Heider and Inderst (2012) propose a model where at the loan approval stage two types of information are obtained: hard information, which is verifiable, and soft information, which is privately observed by the loan officer.

[7] This assumption prevents banks from offering loan interest rates that induce borrowers self-selection.

[8] Borrower's participation constraint always holds for sufficiently high levels of z.

Banks sell loans and a given number S of other services different from loans[9]. They have access to competitive capital markets, where they issue bonds at the risk-free interest rate r_f. Each bank has a fixed cost of installation K, which is assumed to include the fixed cost of producing services other than loans[10]. Market power derives from transportation costs: the lower is transportation cost for unit of length γ, the higher is the sensitivity of loans demand to interest rate differentials and the more competitive is the loans market.

3.1.1. Information

Banks have access to a screening technology that generates information about the likely type of a loan applicant. The information produced through screening is of two types: hard information, which is publicly available at no cost, and soft information, which is privately observed at a positive cost. The amount of soft information produced depends on the effort the bank puts into screening.

In particular the screening of loan applicants yields an imperfect signal $s\in\{b,g\}$ about borrower type and we assume that banks accept borrowers when they observe a good signal and reject borrowers when they observe a bad signal[11]. Thus, denoting by $e\in[0,1]$ the effort of the bank in producing soft information, we can define $\alpha(e)=prob(g|G,e)$ as the acceptance probability for truly good borrowers (i.e. the probability of correctly observing a good signal) and $\beta(e)=prob(g|B,e)$ as the acceptance probability for truly bad borrowers (i.e. the probability of erroneously observing a good signal). Accordingly, imperfect screening generates a type-I error with probability $1-\alpha(e)$ and a type-II error with probability $\beta(e)$.

The higher is the bank's effort in producing soft information e, the higher is the ability of the bank, through the screening of loan applicants, to recognise good borrowers with $\alpha'(e)\geq 0$, $\alpha''(e)\leq 0$, and bad borrowers with $\beta'(e)\leq 0$, $\beta''(e)\geq 0$. If banks do not exert effort in screening (i.e. they do not produce soft information), they use only hard information so that $\alpha(0)=\alpha_H>\theta$ and $\beta(0)=\beta_H<1-\theta$, while at intensity 1 the screening technology is completely informative so that $\alpha(1)=1$ and $\beta(1)=0$.

For concreteness and without loss of generality, we specify the following screening (soft-information producing) technology[12]:

$$\alpha(e)=e+(1-e)\alpha_H$$
$$\beta(e)=(1-e)\beta_H. \qquad (2)$$

The linear specification (2) for the production technology of soft information tells the following story. By producing soft information, the bank generates a probability e to detect the true type; with probability $1-e$ the bank observes an imperfect signal which is correct only with probability α_H and $1-\beta_H$ (the bank always uses the hard information publicly available at no cost) if the true type is, respectively, good and bad[13].

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[9] Because we are concerned with the bank's incentive to produce soft information through screening of loan applicants, we do not model the bank's choice of the range of services to sell.

[10] Variable costs of producing services are assumed to be negligible so that we can consider only the fixed cost. Since in the model services are exogenous, we can imagine that the bank chooses ex ante the number of services to sell and incurs the fixed costs of organising the service activity.

[11] Screening of loan applicants typically takes the form of creditworthiness tests. We model here the creditworthiness test as in Gehrig (1998). Banks observe noisy signals of the borrower type. The test imperfectly assigns borrowers to the two risk classes (bad and good). Only borrowers that pass the test get the loan.

[12] Bester et al. (2012) give the same example for a linear screening technology.

[13] If $1-\beta_H>\alpha_H$ the use of hard information is more efficient in detecting bad borrowers than good borrowers. This case is consistent with Petersen (2004) suggesting that borrowers that are really good, but look bad on paper (i.e. when we look at only the hard information), may be incorrectly denied credit and thus credit rationed. The concern about small firms' and individuals' access to capital in the presence of the growing use of credit scoring-type lending decisions is driven by this problem.

The production of soft information is costly with total cost $C(e)$ assumed to be strictly convex and marginal cost $C'(e)$, with $C'(0)=0$ and $\lim_{e\to 1} C'(e)=\infty$[14]. The production of hard information is not costly, i.e. $C(0)=0$.

3.1.2. Cross-selling

The banking system competes with many specialised institutions selling services in the market for services, and we assume that the bank is price-taker in the service market, where she sells a given number S of services at the given price v[15]. We assume that the probability q to sell a service to a customer is larger than the probability of selling a service to a non-customer, which, for simplicity, we normalise to zero, that is to assume that banks sell services other than loans only to borrowers, and borrowers that are not financed by banks, i.e. borrowing from the capital market, buy services from other suppliers. We also assume that borrowers pay for services in the case of success of the project as well as in the case of failure.

Since we are concerned with studying how cross-selling affects bank's incentives to produce soft information, we assume that the expected revenue from services qvS is small enough that banks will never be willing to finance bad borrowers: $p_B z+qvS<r_f$, so that a bad borrower remains a bad borrower from the point of view of the bank even if the bank sells services to her.

3.1.3. Relationship lending banks and transaction lending banks

Through the screening activity, some synergies can exist in the production of information and services. In fact banks can use the soft information they produce by screening loan applicants to increase the probability of selling services other than loans to borrowers: $q=q(e)$ with $q'(e)>0$ and $q''(e)<0$. Furthermore, by offering services, banks can acquire some information on the characteristics of the potential borrower that they can use to improve the efficiency of the production of soft information: the larger is the range of services S produced by the bank the lower are the total cost of producing soft information ($\partial C(e,S)/\partial S \equiv C_S(e,S)<0$) and the marginal cost of producing soft information ($\partial C'(e,S)/\partial S \equiv C'_S(e,S)<0$).

The capability of a bank to exploit information synergies depends on the bank's information system and on the lending technology adopted. We distinguish between "relationship lending banks" and "transaction lending banks".

In the case of relationship lending banks the loan officer has two tasks to perform: to screen loan applicants, producing soft information about them, and to cross-sell services to borrowers. In this case information synergies are relevant and can be exploited: the soft information produced by loan officers in screening loan applicants can be used to increase the probability of selling services to borrowers and the information collected by loan officers while offering services to loan applicants can improve the efficiency of the production of soft information. The timing of the model for relationship lending banks is as follows. In the first stage banks (loan officers) simultaneously set the equilibrium effort in producing soft information and the equilibrium interest rate so as to maximise expected profits, borrowers apply for loans, and banks (loan officers) offer services at the given price v. In the second

[14] This last assumption implies that $e=1$ will never be optimal for the bank.

[15] In general a borrower has an incentive to buy the services she needs from her creditor bank since she has already paid the transportation cost and changing provider of services is costly. Under these conditions, the price set for services is above marginal cost, including the cost of producing services for the bank and the cost of changing provider for the borrower. However, since modelling the price of services is not our aim nor the determination of the optimal number of services, which is given as well as the demand for services is exogenous in our model, the banks' price-taking assumption, although somehow unrealistic, does not change the results of the model.

stage banks (loan officers) screen loan applicants and extend credit at the announced rate to positively evaluated loan applicants (borrowers). In the third stage banks (loan officers) sell services to borrowers with probability $q(e)$. Services, if bought, are paid at this stage[16]. Finally borrowers run their projects, returns are realised, and, in case of success, the loan is paid off, otherwise the loan is defaulted and the bank will receive nothing.

In the case of transaction lending banks the loan officer does not cross-sell services to borrowers: once the loan application is approved, other employees of the bank will offer services to borrowers. In this case information synergies cannot be exploited: the soft information produced by the loan officer cannot be communicated to the cross-selling officer nor the information collected by the cross-selling officer can be transferred to, and used by, the loan officer so as to improve the efficiency of the screening process. The timing of the model for transaction lending banks is as follows. In the first stage banks (loan officers) simultaneously set the equilibrium effort in producing soft information and the equilibrium interest rate so as to maximise expected profits, and borrowers apply for loans. In the second stage banks (loan officers) screen loan applicants and extend credit at the announced rate to positively evaluated loan applicants (borrowers). In the third stage banks (cross-selling officers) offer services at the given price *v* and sell them to borrowers with probability *q*. Services, if bought, are paid at this stage. Finally borrowers run their projects, returns are realised, and, in case of success, the loan is paid off, otherwise the loan is defaulted and the bank will receive nothing.

3.2. Equilibrium results

We start by analysing the incentives to produce soft information and the optimal loans' pricing for transaction lending banks[17]. This case is indexed by TL.

Each bank *i* decides how much effort to put in the production of soft information and sets the loan interest rate so as to maximise expected profits:

$$E\pi_i^{TL} = L_i[\alpha(e_i^{TL})\eta_G(r_i^{TL}) + \beta(e_i^{TL})\eta_B(r_i^{TL}) - C(e_i^{TL})] - K, \quad (3)$$

where L_i is the demand function (1), α and β are expressed by the screening technology (2), and η_G and η_B denote the unconditional expected profitabilities, including the cross-selling activity, from lending, respectively, to good and bad borrowers:

$$\begin{aligned} &\eta_G(r_i^{TL}) \equiv \theta(p_G r_i^{TL} - r_f + qvS) > 0 \\ &\eta_B(r_i^{TL}) \equiv (1-\theta)(p_B r_i^{TL} - r_f + qvS) < 0. \end{aligned} \quad (4)$$

We denote by $A(e) \equiv \alpha(e)\theta + \beta(e)(1-\theta)$ the selection ratio, measuring the percentage of loan applicants that become borrowers (i.e. that are positively evaluated by banks) and $B(e) \equiv \alpha(e)\theta p_G + \beta(e)(1-\theta)p_B$ the expected ratio of successful borrowers, measuring the percentage of loan applicants that become borrowers and are successful. The production of soft information can either increase or decrease the selection ratio ($A' \equiv (1-\alpha_H)\theta - \beta_H(1-\theta) > or < 0$) and the expected ratio of successful borrowers ($B' \equiv (1-\alpha_H)\theta p_G - \beta_H(1-\theta)p_B > or < 0$), depending on the distribution of borrower types in the population and on the characteristics of the screening technology[18]. The share of successful borrowers over all borrowers

[16] We assume that the borrower pays for services also in case of default out of the loan.

