Juha-Pekka Niinimäki – Tuomas Takalo – Klaus Kultti

The role of comparing in financial markets with hidden information

SUOMEN PANKKI • FINLANDS BANK •
EUROJÄRJESTELMÄ
EUROSYSTEMET

Bank of Finland Research
Discussion Papers
1 • 2006

Suomen Pankki
Bank of Finland
P.O.Box 160
FI-00101 HELSINKI
Finland
☎ + 358 10 8311

http://www.bof.fi

Bank of Finland Research
Discussion Papers
1 • 2006

Juha-Pekka Niinimäki* – Tuomas Takalo** – Klaus Kultti***

The role of comparing in financial markets with hidden information

The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

* Department of Economics, Helsinki School of Economics, juha-pekka.niinimaki@hse.fi
** Monetary Policy and Research Department, Bank of Finland, tuomas.takalo@bof.fi
*** Department of Economics, University of Helsinki, klaus.kultti@helsinki.fi

We thank Bengt Holmström, Ari Hyytinen and participants in several seminars for helpful comments. The paper was partly written while Takalo was visiting IDEI, Toulouse. Financial support from Jenny and Antti Wihuri Foundation and Yrjö Jahnsson Foundation is gratefully acknowledged.

http://www.bof.fi

ISBN 952-462-256-4
ISSN 0785-3572
(print)

ISBN 952-462-257-2
ISSN 1456-6184
(online)

Multiprint Oy
Helsinki 2006

The role of comparing in financial markets with hidden information

Bank of Finland Research
Discussion Papers 1/2006

Juha-Pekka Niinimäki – Tuomas Takalo – Klaus Kultti
Monetary Policy and Research Department

Abstract

This paper studies how comparing can be used to provide information in financial markets in the presence of a hidden characteristics problem. Although an investor cannot precisely estimate the future returns of an entrepreneur's projects, the investor can mitigate the asymmetric information problem by ranking different entrepreneurs and financing only the very best ones. Information asymmetry can be eliminated with certainty if the number of compared projects is sufficiently large. Because comparing favours centralised information gathering, it creates a novel rationale for the establishment of a financial intermediary.

Key words: asymmetric information, banking, corporate finance, financial intermediation, ranking, venture capital

JEL classification numbers: G21, G24

Rahoitusmarkkinoiden rahoituksenhakijoiden vertailu

Suomen Pankin tutkimus
Keskustelualoitteita 1/2006

Juha-Pekka Niinimäki – Tuomas Takalo – Klaus Kultti
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tutkimuksessa esitetään uusi argumentti sille, miksi rahoituksenvälitys ja pankkitoiminta ovat syntyneet ja miksi nämä toimialat ovat usein keskittyneitä. Argumentti perustuu mahdollisuuteen vertailla yrittäjiä ja muita rahoituksen tarvitsijoita. Yksi keskeinen tunnettu peruste rahoituksenvälityksen syntymiselle on epäsymmetrinen informaatio yrittäjien ja rahoittajien välillä. Ajatellaan, että rahoituksenvälittäjät voivat yksittäisiä rahoittajia paremmin arvioida yrittäjien laatua investoimalla riskienhallintatekniikkaan. Aikaisemmissa tutkimuksissa ei ole kuitenkaan otettu huomioon mahdollisuutta vertailla erilaisia yrittäjiä. Vertailemalla rahoituksenhakijoita rahoituksenvälittäjä voi laittaa hakijat paremmuusjärjestykseen ja rahoittaa vain parhaita. Tämä vähentää ja saattaa jopa kokonaan poistaa epäsymmetrisestä informaatiosta aiheutuvia ongelmia ja siten esimerkiksi vähentää merkittävästi pankkien luottotappioita.

Avainsanat: epäsymmetrinen informaatio, rahoituksenvälitys, pankkitoiminta, yritysrahoitus, pääomasijoittaminen.

JEL-luokittelu: G21, G24

Contents

1 Introduction

Asymmetric information has long been recognised as a key problem in financial markets (Stiglitz and Weiss, 1981; de Meza and Webb, 1987). There are several means by which outside investors can mitigate the adverse effects of asymmetric information: ex ante monitoring (Broecker, 1990), interim and ex post monitoring (Holmström and Tirole, 1997; Diamond, 1984), collateral requirements (Bester, 1985) and long-term lending relationships (von Thadden, 1995).[1] It is widely felt that the need for such things in the credit markets can explain the existence of financial intermediaries. The analysis is extended in this paper, which explores how comparing funding applicants can help to mitigate – even eliminate – the asymmetric information problem in financial markets, and how this benefit of comparing is conducive to centralised financial intermediation.

