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Information Technology and Financial Services Competition

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Abstract

We analyze how two dimensions of technological progress affect competition in financial services. While better technology may result in improved information processing, it might also lead to low-cost or even free access to information through, for example, informational spillovers.In the context of credit screening, we show that better access to information decreases interest rates and the returns from screening. However, an improved ability to process information increases interest rates and bank profits. Hence, predictions regarding financial claims' pricing hinge on the overall effect ascribed to technological progress. Our results generalize to other financial markets where informational asymmetries drive profitability, such as insurance and securities markets.

INTRODUCTION

Informational considerations have long been recognized to determine not only the degree of competition but also the pricing and profitability of financial services and instruments. However, recent technological progress has dramatically affected the production and availability of informa- tion, thereby changing the nature of competition in such informationally sensitive markets. This paper investigates how advances in information technology affect competition in the financial ser- vices industry, in particular, credit, insurance and securities markets.[1] We focus on two aspects of improvements in information technology: better processing and easier dissemination of informa-tion.[2]

To fix ideas and illustrate the basic intuition, we formulate our model in the context of credit market competition. In our model, differentially informed financial intermediaries compete for borrowers of varying credit quality. These intermediaries can obtain a privately informative signal by conducting credit assessments whose success depends on the state of the information technologyand the effort expended in gathering and interpreting borrower-specific data.[3] We show that the two dimensions of technological progress, as defined by advances in the ability to process and evaluate information, and in the ease of obtaining information generated by competitors, can have very different impacts on the competitiveness of lending markets.

In situations where banks have established business relationships with borrowers, our model delivers sharp predictions. We find that advances in information technology that improve the ability to *process* information make markets less competitive. This decrease in competition occurs because such improvements widen the informational gap between competitors who invest resources in gathering information and those who do not. Consequently, informed intermediaries obtain higher rents as a result of technological progress and informationally captured borrowers suffer through higher interest rates. Moreover, as returns to processing information increase, banks exert more effort in this direction, compounding the original impact of technological change.

At the same time, technological progress also facilitates the dissemination of information. Other market participants may freely observe part or all of any information collected so that second-hand *access* to proprietary information becomes less costly or even free.[4] We show that easier access to information levels the playing field for competitors and erodes banks' rents, helping borrow- ers avoid informational capture by informed intermediaries. Faster dissemination of information increases competition among lenders and benefits borrowers through lower interest rates. Informa- tional spillovers, however, by decreasing the returns to acquiring information, also decrease banks' incentives to screen borrowers and gather information.

We also allow for competition between banks to establish business relationships. We find that, for a wide set of parameter values, our earlier results concerning improved information processing carry over to situations where intermediaries compete to be an informed lender. Specifically, we show that as long as the information obtained by lenders is not too accurate, technological progress raises the expected interest rates for borrowers. Hence, even such *ex ante* competition between banks does not necessarily imply that all gains from technological progress will be passed along to customers in the guise of lower borrowing costs.

Our results suggest that technological advances have the potential to undermine property rights over information. If so, intermediaries may find it worthwhile to invest resources in asserting these rights. Hence, we extend our model to consider efforts by an information-gathering intermediary to protect its proprietary intelligence. We show that, if outside access to private information is not too widespread, technological advances lead to more effort being spent on decreasing spillovers and preventing expropriation of information. However, when property rights over private information are very weak, further advances will erode bank profits to a point where intermediaries reduce both screening and spillover prevention effort.

We apply our model to insurance and securities markets and find the same effects of technological improvements at work. For example, who most benefits from the wider availability of information through the new SEC regulation Fair Disclosure depends on the ability to obtain and process

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company-specific facts. Hence, our results show that predictions regarding IT's impact on financial service providers and their customers, for a variety of markets, largely depend on the overall effect ascribed to the technological progress.[5] It is often claimed that technological progress is likely to erode intermediaries' profits and force them to alter their business strategies.[6] To the extent that improvements in information technology level the playing field among competitors, this prediction may be true. However, we point out that other types of improvements may further increase the informational gap between competitors and yield very different predictions.

To our knowledge, the impact of information technology on the incentives to collect and pro- cess information in financial markets has been little studied. Instead, the debate has traditionally focused on the consequences of insider trading (Diamond, 1985, Fishman and Haggerty, 1992) or, more recently, on the type of information to disclose (Boot and Thakor, 2001). While the latters' focus is on the kind of information disclosed rather than incentives to collect and process infor- mation, their analysis nevertheless shows the importance of access to and diffusion of information in financial markets. Yosha (1995) and Bhattacharya and Chiesa (1995) are among the first to consider information spillovers as a consequence of disclosure. However, in their models the in- formation externality benefits the firm's competitors and is, therefore, harmful. In our analysis, informed investors generate a positive information externality that benefits other investors. Hence, our focus is on the collection of relevant information rather than its supply.