[17] See Appendix A for derivation and properties of the equilibrium results for both transaction- and relationship-lending banks. All the results require transportation costs to be sufficiently low, satisfying second order conditions. In our framework that is equivalent to assume the market for loans to be relatively competitive.

[18] $A'>0$ implies that the number of accepted good borrowers increases with the production of soft information more than how much the number of accepted bad borrowers decreases so that by producing more soft information the number of borrowers increases; similarly $B'>0$ implies that the number of accepted good borrowers that are successful increases with the production of soft information more than how much the number of accepted bad borrowers that are successful decreases.

$Q(e) \equiv B(e)/A(e)$ is a measure of the quality of the bank's loans and results to be increasing in the production of soft information.

In the symmetric equilibrium the optimal effort in producing soft information e^{TL} and the optimal lending interest rate r^{TL} for transaction lending banks satisfy:

$$\frac{1}{n}[(1-\alpha_H)\eta_G(r^{TL}) - \beta_H \eta_B(r^{TL}) - C'(e^{TL})] = 0 \quad (5)$$

$$-\frac{p}{\gamma}\left[\alpha(e^{TL})\eta_G(r^{TL}) + \beta(e^{TL})\eta_B(r^{TL}) - C(e^{TL})\right] + \frac{1}{n}B(e^{TL}) = 0\,. \quad (6)$$

Equation (5) states that, given the unconditional expected profitabilities from lending to good and bad borrowers (i.e. given the lending interest rate), the marginal benefit of an increased effort in producing soft information has two components:

i) more truly good borrowers are accepted (i.e. soft information reduces type-I error), and

ii) more truly bad borrowers are rejected (i.e. soft information reduces type-II error).

In equilibrium the marginal benefit is equal to the marginal cost.

From equation (5) the optimal effort depends on the unconditional expected profitabilities of the good and the bad borrowers and on the lending interest rate. Given the interest rate, transaction lending banks are incentivised to produce more soft information the more profitable good borrowers and the less profitable bad borrowers are. On the other hand, as the lending interest rate increases, transaction lending banks may produce more or less soft information, since both good and bad borrowers become more profitable: in particular, if, as the interest rate increases, the marginal benefit of producing soft information from accepting truly good borrowers (first component) is greater than the marginal benefit from rejecting truly bad borrowers (second component) - i.e. if $(1-\alpha_H)\theta p_G > \beta_H(1-\theta)p_B$ implying $B'>0$ - the optimal effort in producing soft information is increasing in the lending interest rate[19].

Equation (6) states that, given the effort in producing soft information, the marginal benefit of an increased interest rate is equal to the number of successful borrowers (i.e. the borrowers who repay the loan), and, on the other hand, an increased interest rate reduces expected profits since the demand for loans decreases. In equilibrium the overall effect on expected profits is zero.

From equation (6) the optimal interest rate is given by:

$$r^{TL} = \frac{\gamma}{pn} + \frac{A(e^{TL})}{B(e^{TL})}(r_f - qvS) + \frac{C(e^{TL})}{B(e^{TL})}\,. \quad (7)$$

Therefore the optimal lending interest rate increases with total transportation costs γ/n (the higher the bank's market power the higher the interest rate the bank sets), with the cost of funds for successful borrower $A(e)r_f/B(e)$ and the cost of producing soft information for successful borrower $C(e)/B(e)$, and it decreases with the average success probability p (the less risky the borrowers' population the smaller the interest rate the bank sets) and with the expected income from cross-selling for successful borrower $A(e)qvS/B(e)$.

In the case of relationship lending banks, indexed by RL, bank i's expected profits are given by:

$$E\pi_i^{RL} = L_i[\alpha(e_i^{RL})\eta_G(r_i^{RL}, e_i^{RL}) + \beta(e_i^{RL})\eta_B(r_i^{RL}, e_i^{RL}) - C(e_i^{RL}, S)] - K \quad (8)$$

where:

$$\eta_G(r_i^{RL}, e_i^{RL}) \equiv \theta[p_G r_i^{RL} - r_f + q(e_i^{RL})vS] > 0$$
$$\eta_B(r_i^{RL}, e_i^{RL}) \equiv (1-\theta)[p_B r_i^{RL} - r_f + q(e_i^{RL})vS] < 0. \quad (9)$$

[19] Holding that condition implies that the overall marginal benefit of producing soft information is increasing in the lending interest rate because by producing more soft information the expected ratio of successful borrowers increases.

Note that in the case of relationship lending banks the unconditional expected profitabilities from lending to good and bad borrowers depend not only on the interest rate but also on the effort in producing soft information, and the cost of producing soft information depends on the services banks produce, because information synergies between lending and cross-selling can be exploited.

In the symmetric equilibrium the optimal effort in producing soft information e^{RL} and the optimal lending interest rate r^{RL} for relationship lending banks satisfy:

$$\frac{1}{n}[(1-\alpha_H)\eta_G(r^{RL},e^{RL})-\beta_H\eta_B(r^{RL},e^{RL})+A(e^{RL})q'(e^{RL})vS-C'(e^{RL},S)]=0 \quad (10)$$

$$r^{RL}=\frac{\gamma}{pn}+\frac{A(e^{RL})}{B(e^{RL})}[r_f-q(e^{RL})vS]+\frac{C(e^{RL},S)}{B(e^{RL})}. \quad (11)$$

The marginal benefit of an increased effort in producing soft information has a third component for relationship lending banks (equation (10)):

iii) given the selection ratio, it is more likely to sell services other than loans to borrowers so that the expected income from cross-selling increases.

Again the optimal effort in producing soft information equals the marginal benefit to the marginal cost of producing soft information. Since the marginal benefit of soft information is greater, relationship lending banks, ceteris paribus, are incentivised to produce more soft information than transaction lending banks.

The condition on the optimal interest rate is exactly the same as for transaction lending banks but that expected income from cross-selling depends on soft information.

3.3. The impact of cross-selling on the quality of banks' loans and on the lending interest rate

We study how cross-selling affects the quality of loans and the optimal interest rate for transaction lending banks and for relationship lending banks. Cross-selling impacts banks' incentives to produce soft information through its effect on the marginal benefit, and also the marginal cost in the case of relationship lending banks, of producing soft information. Accordingly, as banks' incentives to produce soft information change, the quality of loans and the optimal interest rate change. The direction and the intensity of the effect depend on the lending technology adopted by the bank.

3.3.1. Cross-selling and the production of soft information under alternative lending technologies

The overall effect of cross-selling on the optimal effort in producing soft information for transaction lending banks is computed as:

$$\frac{de^{TL}}{dS}=\frac{(1-\alpha_H)\frac{\partial\eta_G}{\partial S}-\beta_H\frac{\partial\eta_B}{\partial S}}{\frac{(B')^2}{B(e^{TL})}\frac{\gamma_0^{TL}-\gamma}{pn}} \quad (12)$$

which results to be negative for sufficiently low levels of transportation costs satisfying second order conditions. Thus in the case of transaction lending banks cross-selling reduces the optimal effort in producing soft information. This negative effect results unambiguously from that cross-selling reduces the marginal benefit of producing soft information because it

makes good borrowers less profitable ($\partial\eta_G/\partial S<0$) and bad borrowers more profitable ($\partial\eta_B/\partial S>0$)[20].

In the case of relationship lending banks the overall effect of cross-selling on the optimal effort in producing soft information is computed as:

$$\frac{de^{RL}}{dS} = \frac{(1-\alpha_H)\frac{\partial\eta_G}{\partial S} - \beta_H \frac{\partial\eta_B}{\partial S} + A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S)}{\frac{(B')^2}{B(e^{RL})}\frac{\gamma_0^{RL}-\gamma}{pn}} \tag{13}$$

which can be either positive or negative. Thus in the case of relationship lending banks cross-selling can either increase or decrease the optimal effort in producing soft information. This ambiguous effect results from that cross-selling can either increase or decrease the marginal benefit of producing soft information since it affects all its three components in different directions:

i) it reduces the marginal benefit from accepting more truly good borrowers (first component) by making good borrowers less profitable ($\partial\eta_G/\partial S<0$), as in the case of transaction lending banks;

ii) it can decrease or increase the marginal benefit from rejecting truly bad borrowers (second component) by making bad borrowers either more or less profitable ($\partial\eta_B/\partial S>$ *or* <0)[21];

iii) it increases the marginal benefit from making more likely to sell services to borrowers (third component) by increasing the expected income from cross-selling ($A(e^{RL})q'(e^{RL})v>0$).

Finally cross-selling reduces the marginal cost of producing soft information ($C'_S(e^{RL},S)<0$).

The overall effect of cross-selling on the optimal effort in producing soft information through its effect on the unconditional expected profitabilities of good and bad borrowers results to be negative when the expected ratio of successful borrowers increases as the bank produces more soft information (i.e. $B'>0$). This means that, also when cross-selling makes bad borrowers less profitable, the reduction in the unconditional expected profitability of good borrowers has a dominant effect on the incentives to produce soft information, that is cross-selling makes good borrowers "very less profitable" (in terms of loss of marginal benefit of soft information), softening banks' incentives to produce soft information even if it also makes bad borrowers less profitable[22]. This negative effect may be more than offset by the effects of cross-selling on the marginal benefit of soft information from increasing the probability of selling services and on the marginal cost. This is more likely to be the case the stronger are the positive impact of soft information on the probability of selling services to borrowers and the negative impact of cross-selling on the marginal cost of producing soft information.

These results may be summarised as follows.

[20] The effect of cross-selling on the unconditional expected profitabilities of good and bad borrowers goes through a direct effect of the expected income from selling services, which increases, and the effect on the lending interest rate, which, given the amount of soft information produced, decreases. Appendix B shows that this second effect dominates for good borrowers, while for bad borrowers the first effect prevails.

[21] In the case of relationship lending banks the effect of cross-selling on the unconditional expected profitabilities of good and bad borrowers goes through also the effect on the total cost of producing soft information, which decreases.