What does ex ante monitoring mean in the context of financial markets? Theory suggests that outside investors ought to gather comprehensive information on each entrepreneur or firm applying for funding and on their projects. For example, the skills and experience of the entrepreneur or firm's management, the quality of the business plan, the tangible and intangible assets, the market potential of the products, and the cost efficiency should all be examined in detail. Based on this information, investors can evaluate the expected returns of the funding applicant's projects. If the returns seem to be high enough, investors can provide finance at appropriate (risk-based) pricing. It is, however, not easy to assess expected returns precisely or to price risks correctly. In particular, in new markets where investors have little, or no, prior experience and entrepreneurs' assets are intangible, it is virtually impossible to make precise evaluations. In more familiar sectors, finance for new entrepreneurs with no track record is difficult to price. Even if entrepreneurs or firms seeking outside finance are well known to the investors, rapid changes in the economic environment may hamper the rating of applicants and hence their funding.

In this paper we argue that investors can overcome the difficulties in ex ante monitoring by ranking the entrepreneurs. Although investors are unable to accurately estimate expected returns from an entrepreneur's projects, they can compare the entrepreneurs, choose the very best, and finance their projects. These projects will succeed with above-average probability. Hence comparing enables investors to gather valuable information and thereby to boost their investment yields. Moreover, if an investor compares sufficiently many entrepreneurs, the asymmetric information problem will be eliminated with certainty.

As an example, consider 10 *de novo* entrepreneurs from the same narrow high-tech sector. Such entrepreneurs typically have fresh prototype products, their

[1] Freixas and Rochet (1997) and Gorton and Winton (2003) provide thorough surveys of this literature.

primary assets consist of human capital and intellectual property rights, and they lack funds for the investments required to commercialise the prototypes. Any outside investor will certainly find it a demanding task to assess the value of a prototype, its expected sales revenues, marketing strategy and ability of entrepreneurs, and so on. However, if the investor would contact each of the 10 firms and investigate their prototypes, intellectual property portfolios, and entrepreneurial talent and then compare these, she may discover crucial differences between entrepreneurs' business plans. The investor can rank the entrepreneurs and finance only the best ones. As a result, the investor can be quite confident that the best entrepreneurs' products and plans are of sufficiently high quality that the entrepreneurs will be able to repay the funding.

To benefit from comparing, however, an outside investor needs to evaluate numerous entrepreneurs, even if she can finance only one. With multiple investors operating in isolation, each entrepreneur is evaluated and compared several times. This duplicates the costs of information gathering. Wasteful duplication could be avoided if the investors joined together to establish a financial intermediary, which would evaluate each funding applicant, compare and rank them, and finance only the best ones. Each applicant is evaluated only once, and inefficient duplication is eliminated. Consequently, comparing creates a novel rationale for centralised financial intermediation and delegated information gathering. In this respect our paper is related to the literature on the role of asymmetric information in explaining financial intermediaries. Beyond the seminal contribution by Leland and Pyle (1977), our argument is closely related those of Diamond (1984), Ramakrishnan and Thakor (1984), and Boyd and Prescott (1986). As in these papers, a major advantage of forming a financial intermediary in our model is to reduce monitoring costs. Another advantage is information production in the sprit of Ramakrishnan and Thakor (1984) and Boyd and Prescott (1986). Finally, our intermediary engages in asset transformation as in Diamond (1984) and Boyd and Prescott (1986). Our work thus adds to the long string of literature that extends the basic insights on financial intermediaries as delegated monitors and information gatherers into various dimensions (see, eg Krasa and Villamil, 1992, Winton, 1995, Cerasi and Daltung, 2000, Hellwig, 2000, and Niinimäki, 2001).

Although the intermediary emerging from our analysis is bank-like and we treat entrepreneurs seeking outside finance as loan applicants, most of the analysis deals with a single investor and need not specify the form of the financial contract. Moreover, the benefits of comparing are most evident in the finance of new ideas in new markets, where debt contracts are less predominant. Our paper therefore touches the literature on entities that finance innovation such as private equity and venture capitalists (for an authoritative survey of venture capital finance, see Gompers and Lerner, 2004). In particular, our study sheds light on the question of why and how venture capitalists benchmark their projects as in Bergemann and Hege (2002). In contrast to Bergemann and Hege (2002), which emphasises the value of benchmarking and staggered project finance in alleviating moral hazard, project comparison in our model provides benchmarks that mitigate the hidden information problem.