In addition to the analysis of the issues raised above, one of our main contributions is the development of a simple, tractable model of competition under asymmetric information. Whilewe limit our focus to the consequences of changes in the information-gathering technology, we believe that the simple expressions this model delivers can be easily adapted to the study of related.

topics. The theoretical treatments closest to our own are Rajan (1992), von Thadden (1998), and Hauswald and Marquez (2000). Rajan (1992) analyzes how information advantages generate rents for incumbent banks, while von Thadden (1998) investigates the degree to which borrowers might be captured by their inside bank. Neither paper, however, analyzes how changes in the technology for acquiring information affects the competitive nature of lending markets. Hauswald and Marquez (2000) study intermediaries' incentives to allocate information-gathering resources across different markets, but do not address improvements in their ability to gather information.

Petersen and Rajan (2000) provide evidence on the consequences of technological progress in credit markets. They find that the physical distance between banks and borrowers has increased over the last two decades, and attribute this phenomenon to improvements in banks' ability to collect and process large amounts of "hard" information. However, their results are also consistent with improved networks for the transmission of such information, allowing banks to obtain infor- mation gathered about borrowers located farther away, and to compete for these borrowers. Hence, it is likely that both aspects we highlight in this paper are at work. Their simultaneous presence may explain why there has been improved availability of credit but ambiguous implications for the pricing of loans.

The paper proceeds as follows. In Section 1, we describe the theoretical framework and carry out some preliminary analysis. Section 2.1 characterizes the impact of an improvement in infor- mation processing ability. Section 2.2 contrasts the previous results to those obtained if, instead, information creates a positive externality for other lenders. In Section 3, we discuss extensions to the basic model and endogenize the information acquisition decision. Section 4 applies our results to insurance and securities markets and discusses determinants of the state of information technology. Section 5 concludes. Most of the proofs are relegated to the Appendix.

1 A Model of Lending Competition

Description of Model

Let there be a continuum of borrowers of measure 1. Each potential borrower has an investment project that requires an initial outlay of \$1 and generates a terminal cash flow X. This cash flow

X can be an amount R with probability p_ϑ and 0 with probability $1 - p_\vartheta$, where $\vartheta \in \{l, h\}$ denotes

the borrower's type. We assume that the success probability for the borrower with the better investment opportunity is higher: $p_h > p_l$. Final cash flows are observable and contractible, but borrower type ϑ is unknown to either borrower or lender.[7] The probability that a borrower is of high quality is q and this distribution of borrower types is common knowledge. We also assume that borrowers have no private resources, and that $p_lR < 1 < p_hR$, so that it is efficient to finance

good borrowers but not bad ones. Moreover, letting $p \equiv qp_h + (1 - q)p_l$ denote the average success

probability, we assume that $pR > 1$, so that it is *ex ante* efficient to grant a loan.

Two banks compete for borrowers in this market. We will refer to the first intermediary as the *inside* or informed bank because it has access to a screening technology φ that generates borrower- specific information. The other intermediary, which we call the *outside* bank, does not have access to such technology and, therefore, remains uninformed.[8] Screening of borrowers leads to better credit assessments that provide the inside bank with an informative signal about a borrower's type. In particular, loan screening yields a signal $\eta \in \{l, h\}$ about the borrower's repayment probability, with the probability of successful and erroneous credit assessments given by, respectively,

Technological Progress in Credit Markets

In this section, we analyze the consequences of improved information processing and easier access to information on credit markets and discuss some empirical implications of our results.

Improvements in Information Processing

Having characterized the equilibrium in the screening and lending game, we next study the impact of

The above result can lead to the perverse outcome that easier access to information, by pre- venting banks from profiting from previously private information, results in less borrower screening. Hence, markets could potentially become less efficient to the extent that information acquisition is beneficial: less precise information in the wake of its faster dissemination may lead banks to turn down more high-quality loan applicants. This observation is particularly true if, as suggested below, the amount of information that spills out depends on how much was gathered in the first place.