[22] If by producing more soft information the expected ratio of successful borrowers decreases (i.e. $B'<0$), the negative impact of cross-selling on the total cost of producing soft information partially offsets the discussed negative effect on the incentives to produce soft information.

Proposition 1.

i) Cross-selling always reduces transaction lending banks' incentives to produce soft information:

$$\frac{de^{TL}}{dS} = -\frac{\beta_H \theta(1-\theta)(p_G - p_B)qv}{(B')^2 \dfrac{\gamma_0^{TL} - \gamma}{pn}} < 0 \text{ for } \gamma < \gamma_0^{TL}. \qquad (14)$$

ii) Cross-selling intensify relationship lending banks' incentives to produce soft information for sufficiently high values of $q'(e^{RL})$ and $|C'_S(e^{RL},S)|$ (and $|C_S(e^{RL},S)|$ when $B'<0$):

$$\frac{de^{RL}}{dS} = -\frac{\beta_H \theta(1-\theta)(p_G - p_B)q(e^{RL})v - B'C_S(e^{RL},S)}{(B')^2 \dfrac{\gamma_0^{RL} - \gamma}{pn}} + \frac{A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S)}{\dfrac{(B')^2}{B(e^{RL})} \dfrac{\gamma_0^{RL} - \gamma}{pn}} > 0 \qquad (15)$$

$$\text{if } A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) > \frac{\beta_H \theta(1-\theta)(p_G - p_B)q(e^{RL})v - B'C_S(e^{RL},S)}{B(e^{RL})} \text{ for } \gamma < \gamma_0^{RL}.$$

Proof. See Appendix B.

3.3.2. Cross-selling and the quality of banks' loans under alternative lending technologies

Measuring the quality of banks' loans by the share of successful borrowers over all borrowers ($Q(e)=B(e)/A(e)$) the effect of cross-selling on the quality of banks' loans is computed as:

$$\frac{dQ(e)}{dS} = \frac{B'A(e) - B(e)A'}{[A(e)]^2} \frac{de}{dS} \qquad (16)$$

which is negative for transaction lending banks and positive for relationship lending banks (when $de^{RL}/dS>0$). Cross-selling reduces the quality of transaction lending banks' loans because cross-selling softens banks' incentives to produce soft information when banks adopt a transaction-based lending technology . On the contrary relationship lending banks may finance a portfolio of projects of higher quality because cross-selling improves (under certain conditions) banks' incentives to produce soft information when banks adopt a relationship lending technology.

These results can be summarised as follows.

Proposition 2.

i) Under a transaction-based lending technology the quality of banks' loans worsens with cross-selling:

$$\frac{dQ(e^{TL})}{dS} = \frac{\beta_H \theta(1-\theta)(p_G - p_B)}{[A(e^{TL})]^2} \frac{de^{TL}}{dS} < 0. \qquad (17)$$

ii) Under a relationship lending technology, holding the conditions of Proposition 1 ii), the quality of relationship lending banks' loans improves with cross-selling:

$$\frac{dQ(e^{RL})}{dS} = \frac{\beta_H \theta(1-\theta)(p_G - p_B)}{[A(e^{RL})]^2} \frac{de^{RL}}{dS} > 0. \qquad (18)$$

Proof. See Appendix B.

3.3.3. Cross-selling and the optimal interest rate under alternative lending technologies

The overall effect of cross-selling on the optimal lending interest rate for transaction lending banks is computed as:

$$\frac{dr^{TL}}{dS} = \frac{\partial r^{TL}}{\partial e^{TL}} \frac{de^{TL}}{dS} + \frac{\partial r^{TL}}{\partial S} \tag{19}$$

where de^{TL}/dS is given by equation (14). The overall effect of cross-selling on the optimal lending interest rate is a combination of a direct effect ($\partial r^{TL}/\partial S$) and an indirect effect (through the optimal effort in producing soft information). The direct effect is negative: for given effort in producing soft information, cross-selling reduces interest rates because it increases the expected income from selling services. The indirect effect can be either negative or positive, depending on the sign of the relation between effort and interest rate ($\partial r^{TL}/\partial e^{TL}$)[23]. However the indirect effect becomes small when banks have relatively low market power (γ low). In other words, when the market for loans is relatively competitive, transaction lending banks reduce interest rates because they earn more commission and fees income, while producing less soft information.

In the case of relationship lending banks the overall (direct plus indirect) effect of cross-selling on the optimal interest rate is computed as:

$$\frac{dr^{RL}}{dS} = \frac{\partial r^{RL}}{\partial e^{RL}} \frac{de^{RL}}{dS} + \frac{\partial r^{RL}}{\partial S} \tag{20}$$

where de^{RL}/dS is given by equation (15). The direct effect is again (more strongly) negative: for given effort in producing soft information, cross-selling reduces interest rates because it increases the expected income from selling services and because it reduces the total cost of producing soft information. Compared with the result for transaction lending banks, being the amount of soft information produced equal, relationship lending banks are able to reduce interest rates more than transaction lending banks because cross-selling lets them improve the efficiency of the production of soft information. As for transaction lending banks the indirect effect can be either negative or positive depending on the direction of the effect of an increased effort in producing soft information on interest rates[24]. However a relatively competitive market structure (γ low) can dampen the indirect effect. In this case relationship lending banks reduce interest rates not only because they earn more commission and fees income, but also because they are able to reduce the total cost of producing soft information, while producing more soft information.

These results may be summarised as follows.

Proposition 3.

i) Cross-selling reduces transaction lending banks' optimal interest rate:

$$\frac{dr^{TL}}{dS} = \frac{B'}{B(e^{TL})} \frac{\gamma}{pn} \frac{de^{TL}}{dS} - \frac{A(e^{TL})}{B(e^{TL})} qv < 0 \text{ always if } B'>0 \text{ and for } \gamma < \hat{\gamma}^{TL} \text{ if } B'<0. \tag{21}$$

ii) Holding the conditions of Proposition 1 ii), cross-selling reduces relationship lending banks' optimal interest rate:

[23] Since cross-selling reduces transaction lending banks' incentives to produce soft information, if producing less soft information reduces the marginal benefit of an increased interest rate because it reduces the number of accepted borrowers that are successful (i.e. $B'>0$), banks set lower interest rates; the opposite holds if $B'<0$.

[24] When cross-selling strengthens relationship lending banks' incentives to produce soft information (i.e. $de^{RL}/dS>0$), if producing more soft information reduces the marginal benefit of an increased interest rate because it reduces the number of accepted borrowers that are successful (i.e. $B'<0$), banks set lower interest rates; the opposite holds if $B'>0$.

$$\frac{dr^{RL}}{dS} = \frac{B'}{B(e^{TL})}\frac{\gamma}{pn}\frac{de^{RL}}{dS} - \frac{A(e^{RL})}{B(e^{RL})}q(e^{RL})v + \frac{C_S(e^{RL},S)}{B(e^{RL})} < 0 \quad \textit{always if } B'<0 \textit{ and for } \gamma < \hat{\gamma}^{RL} \textit{ if } B'<0. \tag{22}$$

Proof. See Appendix B.

Propositions 2 and 3 are tested empirically in the next Section.

4. The empirical analysis

The theoretical model presented in Section 3 has shown that, in a setting where positively evaluated loan applicants are more likely to buy other services from their lending bank, if banks adopt a transaction-based lending technology the higher is banks' cross-selling activity the lower is their equilibrium effort in producing soft information and thus the quality of their project pool. On the other hand, if banks adopt a relationship lending technology cross-selling may increase banks' optimal effort in producing soft information and the quality of banks' loans. The model has also shown that, under relatively competitive market structure, cross-selling reduces the optimal lending rate for both transaction lending banks and relationship lending banks.

The impact of cross-selling on the quality of banks' loans (Proposition 2 in the model) and on the optimal lending rate (Proposition 3 in the model), therefore, depends on the bank's information system and on the lending technology adopted. The empirical analysis is devoted to test these Propositions on a sample of European banks over the period 2001-2006. To this end we distinguish between "relationship lending banks" and "transaction lending banks" and we test whether the impact of cross-selling (proxied by the share of revenues coming from commission and fees income) on the quality of banks' loans and on the optimal lending rate differs between the two typologies of banks.

4.1. Data and variables

The source of the data is the Bankscope database. In order to have a homogeneous sample we focus on European countries (France, Germany, United Kingdom, Italy, Netherlands and Spain) and on banks with a minimum value of assets of 20 billions US dollars in 2006, thus obtaining a sample of 379 banks observed over the period 2001-2006. However, many banks have missing data for some of the variables used in the empirical analysis (in particular for impaired loans) so that we end up with a total number of 217 observations for the equation where the dependent variable is the share of impaired loans and with a total number of 386 observations for the interest margin equation (the sample is unbalanced).

Distinguishing between relationship lending banks and transaction lending banks is not an easy task since it would require information on the organisation and on the lending technology adopted by the bank that is not available in balance sheet data. Although the bank's size may be the best single proxy for identifying a potential relationship lending bank (in our case, a client-oriented bank in that the loan officer is in charge also of cross-selling other products to the borrower), this uni-dimensional approach would fail to identify some larger banks that are likely to adopt a relationship lending technology. We therefore construct a multi-dimensional filter based on the following three criteria: i) the size of the bank (measured by its assets), ii) the degree of personalisation of the services offered to depositors (measured by the number of employees per unit of deposit), and iii) its juridical form (in particular being a cooperative bank).

i) The size of the bank may affect the way in which banks collect information: the larger is a bank the more likely it is a centralised and hierarchical organisation not suitable to use soft

information (see Berger and Udell, 2002; Berger et al., 2007). DeYoung and Rice (2004) distinguish between large banks, taking advantage of economies of scale and earning low interest margins (because the products they produce are essentially financial commodities, and the markets they sell them into are extremely competitive), and small banks, operating in local markets, developing relationships with their depositors and their borrowers, making loans to informationally opaque borrowers and earning high interest margins (they pay low interest rates to a loyal base of low-cost core depositors, and they charge high interest rates to borrowers over which they have market power). They show that non interest income is essential for large banks while it is less important for small banks. In our empirical analysis we have a much more homogeneous sample of banks (with a minimum value of assets of 20 billions US dollars in 2006) for which we expect non interest income to be a relevant source of overall income.

ii) Banks characterised by a larger number of employees per unit of deposits are likely to supply, despite their size, a personalised service to the borrower, to be able to exploit information synergies, and therefore to have a customer-oriented approach (DeYoung and Rice, 2004).

iii) Cooperative banks tend to adopt a business model emphasising personalised services and relationships based on soft information. Cooperative banks differ from stockholder banks by their organisation, their goals, their values and their governance. They are based on the values of self-help, self-responsibility, democracy, equality, equity and solidarity. Cooperative banks are deeply rooted inside local areas and communities. They are involved in local development and contribute to the sustainable development of their communities, as their members and management board usually belong to the communities in which they exercise their activities.

In conclusion, we may identify as potentially "relationship lending banks" those that are not large, that are characterised by a large number of employees per deposits or that are cooperative. In order to construct this typology of banks we take banks that are in the first quartile in terms of total assets or that are cooperatives or that are in the last quartile in terms of the ratio of employees to total deposits. Table 1 reports summary statistics for relationship lending banks and transaction lending banks over the estimation period.

From table 1 we observe that relationship lending banks follow a significantly different strategy with respect to transaction lending banks in that they make, as expected, more loans and obtain higher interest margins; on the other hand, transaction lending banks have almost a double share of net trading income with respect to relationship lending banks. It is also interesting to note that, differently from DeYoung and Rice (2004) whose sample included very small banks, our "relationship lending banks" give importance to the cross-selling activity (they have slightly more commission income than "transaction lending banks"). Relationship lending banks are also characterised by a significantly higher equity ratio (smaller banks have less access than larger ones to less costly sources of funding) and, by construction, by a smaller size (they have lower assets), a higher share of employees to deposits and a higher share of personnel expenses. Overall, the multi-dimensional approach adopted seems to be able to identify in our sample a group of banks that are likely to adopt a relationship lending technology, although they are characterised by a share of net commission income and of impaired loans over total loans similar to the other ones.

However, in order to better evaluate the effectiveness of our multi-dimensional filter in identifying potential "relationship lending banks", we will compare the results obtained using this filter to those obtained distinguishing banks only on the basis of their size.

Table 1
Summary statistics for relationship lending and transaction lending European banks, 2001-2006

	Relationship Lending	Transaction Lending		
	Mean	Mean	t-test on differences	
Impaired loans/total loans	0.03	0.028	-0.606	
Net interest income share	0.608	0.561	-1.899	*
Commission and fees income share	0.274	0.25	-1.654	*
Trading income share	0.056	0.107	2.937	***
Assets ($b)	93800	404000	5.266	***
Employees/deposits ($m)	0.029	0.014	-7.801	***
Loans/assets	0.664	0.523	-5.206	***
Rate of growth of assets	0.095	0.111	0.708	
Equity/assets	0.069	0.047	-6.916	***
Interest margin	2.205	1.392	-7.062	***
Personnel expenses/assets	0.001	0.007	-6.742	***
Loan loss provisions/net interest revenues	14.69	15.54	0.417	

Source: Bankscope

Notes: *, **, *** denote respectively a significant difference in the means of the two groups at the 10, 5 and 1 percent levels.

4.2. The estimated equations

The main purpose of the empirical analysis is to test Propositions 2 and 3 of the model, i.e. to look at the impact of selling services on the quality of banks' project pool and on the optimal lending rate for transaction lending banks and for relationship lending banks. We measure the quality of the project pool with the share of impaired loans to banks' total loans and cross-selling activity with the share of commission and fees income to total income. Due to the short time series, in the basic specification, we pool the observations over time in order to capture both the cross-section and time-series variation in the variables (coefficients are weighted averages of the within and between effects). We also report robustness tests using the fixed effects estimator.

4.2.1. The quality of banks' loans equation

According to our model the quality of banks' loans (measured by the share of successful borrowers over all borrowers) depends on the effort they put in producing soft information, which, in turn, is affected by the lending technology banks adopt. Whenever banks adopt a transaction-based lending technology, cross-selling softens banks' incentives to produce soft information, so it reduces the quality of banks' loans. On the contrary, whenever banks adopt a relationship lending technology, cross-selling improves (under certain conditions) banks' incentives to produce soft information, so it may increase the quality of banks' loans. We therefore regress the quality of banks' loans, measured as the ratio of impaired loans to total loans, on cross-selling, measured as the share of commission and fees income on total income, for all banks and distinguishing between relationship lending banks and transaction lending banks.

In the equation for the quality of banks' loans we control for banks' size (banks' total assets), the loan ratio (loans divided by total assets), the equity ratio (equities divided by total assets), and the rate of growth of assets (allowing for a non linear effect). Total assets control for any systematic difference in the quality of banks' project pool across size. The loan and equity ratios may represent banks' attitude towards risk, e.g. risk-loving banks may make more loans, hold less assets and end up with a higher proportion of impaired loans. Finally, asset growth may be a proxy of the quality of banks' management so that we expect a negative relationship with the ratio of impaired loans to total loans. However, banks growing too fast may be more risky, we, therefore, allow for a non linear effect of growth on impaired loans. The basic empirical specification is the following:

$$ILTL_{it} = \alpha_0 + \alpha_1 COMI_{it} + \alpha_2 LASSET_{it} + \alpha_3 LOANASS_{it} + \alpha_4 EQUITYASS_{it} + \\ + \alpha_5 GRASS_{it} + \alpha_6 GRASS_{it}^2 + e_{it} \quad (23)$$

where *ILTL* denotes the ratio of impaired loans to total loans for bank *i* at time *t*, *COMI* is the share of net commission and fees income over total income, *LASSET* is the logarithm of total assets in constant prices, *LOANASS* is the ratio of loans to total assets, *EQUITYASS* is the ratio of equities to total assets, *GRASS* is the rate of growth of assets (in constant prices). Year dummies and country dummies are also included in order to control for differences in the banking environment over time and across countries. All coefficients are allowed to vary between relationship lending banks and transaction lending banks.

4.2.2. The interest margin equation

According to our model the lending interest rate banks set is related to their cross-selling activity. For both transaction lending banks and relationship lending banks, given the effort they put in producing soft information, cross-selling reduces lending interest rates because it increases the expected income from selling services other than loans. Moreover, in this case, the decrease in the interest rate is larger for relationship lending banks because, by cross-selling services other than loans, they can reduce the cost of producing soft information. In our model cross-selling has also an indirect effect on the optimal interest rate by affecting banks' effort in producing soft information. The sign of this indirect effect is ambiguous for both transaction lending banks and relationship lending banks, however its intensity is low under relatively competitive market conditions. We therefore regress the interest margin on cross-selling for all banks and distinguishing between transaction lending banks and relationship lending banks.

In the interest margin equation we control for banks' size (banks' total assets), the loans to deposits ratio, the equity ratio (the ratio between total equities and total assets), personnel expenditures over assets and loan loss provisions over net interest revenue[25]. The size of the bank, defined as banks' total assets, is a proxy of bank market power which is often associated with higher lending rates. However, because of the "too big to fail" effect, banks operating in a relatively competitive environment may prefer to decrease their risk premium in order to attract borrowers. We may expect therefore, in this case, a negative relationship between interest margins and banks' total assets. The ratio of loans to total deposits is a proxy of bank's liquidity risk, we therefore expect a positive relationship between the loans to deposits ratio and interest margins. Banks characterised by a higher ratio of equity to total assets may require a higher spread to cover the higher cost of equity financing compared to other sources of funding, so we expect a positive coefficient for the equity ratio. Regarding personnel expenses the literature provides mixed results on the expected coefficient. On the

[25] The control variables are those usually considered in the optimal bank interest margin literature (Klein, 1971; Monti, 1972; Ho and Saunders, 1981; Angbazo, 1997; Wong, 1997; Saunders and Schumacher, 2000; Drakos, 2003; Fernandez de Guevara and Maudos, 2004).

one hand, higher personnel costs may be associated with better screening and monitoring of borrowers and therefore with lower default risk premium charged on loans; on the other hand, since the cost of granting loans increases with personnel expenses, they may be considered a proxy of the cost of producing soft information, in this respect banks characterised by higher personnel costs, consistently with our model, should charge a higher premium. Finally, the ratio of loan loss provisions to net interest revenues is considered as a measure of the average riskiness of the borrowers population so that we expect that, consistently with our model, a higher premium should be charged by banks to offset higher credit risk. We then add commission and fees income among the explanatory variables to capture banks' cross-selling activity. The estimated equation is therefore:

$$IM_{it} = \beta_0 + \beta_1 COMI_{it} + \beta_2 LASSET_{it} + \beta_3 LOANDEP_{it} + \beta_4 EQUITYASS_{it} + \\ + \beta_5 PEXP_{it} + \beta_6 LLP_{it} + e_{it} \quad (24)$$

where *IM* denotes the interest margin for bank *i* at time *t*, *COMI* is the share of net commission and fees income over total income, *LASSET* is the logarithm of total assets in constant prices, *LOANDEP* is the ratio of loans to total deposits, *EQUITYASS* is the ratio of equities to total assets, *PEXP* is the ratio of total personnel expenses to total assets and *LLP* is the ratio of loan loss provisions to net interest revenues. Year dummies and country dummies are also included in order to control for differences in the banking environment over time and across countries. All coefficients are allowed to vary between relationship lending banks and transaction lending banks.

4.3. Regression results

4.3.1. The impact of cross-selling on the quality of banks' project pool

Table 2 reports the results of the estimation of the ratio of impaired loans to total loans for all banks and distinguishing between relationship lending banks and transaction lending banks. The table reports results for both the uni-dimensional (based on the bank's size) and the multi-dimensional approach (based on the three criteria discussed above) to the identification of relationship lending banks.

We can observe that, for the whole sample, the larger is banks' share of net commission income, the higher is the ratio of impaired loans to total loans.