We should also emphasize that we are only analyzing situations where information advantages over competitors generate rents for the bank. There may, however, be situations where the in- centives of the intermediary are aligned with those of its client, so that the release of information might be beneficial. An example can be found in the underwriting of public equity offers. Here, an investment bank may prefer to disclose information it has gathered about its client in order to lower investors' information asymmetries and obtain a higher price for the equity issue.[10]

Implications for Financial Services

While we think of improved information processing and easier access to information as two different dimensions of technological progress, they might simultaneously be present in practice. In recent years, we have seen dramatic increases in both the ability to process information as well as the ease with which information can be transmitted. Which effect is likely to dominate depends on the specific circumstances and the market in question, as well as the relative magnitudes of these changes. Whenever the ability of clients to disseminate information increases, we would expect competition to become more intense as intermediaries in those markets operate on a more level playing field. Conversely, when most of the progress lies in the use of computing and processing equipment, e.g., for proprietary pricing, risk assessment or credit scoring models, we should expect the gulf between those who are informed and those who remain uninformed to increase. Determining which effect is more important is an empirical matter.

There is a second, more subtle reason why disentangling these two effects may prove delicate.

While we have treated $\boldsymbol{I}$ and t as distinct, it seems plausible that much of the information that spills over is second hand and depends on the amount of privately generated information, which is a function of both the state of information technology $\boldsymbol{I}$ as well as the effort spent on acquiring and processing information. This effect can be captured by allowing the quality of the publicly observed signal, φ_p, to be an increasing function of φ, the quality of the privately generated signal. In our reduced form model, we could equivalently assume that the spillover parameter t is a function of the variables that define the amount of information generated, i.e., $t = t(Ie)$. More stringent disclosure standards for both publicly quoted firms (SEC's Regulation Fair Disclosure), or borrowers and lenders (credit bureaus, regulatory disclosure) might justify this specification.[11]

Improvements in information technology now have a direct and indirect effect on the informed intermediary's informational advantage: $\frac{d\varphi}{dt} = \frac{\partial\varphi}{\partial t} + \frac{\partial\varphi}{\partial I}\frac{\partial I}{\partial t}$. Since the direct effect is positive and $\frac{\partial\varphi}{\partial I}$ is negative, the indirect effect reduces the competitive advantage from information process- ing improvements through spill-overs $\frac{\partial I}{\partial t} > 0$. While it is unlikely that the indirect effect would dominate, intermediaries may not be able to fully appropriate the gains from improved processing ability. Moreover, there is a similar effect stemming from increases in effort, in that part of the in- creased proprietary information generated may also dissipate with the public signal ($\frac{\partial I}{\partial t} > 0$). Taken together, these effects could further reduce the incentives for intermediaries to spend resources on generating information.

While an empirical examination of the two effects' relative magnitudes is beyond the scope of this paper, our analysis offers some testable implications for such an endeavor. In particular, we would expect increasing information technology investments in markets with captive customers such business lending to be accompanied by rising loan rates *ceteris paribus*. At the same time, one should observe more dispersed loan pricing[12] and an expanded customer base, as conjectured by Emmons and Greenbaum (1998). Conversely, financial markets characterized by spillovers and wider information dissemination initiated by regulation or customers should exhibit less disperse and falling prices as information technology improves (e.g., securities underwriting: see Wilhelm,

Extensions and Generalizations

This section extends our model in several dimensions. We first consider efforts by the inside bank to prevent informational spillovers and protect its proprietary information. We then endogenize a banks' decision to become an inside lender.

Preventing Expropriation of Information

In our model, intermediaries face the threat that they cannot fully appropriate the gains from customer-specific informational investments. In practice, we would expect banks to react to tech- nological advances that undermine their property rights over information by exerting effort to protect these rights. In their analysis of the public good aspects of private information in banking, Anand and Galetovic (2000) show how repeated interaction can lead to self-enforcing agreements by intermediaries not to poach private information, nor the human capital behind it. In this section, we focus on actions that intermediaries can take to directly protect their investments in the gener- ation of information, and provide an alternative channel for intermediaries to assert their property rights over information.[13]

Suppose that, in addition to the effort e spent on generating information, the inside bank can exert costly effort $\tilde{e} \in [0, 1]$ to prevent information leakage or expropriation. Such effort might include signing and enforcing confidentiality agreements with clients and employees, building secure systems and firewalls, and taking legal action against competitors to protect intellectual property. Let the spillover variable $t \geq 1$ be given by

the effect stemming from the *ex post* monopoly dominates. When the probability of screening is high, however, increased competition among informed lenders forces intermediaries to pass on the benefits of improvements in information technology to customers, and interest rates fall.