Interestingly, we also find that the relationship between commission income and impaired loans differs significantly between relationship lending banks and transaction lending banks: while (consistently with Proposition 2 i) of the model) for transaction lending banks higher income from commissions leads to a higher ratio of impaired loans to total loans, the opposite (consistently with Proposition 2 ii) of the model) occurs for relationship lending banks. These results are robust to the two different criteria used to identify relationship lending banks. It is also interesting to observe that the use of the multi-dimensional filter leads to a higher difference in the impact of cross-selling on the quality of the project pool between relationship lending and transaction lending banks. This supports our hypothesis that larger banks supplying a personalised service or that are cooperative tend to behave similarly to smaller banks in their capability of engaging in relationship lending. Overall the results support the hypothesis that selling services other than loans leads to a lower effort in producing soft information and a lower quality of the pool of financed projects for banks that adopt a transaction-based lending technology, while for relationship lending banks cross-selling increases the quality of the project pool.

Regression results for all typologies of banks also show that the ratio of impaired loans to total loans increases with banks' size. Furthermore, it increases with the ratio of loans to assets, it decreases with the ratio of equities to assets and it decreases non monotonically with banks' growth. The positive effect of banks' size and the negative impact of banks' growth

on loans' quality is significantly higher for relationship lending banks than for transaction lending banks.

Table 2 Regression results for the quality of banks' loans equation

	All banks	Relationship Lending (a)	Transaction Lending (a)	Difference (a)	Relationship Lending (b)	Transaction Lending (b)	Difference (b)
COMI	0.010	-0.071	0.027	-0.098	-0.044	0.028	-0.072
	(2.04)**	(4.45)***	(3.67)***	(-5.31)***	(-2.40)**	(4.00)***	(-3.49)***
LASSET	0.002	0.006	0.002	0.004	0.015	0.001	0.014
	(5.99)***	(3.86)***	(2.77)***	(2.47)***	(4.03)***	(2.94)***	(3.65)***
LOANASS	0.014	0.015	0.020	-0.005	0.022	0.017	0.005
	(6.67)***	(1.74)*	(4.94)***	(-0.36)	(3.96)***	(4.53)***	(1.02)
EQUITYASS	-0.042	-0.029	0.043	-0.072	0.024	-0.033	0.057
	(-3.01)***	(-0.91)	(1.44)	(-1.28)	(0.82)	(-0.92)	(1.23)
GRASS	-0.022	-0.058	-0.016	-0.042	-0.044	-0.020	-0.024
	(-7.24)***	(-4.11)***	(-3.56)***	(-2.54)***	(-3.80)***	(-4.04)***	(-1.89)*
$GRASS^2$	0.044	0.110	0.052	0.058	0.075	0.051	0.024
	(6.45)***	(3.38)***	(5.01)***	(1.49)	(3.47)***	(4.88)***	(0.93)
N	217	75	142	217	52	165	217

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$; z-values in brackets. In columns (a) relationship lending banks are defined on the basis of size, employees per deposit and being cooperative; in columns (b) they are defined only on the basis of their size. Results are heteroscedasticity consistent. Dummy variables for time periods and countries are included although coefficients are not reported. Banks with zero or very low levels (first percentile) of the ratio of loans to assets have been excluded from the analysis.

In order to check for the robustness of these results we estimate different specifications using the multi-dimensional filter (see table 3)[26]. In particular, in specification (1) we introduce trading income among the regressors, in specification (2) we use the lagged value of commission and fees income and in specification (3) we introduce banks' fixed effects.

The robustness checks aim at ruling out alternative explanations of the relationship between commission and fees income and impaired loans.

First, one can argue that commission and fees income, being a component of non interest income, may proxy banks' diversification so that its coefficient may capture the relationship between banks' diversification and risk[27] rather than the impact of cross-selling on the production of soft information. If this was the case, we could expect a similar relationship between trading income and impaired loans to that found between commission and fees income and impaired loans. On the contrary the results in column (1) of table 3 show that trading income, differently from commission and fees income, has no impact on the ratio of impaired loans to total loans and this is true for the entire sample and also when distinguishing between relationship lending banks and transaction lending banks.

[26] For reasons of space we report only estimates using the multi-dimensional filter. Results using the uni-dimensional approach are not qualitatively different and are available on request.

[27] See Lepetit et al. (2008a).

Table 3 Robustness tests for the quality of banks' loans equation

	(1) All sample	(1) Relationship Lending	(1) Transaction Lending	(2) All sample	(2) Relationship Lending	(2) Transaction Lending	(3) All sample	(3) Relationship Lending	(3) Transaction Lending
COMI	0.009	-0.073	0.025				0.052	-0.012	0.048
	(1.79)*	(4.67)***	(3.47)***				(2.26)**	(0.37)	(1.69)*
COMILAG				0.010	-0.079	0.036			
				(2.05)**	(-4.92)***	(5.55)***			
TRADI	0.001	-0.015	0.007						
	(0.17)	(0.98)	(1.17)						
LASSET	0.002	0.007	0.001	0.002	0.004	0.001	-0.026	-0.016	-0.029
	(5.87)***	(3.91)***	(2.31)**	(5.51)***	(2.86)***	(2.08)**	(-3.58)***	(-1.64)	(-2.54)**
LOANASS	0.016	0.013	0.022	0.014	0.014	0.017	-0.016	0.003	-0.008
	(5.88)***	(1.45)	(4.65)***	(6.04)***	(1.49)	(4.08)***	(-1.03)	(0.13)	(0.43)
EQUITYASS	-0.033	-0.044	0.058	-0.044	-0.016	0.000	0.088	-0.035	0.141
	(-2.19)**	(-1.21)	(1.93)*	(-3.15)***	(-0.39)	(0.01)	(0.74)	(-0.37)	(0.77)
GRASS	-0.022	-0.057	-0.016	-0.021	-0.061	-0.019	0.007	0.001	0.009
	(-7.02)***	(-3.98)***	(-3.32)***	(-6.63)***	(-3.48)***	(-3.57)***	(0.96)	(0.12)	(0.84)
$GRASS^2$	0.042	0.106	0.050	0.043	0.078	0.045	0.045	0.040	0.039
	(5.70)***	(3.22)***	(4.46)***	(5.72)***	(1.77)*	(4.03)***	(2.92)***	(1.77)*	(1.83)*
N	217	75	142	211	72	139	217	75	142

Notes: * p <0.1; ** p <0.05; *** p <0.01; z-values in brackets. Results are heteroscedasticity consistent. Relationship lending banks are defined on the basis of size, employees per deposit and being cooperative. Dummy variables for time periods and countries are included in specifications (1) and (2) although coefficients are not reported. Banks with zero or very low levels (first percentile) of the ratio of loans to assets have been excluded from the analysis. In specification (1) we add trading income (TRADI); in specification (2) we use the lagged value of commission and fees income (COMILAG); in specification (3) we introduce banks' fixed effects.

A second concern is the existence of a reverse causality story as banks that are not good in making loans shift their focus towards non interest-bearing activities. Although the reverse causality explanation is not consistent neither with the different results found for relationship lending banks and transaction lending banks, nor with the different impact of commission income and trading income on the quality of banks' loans that emerged from the empirical analysis (specification (1)), we further address this concern by using lagged values of commission income. The results reported in column (2) show again a positive (negative) impact of commission income on the ratio of impaired loans to total loans for transaction (relationship) lending banks[28].

As a final robustness check, in order to control for bank-specific unobserved factors that might drive the relationship between commission and fees income and impaired loans, we report fixed effects estimates. The results reported in column (3) show again a positive and significant impact of commission and fees income on impaired loans for transaction lending banks and a negative (although insignificant) impact for relationship lending banks. Overall the results of the robustness check support the prediction of our model that a high cross-selling activity is detrimental (in terms of the quality of the selected project pool) for transaction lending banks while it can benefit relationship lending banks.

4.3.2. The impact of cross-selling on the optimal lending rate

Table 4 reports the results of the estimation of the interest margin equation for all banks and distinguishing between relationship lending banks (identified by both uni-dimensional and multi-dimensional filters) and transaction lending banks. We can observe that for both typologies of banks (consistently with Proposition 3 i) and ii) of the model) the interest margin decreases with the commission and fees income share. More interestingly, we can also observe that the decrease in the interest margin is higher for relationship lending banks than for transaction lending banks.

The results for all banks also show that, as expected, the interest margin increases with the ratio of loans to deposits, with the ratio of loan loss provisions to net interest revenue and with the ratio of equities to assets. It also increases with personnel expenditures, consistently with the interpretation that they represent a proxy of the cost of producing soft information. However, we can observe significant differences between relationship lending banks and transaction lending banks. In particular, the positive impact on the interest margin of the equity ratio and of the ratio of personnel expenses is higher for transaction lending banks than for relationship lending banks, while loan loss provisions lead to higher margins only for transaction lending banks.

In order to check for the robustness of these results we estimate different specifications using the multi-dimensional filter (see table 5). In particular, in specification (1) we report "between" estimates, in specification (2) we replace time dummies with a time trend and in specification (3) we report fixed effects estimates. The robustness checks aim at ruling out alternative explanations of the relationship between commission income and interest margin (see also Lepetit et al. 2008b). Looking at "between" estimates and introducing a time trend in the regression aim at ruling out the trend hypothesis, i.e. that increasing competition in the lending market over time has led banks to simultaneously lower interest margins and to shift towards non interest-bearing activities. The introduction of fixed effects controls for unobserved bank-specific factors that could simultaneously lead banks to lower interest margins and to increase commission and fees income.

[28] In order to test for reverse causality, we also regressed commission and fees income on the lagged value of impaired loans to total loans and the variable was not significant. Results are available on request.