Equation (7) indicates that a broad range of parameter values yields low screening probabilities σ. For instance, high screening costs c deter either bank from acquiring information because duplicated screening is then very costly. Hence, we can restate Proposition 5 in terms of effort cost: there exists a value $0 < \tilde{c} < E[\pi(\eta)]$ such that increases in I lead to rising interest rates if and only if $c > \tilde{c}$. Similarly, we see that low values of I translate into low screening probabilities because profits from information acquisition are correspondingly low (Proposition 1). Initial improvements in information processing now imply higher expected interest rates as banks begin to make use of their informational advantage. Only as information processing becomes very efficient (high I) does information duplication translate into competitive gains for borrowers.

Finally, it should be noted that *ex ante* expected profits for both banks are zero in this mixed- strategy equilibrium. Hence, we might expect that most of the benefits from technological im- provements are passed on to customers as banks compete away their rents. However, this setting is most likely to apply to banks either entering new markets or serving new customers. Once business relationships are established, it is unlikely that the benefits to an inside bank of any subsequent technological improvements will be entirely bid away because we are, once again, in the *ex post* monopoly setting of the previous sections. Hence, the mixed strategy equilibrium from Proposition 5 probably applies best to situations where no intermediary has a market presence, whereas Section

2.1 covers the case of technological progress in established markets.

Applications and Discussion

Improvements in information technology also affect other financial markets so that we now gener- alize our model and present examples from the insurance and securities industries. We also discuss determinants of the information technology state variables in light of our results. $^{\rho}$

nsurance

Medical and computer science advances have given rise to new data storage and risk assessment technologies that allow much more detailed insurance classifications. Examples of this trend can be found in the advent of genetic screening and the computerization of medical records. To study their impact, consider differentially informed insurance companies that compete for customers of low or high risk type $\vartheta \in \{l, h\}$. Outcomes (losses) for policy holders can be $X = -V$ with probability p_ϑ and $X = 0$ with complementary probability. Insurance companies compete in loss payouts v per $1 of premium income.[15] All our earlier results carry over but the conclusions of Propositions 2 and 3 are reversed: expected payout rates decrease in the state of information technology I and increase in t. As improvements in information processing lead to lower payout rates and higher profitability for informed insurers, their screening effort increases and policy holders become informationally more captured. However, much of the data collected by insurance and related companies routinely finds its way into the public domain, too. In the presence of significant informational spillovers, insurance customers benefit and we would expect payout rates to rise and insurer profitability to fall with technological progress.

Underwriting Securities

The recently adopted SEC Regulation Fair Disclosure (FD) bars the selective dissemination of non- public information by listed companies. As a result, publicly quoted companies have started to use electronic news media (internet) to disclose much more information and, especially, more detailed financial (statement) information to investors.[16] To illustrate the consequences of Regulation FD in the context of our model, suppose that a firm of unknown quality $\vartheta \in \{l, h\}$ is going public. Institutional (informed) as well as less informed (retail) investors bid for a dollar amount s in the firm.[17] The market agrees that the firm is worth $X = S > 0$ with probability p_ϑ and $X = 0$

otherwise.

By Propositions 2 and 3, the value of cash flow rights to informed investors such as large mu- tual funds or investment banks increases in the state of information technology I, but decreases in information dissemination t. Since the latter prevents informed investors from fully appropriating the gains from screening, such an improvement raises IPO prices and diminishes information rents because of a reduction in the winner's curse. This result shows how technology can also be respon- sible for the "crowding out effects" demonstrated by Diamond (1985) or Fishman and Haggerty (1992) in the context of insider trading. As spillovers reduce the informed investors' informational advantage, their incentives to gather costly information fall.

Determinants of the State of Technology

Our analysis shows how economic factors such as borrower heterogeneity, screening cost, competi- tion in information acquisition, and the state of information technology determine the intermedi- aries' optimal choice of screening and leakage prevention efforts ϵ and $\tilde{\epsilon}$ through their impact on bank profitability. Throughout, we have treated I and t as information technology state variables so that banks view them as exogenously given when choosing their effort levels and lending strategies. However, these variables, while fixed at any moment in time, constantly evolve, which is consistent with our focus on how changes in these variables affect credit markets. Here, we discuss how certain underlying economic factors might drive the evolution of these state variables over time.