Table 4 Regression results for the interest margin equation

	All banks	Relationship Lending (a)	Transaction Lending (a)	Difference (a)	Relationship Lending (b)	Transaction Lending (b)	Difference (b)
COMI	-0.882	-1470	-0.891	-0.579	-1724	-1103	-0.621
	(-10.54)***	(-4.29)***	(-8.04)***	(-1.71)*	(-4.43)***	(8.98)***	(-1.62)*
LASSET	0.002	-0.014	-0.013	-0.001	-0.175	-0.012	-0.163
	(0.27)	(0.63)	(1.10)	(-0.08)	(-0.92)	(0.98)	(-1.27)
LOANSDEP	0.033	0.004	0.020	-0.016	-0.019	0.027	-0.046
	(2.02)**	(0.12)	(0.93)	(-0.13)	(-0.56)	(1.47)	(-1.23)
EQUITYASS	8998	2107	12909	-10802	1938	11056	-9118
	(11.72)***	(1.74)*	(10.37)***	(-5.74)***	(1.12)	(13.71)***	(-4.87)***
PEXP	61420	54786	78951	-24165	56034	89737	-33703
	(15.93)***	(7.36)***	(13.55)***	(-2.54)***	(6.68)***	(18.34)***	(-3.32)***
LLP	0.006	-0.002	0.006	-0.008	-0.005	0.007	-0.012
	(6.50)***	(-0.88)	(8.04)***	(-3.49)***	(-1.24)	(10.42)***	(-2.60)***
N	386	148	238	386	107	279	386

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$; z-values in brackets. In columns (a) relationship lending banks are defined on the basis of size, employees per deposit and being cooperative; in columns (b) they are defined only on the basis of their size. Results are heteroscedasticity consistent. Dummy variables for time periods and countries are included although coefficients are not reported. Banks with zero or very low levels (first percentile) of the ratio of loans to assets have been excluded from the analysis.

Table 5 Robustness tests for the interest margin equation

	(1) All sample	(1) Relationship Lending	(1) Transaction Lending	(2) All sample	(2) Relationship Lending	(2) Transaction Lending	(3) All sample	(3) Relationship Lending	(3) Transaction Lending
COMI	-0.976	-1602	-1342	-0.925	-1436	-0.830	-1716	-2073	-1148
	(2.01)**	(1.69)*	(2.12)**	(7.56)***	(5.02)***	(7.35)***	(4.02)***	(2.35)**	(2.65)***
LASSET	-0.004	0.068	-0.017	0.000	-0.006	-0.018	-0.085	0.140	-0.257
	(0.10)	(0.79)	(0.35)	(0.01)	(0.29)	(1.43)	(0.97)	(0.98)	(2.16)**
LOANDEP	0.072	0.095	0.040	0.033	0.010	0.023	-0.011	-0.036	0.018
	(1.24)	(0.82)	(0.66)	(3.01)***	(0.39)	(1.18)	(1.11)	(3.59)***	(0.75)
EQUITYASS	12962	11019	13488	8487	2198	12333	0.502	3620	1228
	(5.56)***	(2.76)***	(4.46)***	(10.42)***	(2.01)**	(11.46)***	(0.24)	(1.42)	(0.36)
PEXP	83834	53036	99176	62761	56062	79607	34402	26143	37206
	(6.51)***	(2.71)***	(5.42)***	(13.60)***	(8.50)***	(13.15)***	(2.06)**	(1.60)	(1.37)
LLP	0.018	-0.004	0.018	0.006	-0.003	0.006	-0.000	-0.001	0.000
	(3.97)***	(0.49)	(3.93)***	(6.89)***	(1.03)	(7.29)***	(1.08)	(0.49)	(0.50)
Year				0.028	0.115	0.017			
				(2.71)***	(5.04)***	(2.01)**			
N	386	148	238	386	148	238	386	148	238

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$; z-values in brackets. Results are heteroscedasticity consistent. Relationship lending banks are defined on the basis of size, employees per deposit and being cooperative. Dummy variables for countries are included in specification (2) although coefficients are not reported. Banks with zero or very low levels (first percentile) of the ratio of loans to assets have been excluded from the analysis. In specification (1) we report between estimates; in specification (2) we introduce a time trend (Year) rather than time period fixed effects; in specification (3) we introduce banks' fixed effects.

The results reported in columns (1), (2) and (3) show respectively that the negative relationship between commission and fees income also holds in the cross-section, that it is unaffected by the introduction of the time trend and that it is robust to controlling for bank specific fixed effects. Moreover, the results hold for both relationship and transaction lending banks.

Overall, the results for the quality of banks' loans and those for the interest margin question the conclusion of Lepetit et al. (2008b) that borrower default risk is underpriced in the lending rates charged by banks with higher fee-income shares. Lepetit et al. (2008b) argue that banks may use loans as a loss leader, raising the issue of how cross-selling strategies should be addressed by regulators to control for bank risk. In our model this may be the appropriate interpretation in the case of transaction lending banks, for which lower interest rates are associated with lower quality of the pool of financed projects. In this case, supported by our empirical analysis, the cross-subsidisation between loans and other services leads to mispricing of risk and excessive lending. On the contrary, in the case of relationship lending banks lower interest rates are not necessarily associated with a lower quality of loans. For given effort in producing soft information, an increase in cross-selling reduces the optimal lending rate even more than in the case of transaction lending banks, because it improves the efficiency of the soft-information production through screening. In this case, supported again by our empirical analysis, there is no mispricing of risk, but financing better projects at lower interest rates.

5. Conclusion

In the last decade Basel II regulation, together with the relevant progress in information technology that lowered the cost of processing hard information, induced banks to switch from the adoption of a screening approach based on soft information to one based on credit scoring. The adoption of credit scoring may be more than just providing the loan officer with a new tool, it may coincide with a fundamental change in the lending regime, reducing the loan officer's role to that of a salesperson (Inderst, 2009). Whenever the loan officer no longer produces soft information, the informativeness of the lending decision decreases.

The growing propensity of banks to supply services other than loans and deposits may contribute to this change by further reducing their incentives to produce soft information. Our theoretical model shows that the effect of cross-selling on the amount of soft information produced by a bank depends on the lending technology adopted by the bank. Since a bank may exploit scope economies in the joint use of hard and soft information but only hard information can be used by different users, a bank adopting a "relationship lending" technology is more likely to exploit information synergies than a bank adopting a "transaction lending" technology. According to our theoretical model for transaction lending banks (those where the loan officer has only the task of screening loan applicants) an increase in cross-selling activity lowers the equilibrium effort in producing soft information and the quality of banks' loans, whereas for relationship lending banks (those where the loan officer has the task of both screening loan applicants and cross-selling other services to borrowers) it is more likely that cross-selling increases banks' optimal effort in producing soft information and the quality of banks' loans. The model also shows that, when the lending market is sufficiently competitive, cross-selling reduces the optimal lending interest rate for both typologies of banks.

Our econometric analysis supports the theoretical findings: regression results show that a higher share of commission and fees income reduces the quality of banks' loans for transaction lending banks while it increases it in the case of relationship lending banks and that a higher share of commission and fees income leads to a lower interest rate for both

transaction lending and relationship lending banks with a higher impact for relationship lending banks.

Overall the results of our analysis suggest that the conclusion of Lepetit et al. (2008b) that borrower default risk is underpriced in the lending rates charged by banks with higher fee-income shares may hold only for transaction lending banks. Regulators should therefore address cross-selling strategies to control for bank risk in very different (opposite) ways depending on the lending technology adopted by the bank. While cross-selling tends to increase bank risk for transaction lending banks, it tends to decrease bank risk for relationship lending banks. In the case of relationship lending banks we find that, because of cross-selling, less risky investment projects may be financed at lower interest rates.

Appendix A. Derivation and properties of equilibrium results

A.1. Symmetric equilibrium

The first order conditions for the maximisation problem of transaction lending bank *i* are:

$$\begin{aligned} &L_i[(1-\alpha_H)\eta_G(r_i^{TL})-\beta_H\eta_B(r_i^{TL})-C'(e_i^{TL})]=0 \\ &-\frac{p}{\gamma}\left[\alpha(e_i^{TL})\eta_G(r_i^{TL})+\beta(e_i^{TL})\eta_B(r_i^{TL})-C(e_i^{TL})\right]+L_iB(e_i^{TL})=0. \end{aligned} \tag{A1}$$

The solution of system (A1) in the symmetric equilibrium gives the optimal effort in producing soft information e^{TL} and the optimal interest rate r^{TL} satisfying:

$$\frac{1}{n}[(1-\alpha_H)\eta_G(r^{TL})-\beta_H\eta_B(r^{TL})-C'(e^{TL})]=0 \tag{A2}$$

$$-\frac{p}{\gamma}\left[\alpha(e^{TL})\eta_G(r^{TL})+\beta(e^{TL})\eta_B(r^{TL})-C(e^{TL})\right]+\frac{1}{n}B(e^{TL})=0\,. \tag{A3}$$

Equation (A3) solved by r^{TL} gives equation (7) in the text.

Second order conditions are satisfied:

$$-\frac{1}{n}C''(e^{TL})<0$$

$\frac{p}{n\gamma}C''(e^{TL})B(e^{TL})-\frac{(B')^2}{n^2}>0$ for sufficiently low levels of transportation costs:

$$\gamma<\frac{pnC''(e^{TL})B(e^{TL})}{(B')^2}\equiv\gamma_0^{TL}\,. \tag{A4}$$

The maximisation problem of relationship lending bank *i* is solved by the following first order conditions:

$$\begin{aligned} &L_i\left[(1-\alpha_H)\eta_G(r_i^{RL},e_i^{RL})-\beta_H\eta_B(r_i^{RL},e_i^{RL})+A(e_i^{RL})q'(e_i^{RL})vS-C'(e_i^{RL},S)\right]=0 \\ &-\frac{p}{\gamma}\left[\alpha(e_i^{RL})\eta_G(r_i^{RL},e_i^{RL})+\beta(e_i^{RL})\eta_B(r_i^{RL},e_i^{RL})-C(e_i^{RL},S)\right]+L_iB(e_i^{RL})=0. \end{aligned} \tag{A5}$$

The solution of system (A5) in the symmetric equilibrium gives the optimal effort in producing soft information e^{RL} and the optimal interest rate r^{RL} satisfying:

$$\frac{1}{n}\left[(1-\alpha_H)\eta_G(r^{RL},e^{RL})-\beta_H\eta_B(r^{RL},e^{RL})+A(e^{RL})q'(e^{RL})vS-C'(e^{RL},S)\right]=0 \tag{A6}$$

$$-\frac{p}{\gamma}\left[\alpha(e^{RL})\eta_G(r^{RL},e^{RL})+\beta(e^{RL})\eta_B(r^{RL},e^{RL})-C(e^{RL},S)\right]+\frac{1}{n}B(e^{RL})=0\,. \tag{A7}$$

Equation (A7) solved by r^{RL} gives equation (11) in the text.

Second order conditions are assumed to be satisfied:

$$-\frac{1}{n}|SOC|<0$$

$\frac{p}{n\gamma}|SOC|B(e^{RL})-\frac{(B')^2}{n^2}>0$ for sufficiently low levels of transportation costs:

$$\gamma<\frac{pn|SOC|B(e^{RL})}{(B')^2}\equiv\gamma_0^{RL} \tag{A8}$$

where:

$$|SOC|\equiv C''(e^{RL},S)-A(e^{RL})q''(e^{RL})vS-2A'q'(e^{RL})vS\,.$$

A.2. The effect of unconditional expected profitabilities on the production of soft information

By totally differentiating equations (A2) and (A6), the optimal effort in producing soft information is increasing in the unconditional expected profitability of good borrowers:

$$-C''(e^{TL})de^{TL} + (1-\alpha_H)d\eta_G^{TL} = 0$$

$$\frac{de^{TL}}{d\eta_G^{TL}} = \frac{1-\alpha_H}{C''(e^{TL})} > 0, \qquad \text{(A9)}$$

$$-|SOC|\,de^{RL} + (1-\alpha_H)d\eta_G^{RL} = 0$$

$$\frac{de^{RL}}{d\eta_G^{RL}} = \frac{1-\alpha_H}{|SOC|} > 0. \qquad \text{(A10)}$$

By totally differentiating equations (A2) and (A6), the optimal effort in producing soft information is decreasing in the unconditional expected profitability of bad borrowers:

$$-C''(e^{TL})de^{TL} - \beta_H d\eta_B^{TL} = 0$$

$$\frac{de^{TL}}{d\eta_B^{TL}} = -\frac{\beta_H}{C''(e^{TL})} < 0, \qquad \text{(A11)}$$

$$-|SOC|\,de^{RL} - \beta_H d\eta_B^{RL} = 0$$

$$\frac{de^{RL}}{d\eta_B^{RL}} = -\frac{\beta_H}{|SOC|} < 0. \qquad \text{(A12)}$$

A.3. The effect of the interest rate on the production of soft information

By totally differentiating equations (A2) and (A6), the optimal effort in producing soft information is increasing in the interest rate if, as the interest rate increases, the marginal benefit of soft information from accepting good borrowers ($(1-\alpha_H)\partial\eta_G/\partial r$) is greater than the marginal benefit from rejecting bad borrowers ($\beta_H\partial\eta_B/\partial r$), implying $B'>0$:

$$-C''(e^{TL})de^{TL} + \left[(1-\alpha_H)\frac{\partial\eta_G}{\partial r^{TL}} - \beta_H\frac{\partial\eta_B}{\partial r^{TL}}\right]dr^{TL} = 0$$

$$\frac{de^{TL}}{dr^{TL}} = \frac{(1-\alpha_H)\theta p_G - \beta_H(1-\theta)p_B}{C''(e^{TL})} > 0 \text{ if } (1-\alpha_H)\theta p_G > \beta_H(1-\theta)p_B \Rightarrow B'>0, \qquad \text{(A13)}$$

$$-|SOC|\,de^{RL} + \left[(1-\alpha_H)\frac{\partial\eta_G}{\partial r^{RL}} - \beta_H\frac{\partial\eta_B}{\partial r^{RL}}\right]dr^{RL} = 0$$

$$\frac{de^{RL}}{dr^{RL}} = \frac{(1-\alpha_H)\theta p_G - \beta_H(1-\theta)p_B}{|SOC|} > 0 \text{ if } (1-\alpha_H)\theta p_G > \beta_H(1-\theta)p_B \Rightarrow B'>0. \qquad \text{(A14)}$$

A.4. The effect of the production of soft information on the interest rate

By totally differentiating equations (A3) and (A7), the optimal interest rate is increasing in the effort in producing soft information if the number of accepted borrowers that are successful increases as banks produce more soft information[29]:

$$-\frac{p}{\gamma}\left[\alpha(e)\frac{\partial\eta_G}{\partial r} + \beta(e)\frac{\partial\eta_B}{\partial r}\right]dr + \frac{1}{n}B'de = 0$$

$$\frac{dr}{de} = \frac{B'}{\alpha(e)\theta p_G + \beta(e)(1-\theta)p_B}\frac{\gamma}{pn} > 0 \text{ if } B'>0. \qquad \text{(A15)}$$

[29] The indexes TL and RL are omitted because it holds for both lending technologies.

Appendix B. Propositions and proofs

B.1. Proposition 1

For transaction lending banks equation (5) implicitly defines e^{TL} as a function of *S*:

$$F(e^{TL},S)\equiv\frac{1}{n}[(1-\alpha_H)\eta_G(e^{TL},S)-\beta_H\eta_B(e^{TL},S)-C'(e^{TL})]=0 \quad \text{(B1)}$$

where:

$$\eta_G(e^{TL},S)=\theta[p_G r(e^{TL})-r_f+qvS]$$

$$\eta_B(e^{TL},S)=(1-\theta)[p_B r(e^{TL})-r_f+qvS]$$

$$r(e^{TL})=\frac{\gamma}{pn}+\frac{A(e^{TL})}{B(e^{TL})}(r_f-qvS)+\frac{C(e^{TL})}{B(e^{TL})}.$$

Totally differentiating equation (B1) yields:

$$\frac{\partial F}{\partial e^{TL}}de^{TL}+\frac{\partial F}{\partial S}dS=0$$

$$\frac{de^{TL}}{dS}=-\frac{\partial F/\partial S}{\partial F/\partial e^{TL}} \quad \text{(B2)}$$

In equation (B2):

$$\frac{\partial F}{\partial S}=(1-\alpha_H)\frac{\partial\eta_G}{\partial S}-\beta_H\frac{\partial\eta_B}{\partial S} \quad \text{(B3)}$$

where:

$$\frac{\partial\eta_G}{\partial S}=\theta\left(p_G\frac{\partial r^{TL}}{\partial S}+qv\right)=\theta\left[-\frac{A(e^{TL})}{B(e^{TL})}p_G+1\right]qv= \quad \text{(B4)}$$

$$=-\frac{\beta(e^{TL})\theta(1-\theta)(p_G-p_B)}{B(e^{TL})}qv<0,$$

i.e. cross-selling makes good borrowers less profitable, because the effect that goes through the decrease in interest rate is stronger than the effect through the increase in expected income from selling services ($A(e^{TL})p_G/B(e^{TL})>1$),

$$\frac{\partial\eta_B}{\partial S}=(1-\theta)\left(p_B\frac{\partial r^{TL}}{\partial S}+qv\right)=(1-\theta)\left[-\frac{A(e^{TL})}{B(e^{TL})}p_B+1\right]qv= \quad \text{(B5)}$$

$$=\frac{\alpha(e^{TL})\theta(1-\theta)(p_G-p_B)}{B(e^{TL})}qv>0,$$

i.e. cross-selling makes bad borrowers more profitable, because the direct effect is stronger than the effect through the decrease in interest rate ($A(e^{TL})p_B/B(e^{TL})<1$), and

$$\frac{\partial F}{\partial e^{TL}}=\left[(1-\alpha_H)\frac{\partial\eta_G}{\partial r^{TL}}-\beta_H\frac{\partial\eta_B}{\partial r^{TL}}\right]\frac{\partial r^{TL}}{\partial e^{TL}}-C''(e^{TL})=\frac{(B')^2}{B(e^{TL})}\frac{\gamma}{pn}-C''(e^{TL})$$

which, from equation (A4), can be written as:

$$\frac{\partial F}{\partial e^{TL}}=-\frac{(B')^2(\gamma_0^{TL}-\gamma)}{B(e^{TL})pn}<0 \text{ for } \gamma<\gamma_0^{TL}. \quad \text{(B6)}$$

Substituting equations (B4) and (B5) in (B3), the numerator of (B2) is given by:

$$\frac{\partial F}{\partial S}=-\frac{\beta_H\theta(1-\theta)(p_G-p_B)}{B(e^{TL})}qv<0. \quad \text{(B7)}$$

Finally substituting (B7) and (B6) in (B2) yields equation (14) in the text, which demonstrates Proposition 1 i).