Intermediaries themselves may be leaders in the development of new information processing capabilities (e.g., development of credit scoring systems, the next generation of IT in financial services. At the very least, financial intermediaries create a market for information technology (storage, processing, dissemination) and generate a large part of the demand for such improvements that, in turn, may lead to greater profits. Hence, there is a compounding effect in the development of information processing ability: improvements (increases in I) raise the profits of banks that make use of technological progress, which then provides greater resources for the further development of such technologies. The upshot is a cycle where initial improvements and early adoption may translate into significant IT improvements through higher profitability as intermediaries allocate more resources towards R&D.

These feedback effects between informational rents and IT development might be intensified by other economic factors that reinforce the use of technology. For example, as we point out in Section 3.1, greater borrower heterogeneity Δ_p leads to greater screening effort as credit assessments become more important when borrowers are more dissimilar. From equation (6) we also see that $\frac{\partial^2 E[\pi_i(\eta)]}{\partial \Delta_p \partial I} > 0$, so that technological improvements have a greater impact when borrower heterogeneity is high. Hence, we might expect to see more resources being devoted to the development of improved processing technology when the return to doing so is higher, which is precisely when borrowers have widely divergent characteristics.

Conclusion

In our analysis of how changes in the state of information technology affect financial markets, we differentiate between two possible effects. One aspect of technological progress is that financial ser-vice providers can better process information. In this scenario, resources invested towards gathering and analyzing information become more productive as processing ability improves. Consequently, an advance in information technology increases the informational advantage of intermediaries that gather information relative to competitors who remain uninformed. As the scope for information rents improves, financial markets ultimately become less competitive. In the context of credit markets, for example, this translates into higher interest rates for borrowers.

A competing view holds that improved access to information makes data much more widely and readily available. Proprietary information gathered by one intermediary quickly disseminates to its competitors. An improvement in information technology that generates spillovers has the opposite implications to one that affects processing ability. Improved access to information or greater information leakage erodes informational advantages and serves to level the playing field for all market participants. The net result is that markets may become more competitive so that customers benefit from technological progress.

In practice, one would expect both aspects of

advances in information technology to affect financial services competition. While determining the importance of each effect is an empirical question, this paper suggests that advances in information technology need not necessarily be ben-
eficial for customers. Hence, it is important to carefully identify the relevant type of technological improvement one has in mind for any analysis of its expected consequences.
While there are other aspects of technological progress that might be of relevance to the study of competition and price formation in financial services, we believe that our model can easily be adapted to a more general analysis of competition under asymmetric information. For example, Rajan (1992) argues in the context of credit markets that the potential for information monopoly on the side of a lender may lower a borrower's incentive to exert effort. Padilla and Pagano (1997) show how information sharing, i.e., voluntary informational spillovers, can mitigate such effort problems. Our specification might be useful in this context to analyze the incidence of technological progress which, however, is beyond the scope of this paper.

Proof of Proposition 1 (Sketch). For a proof of the nonexistence of a pure strategy equilibrium in a similar framework, see von Thadden (1998) or Hauswald and Marquez (2000). A mixed strategy equilibrium over interest rate offers does, however, exist. The above papers show that the equilibrium distribution functions, F_i and F_u, are continuous and strictly increasing over an interval $[\underline{r}, R)$. Moreover, it is a standard result in models of competition under asymmetric information that a bidder, all of whose information is known by some other competitor, cannot make positive expected profits (see, e.g., Engelbrecht-Wiggans et al., 1983). Therefore, we can conclude that the uninformed lender must make zero expected profits in equilibrium.
To calculate profits for the informed bank, we proceed as follows. Define π_u as the expected profits to the uninformed bank. Since the uninformed bank must make zero profit for every one of its possible bids, it must make zero profits also at the lowest possible bid, $\underline{r}$. Offering that rate must guarantee the uninformed bank of having the lowest rate and winning the interest rate auction.
Hence, $\pi_u(\underline{r}) = 0 \Leftrightarrow \underline{r}\bar{p} - 1 = 0 \Rightarrow \underline{r} = \frac{1}{\bar{p}}$.
Upon observation of a low signal ($\eta = l$), the informed
bank abstains from making a loan offer and its profits are $\pi_i(l) = 0$.[18] However, upon observing a high signal ($\eta = h$), the informed bank bids and obtains expected profits

Note that, in equilibrium, all its loan offers conditional on a high-quality credit assessment yield the same profit. The calculation of *ex ante* expected profits as stated in the proposition then follows directly by substituting for $\pi_i(l) = 0$ and $\pi_i(h)$ from the above expression, and simplifying.
Finally, the calculation of the distribution functions can be obtained by solving the following
expression for expected profits, where $\pi_i(r, h)$ represents the profits to an informed bank of bidding

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