For relationship lending banks equation (10) implicitly defines e^{RL} as a function of *S*:

$$F(e^{RL},S) \equiv \frac{1}{n}[(1-\alpha_H)\eta_G(e^{RL},S) - \beta_H \eta_B(e^{RL},S) + A(e^{RL})q'(e^{RL})vS - C'(e^{RL},S)] = 0 \quad \text{(B8)}$$

where:

$$\eta_G(e^{RL},S) = \theta[p_G r(e^{RL}) - r_f + q(e^{RL})vS]$$

$$\eta_B(e^{RL},S) = (1-\theta)[p_B r(e^{RL}) - r_f + q(e^{RL})vS]$$

$$r(e^{RL}) = \frac{\gamma}{pn} + \frac{A(e^{RL})}{B(e^{RL})}[r_f - q(e^{RL})vS] + \frac{C(e^{RL})}{B(e^{RL})}.$$

Totally differentiating equation (B8) yields:

$$\frac{\partial F}{\partial e^{RL}} de^{RL} + \frac{\partial F}{\partial S} dS = 0$$

$$\frac{de^{RL}}{dS} = -\frac{\partial F / \partial S}{\partial F / \partial e^{RL}}. \quad \text{(B9)}$$

In equation (B9):

$$\frac{\partial F}{\partial S} = (1-\alpha_H)\frac{\partial \eta_G}{\partial S} - \beta_H \frac{\partial \eta_B}{\partial S} + A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) \quad \text{(B10)}$$

where:

$$\frac{\partial \eta_G}{\partial S} = \theta\left[p_G \frac{\partial r^{RL}}{\partial S} + q(e^{RL})v\right] = \theta\left\{p_G\left[-\frac{A(e^{RL})}{B(e^{RL})}q(e^{RL})v + \frac{C_S(e^{RL},S)}{B(e^{RL})}\right] + q(e^{RL})v\right\} =$$

$$= -\frac{\beta(e^{RL})\theta(1-\theta)(p_G - p_B)}{B(e^{RL})}q(e^{RL})v + \theta p_G \frac{C_S(e^{RL},S)}{B(e^{RL})} < 0, \quad \text{(B11)}$$

i.e. cross-selling makes good borrowers less profitable, because the effect through the interest rate is stronger than the direct effect,

$$\frac{\partial \eta_B}{\partial S} = (1-\theta)\left[p_B \frac{\partial r^{RL}}{\partial S} + q(e^{RL})v\right] = (1-\theta)\left\{p_B\left[-\frac{A(e^{RL})}{B(e^{RL})}q(e^{RL})v + \frac{C_S(e^{RL},S)}{B(e^{RL})}\right] + q(e^{RL})v\right\} =$$

$$= \frac{\alpha(e^{RL})\theta(1-\theta)(p_G - p_B)}{B(e^{RL})}q(e^{RL})v + (1-\theta)p_B \frac{C_S(e^{RL},S)}{B(e^{RL})} > or < 0, \quad \text{(B12)}$$

i.e. cross-selling can make bad borrowers either more or less profitable, depending on the relative size of the direct effect to the effect through the interest rate, and

$$\frac{\partial F}{\partial e^{RL}} = \left[(1-\alpha_H)\frac{\partial \eta_G}{\partial r^{RL}} - \beta_H \frac{\partial \eta_B}{\partial r^{RL}}\right]\frac{\partial r^{RL}}{\partial e^{RL}} - |SOC| = \frac{(B')^2}{B(e^{RL})}\frac{\gamma}{pn} - |SOC|$$

which, from equation (A8), can be written as:

$$\frac{\partial F}{\partial e^{RL}} = -\frac{(B')^2(\gamma_0^{RL} - \gamma)}{B(e^{RL})pn} < 0 \text{ for } \gamma < \gamma_0^{RL}. \quad \text{(B13)}$$

Substituting equations (B11) and (B12) in (B10), the numerator of (B9) is given by:

$$\frac{\partial F}{\partial S} = -\frac{\beta_H \theta(1-\theta)(p_G - p_B)}{B(e^{RL})}q(e^{RL})v + \frac{B'C_S(e^{RL},S)}{B(e^{RL})} + A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) > 0$$

$$\text{if } A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) > \frac{\beta_H \theta(1-\theta)(p_G - p_B)}{B(e^{RL})}q(e^{RL})v - \frac{B'C_S(e^{RL},S)}{B(e^{RL})}. \quad \text{(B14)}$$

Finally substituting (B14) and (B13) in (B9) yields equation (15) in the text, which demonstrates Proposition 1 ii).

B.2. Proposition 2

In equation (16) in the text:

$$\frac{B'A(e)-B(e)A'}{[A(e)]^2}=\frac{\beta_H\theta(1-\theta)(p_G-p_B)}{B(e^{RL})}>0 \qquad \text{(B15)}$$

implying that the sign of $dQ(e)/dS$ is determined by the sign of de/dS.

For transaction lending banks:

$$\frac{de^{TL}}{dS}<0\Rightarrow\frac{dQ(e^{TL})}{dS}<0,$$

which demonstrates Proposition 2 i).

For relationship lending banks, holding the conditions of Proposition 1 ii):

$$\frac{de^{RL}}{dS}>0\Rightarrow\frac{dQ(e^{TL})}{dS}>0,$$

which demonstrates Proposition 2 ii).

B.3. Proposition 3

For transaction lending banks differentiating equation (7) in the text with respect to S yields:

$$\frac{dr^{TL}}{dS}=\frac{\partial r^{TL}}{\partial S}+\frac{\partial r^{TL}}{\partial e^{TL}}\frac{de^{TL}}{dS} \qquad \text{(B16)}$$

where:

$$\frac{\partial r^{TL}}{\partial S}=-\frac{A(e^{TL})}{B(e^{TL})}qv<0 \qquad \text{(B17)}$$

is the direct effect of cross-selling on the optimal lending interest rate (negative),

$$\frac{\partial r^{TL}}{\partial e^{TL}}\frac{de^{TL}}{dS}=-\frac{\gamma\beta_H\theta(1-\theta)(p_G-p_B)qv}{(\gamma_0^{TL}-\gamma)B'B(e^{TL})} \qquad \begin{matrix}<0 \text{ if } B'>0\\ >0 \text{ if } B'<0\end{matrix} \qquad \text{(B18)}$$

is the indirect effect of cross-selling on the optimal interest rate (negative or positive: opposite sign with respect to B').

Substituting equations (B17) and (B18) in equation (B16), the overall effect of cross-selling on the optimal interest rate is given by:

$$\frac{dr^{TL}}{dS}=-\frac{(\gamma_0^{TL}-\gamma)A(e^{TL})B'+\gamma\beta_H\theta(1-\theta)(p_G-p_B)}{(\gamma_0^{TL}-\gamma)B'B(e^{TL})}qv<0$$ always if $B'>0$ and for $\gamma<\hat{\gamma}^{TL}$ if

$B'<0$, where $\hat{\gamma}^{TL}\equiv\gamma_0^{TL}\dfrac{A(e^{TL})|B'|}{A(e^{TL})|B'|+\beta_H\theta(1-\theta)(p_G-p_B)}<\gamma_0^{TL}$, $\qquad$ (B19)

i.e. it is unambiguously negative if $B'>0$: an increase in cross-selling reduces transaction lending banks' optimal interest rate because it increases the expected income from selling services to borrowers (direct effect) and because it softens transaction lending banks' incentives to produce soft information, which, in turn, reduces the number of accepted borrowers that are successful (indirect effect); if $B'<0$, the direct effect is still negative (equation (B17)), but the indirect effect becomes positive (equation (B18)): a lower effort in producing soft information increases the number of accepted borrowers that are successful, thus increasing the marginal benefit of an increased interest rate. The sign of the overall effect therefore depends on the relative size of the direct effect to the indirect effect. However the weight of the indirect effect depends on banks' market power: in our specification the

lower γ, the lower banks' market power, the more competitive the market structure, the weaker the indirect effect relative to the direct one.
This proves Proposition 3 i).
For relationship lending banks differentiating equation (11) in the text with respect to S yields:

$$\frac{dr^{RL}}{dS} = \frac{\partial r^{RL}}{\partial S} + \frac{\partial r^{RL}}{\partial e^{RL}} \frac{de^{RL}}{dS} \tag{B20}$$

where, holding the condition of Proposition 1 ii):

$$\frac{\partial r^{RL}}{\partial S} = -\frac{A(e^{RL})}{B(e^{RL})} q(e^{RL})v + \frac{C_S(e^{RL},S)}{B(e^{RL})} < 0 \tag{B21}$$

is the direct effect of cross-selling on the optimal lending interest rate (negative),

$$\frac{\partial r^{RL}}{\partial e^{RL}} \frac{de^{RL}}{dS} = \frac{\gamma}{(\gamma_0^{RL} - \gamma)B'} \left[-\frac{\beta_H \theta(1-\theta)(p_G - p_B)q(e^{RL})v - B'C_S(e^{RL},S)}{B(e^{RL})} + A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) \right]$$

<0 if $B'<0$ (B22)
>0 if $B'>0$

is the indirect effect of cross-selling on the optimal interest rate (negative or positive: same sign as B').
Substituting equations (B21) and (B22) in equation (B20), the overall effect of cross-selling on the optimal interest rate is given by:

$$\frac{dr^{RL}}{dS} = -\frac{(\gamma_0^{RL} - \gamma)A(e^{RL})B' + \gamma\beta_H\theta(1-\theta)(p_G - p_B)}{(\gamma_0^{RL} - \gamma)B'B(e^{RL})} q(e^{RL})v + \frac{\gamma_0^{RL} C_S(e^{RL},S)}{(\gamma_0^{RL} - \gamma)B(e^{RL})} +$$

$$+ \frac{\gamma[A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S)]}{(\gamma_0^{RL} - \gamma)B'} < 0$$ always if $B'<0$ and for $\gamma < \hat{\gamma}^{RL}$ if $B'>0$, where

$$\hat{\gamma}^{RL} \equiv \gamma_0^{RL} \frac{\frac{A(e^{RL})B'q(e^{RL})v}{B(e^{RL})} - \frac{B'C_S(e^{RL},S)}{B(e^{RL})}}{\frac{A(e^{RL})B'q(e^{RL})v}{B(e^{RL})} + A(e^{RL})q'(e^{RL})v - C'_S(e^{RL},S) - \frac{\beta_H\theta(1-\theta)(p_G - p_B)q(e^{RL})v}{B(e^{RL})}} < \gamma_0^{RL} \tag{B23}$$

i.e. it is unambiguously negative if $B'<0$: both the direct and the indirect effects are negative implying that an increase in cross-selling reduces relationship lending banks optimal interest rate because it increases the expected income from selling services to borrowers and reduces the total cost of producing soft information (direct effect) and because it strengthens relationship lending banks' incentives to produce soft information, which, in turn, reduces the number of accepted borrowers that are successful, thus lowering the marginal benefit of an increased interest rate (indirect effect); if $B'>0$, the direct effect is still negative (equation (B21)), but the indirect effect becomes positive (equation (B22)): a higher effort in producing soft information increases the number of accepted borrowers that are successful, thus increasing the marginal benefit of an increased interest rate. The sign of the overall effect therefore depends on the relative size of the direct effect to the indirect effect. Again for sufficiently low banks' market power ($\gamma < \hat{\gamma}^{RL}$) the direct effect is greater than the indirect one.
This proves Proposition 3 ii).

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