Another connection with the works of Bergeman and Hege (1998, 2002) is that comparing can be seen as a special form of costly learning or experimentation in financial markets. Although comparing mitigates the asymmetric information problem, it is costly, since an investor must monitor numerous funding applicants to gather information. Thus the investor has to weigh the opportunity cost of comparing against the future informational benefits, as in the theory of experimentation. The key difference versus the learning and experimentation literature is that information derived by comparing exploits the differences between funding applicants and does not require observations on the same applicant over time. Indeed, in our model no additional information is gained by observing the same applicant more than once.

The paper is organised as follows. In sections 2–3 we develop the main ideas and present the costs and benefits of comparing using a simple model with one investor and at most two entrepreneurs. In section 4 we consider a more general environment where the number of potential entrepreneurs can increases without bound. In section 5 we allow for multiple investors and show how comparing can explain the existence of financial intermediaries. Section 6 concludes.

2 The economy

2.1 Financial market participants

In the basic model there are, $N \in Z^+$, risk-neutral entrepreneurs and one risk-neutral investor. In section 5 we allow for multiple investors. The entrepreneurs lack funds, but each has a project that requires a fixed start-up investment of unit size. The funding can be obtained from the investor (she), who has a unit of capital but no project of her own. The project of an entrepreneur (he) is good with probability g and bad with probability $1-g$. Project quality is the private information of entrepreneurs and, without risk of confusion, we refer to good and bad entrepreneurs. A good project yields a transferable income Y with certainty, and a bad project only generates a non-transferable private benefit B to the entrepreneur.

We assume that *contacting* an entrepreneur is costly. This cost, denoted by c, includes, eg, the costs of waiting or searching for an entrepreneur, evaluating and monitoring his project, making the funding decision, and writing the funding contract or informing of the rejection of funding application. The cost occurs when the investor contacts and monitors an entrepreneur, and it cannot be avoided. A contact provides an informative signal about the entrepreneur's type, which will be specified in the next subsection.[2]

Since there is only one investor we assume, without loss of generality, that the investor has full bargaining power. Besides simplifying the analysis, the assumption is convenient when we look more closely at the benefits of centralised financial intermediation with multiple investors in section 5, since the assumption implies that investors have no incentive to form a financial intermediary to gain market power. The assumption also means that the form of financial contract is indeterminate: the investor can seize the output of a good project by driving the entrepreneur to the zero profit level. In anticipation of the discussion of financial intermediation in section 5, we refer to entrepreneurs as loan applicants, in which case the loan interest rate is Y. It is assumed that $Y - r - c > 0$ where $r \geq 1$ denotes the economy's risk-free interest rate (investor's opportunity cost). Hence a good project has a positive net present value. In contrast, a bad entrepreneur is assumed to have a project with negative net present value, ie, $B - r < 0$.[3]

2.2 Signals

Upon contacting an entrepreneur, the investor receives an informative signal on the entrepreneur's type. The signal can originate from any information reflecting profitability of the entrepreneur's project and can take any of three values: s_1, s_2, and s_3. Besides entrepreneur's type, the value of a signal depends on the state of the world:

- With probability h, the state of the world is *high*, in which case a good entrepreneur's signal is invariably s_1 and a bad entrepreneur's signal is invariably s_2.

- With probability $1 - h$, the state of the world is *low*, in which case a good entrepreneur's signal is invariably s_2 and a bad entrepreneur's signal s_3.

It is instructive (but not necessary) to assume that $s_1 > s_2 > s_3$. Then an average signal is high in a high state of the world and low in a low state of the world. For simplicity, we do not allow the state of the word to affect the project return but

[2] Although we believe that unavoidable contacting and monitoring costs are empirically relevant, the assumption is essentially a short-cut. We could have regarded c as a signal extraction expense and assumed that it can be avoided but only at the cost of not receiving the signal. This would have complicated the analysis by adding one layer to the decision problem of the investor but would not qualitatively have changed the main results.

[3] Strictly speaking we do not need the assumption that $B < r$, but it is more appropriate to label entrepreneurs bad if their projects have negative net present value.

only the value of the signal. Because a good entrepreneur cannot emit the signal s_3 and a bad entrepreneur cannot emit s_1, the signals s_1 and s_3 are perfectly informative in that they fully reveal both the state of the world and type of loan applicant. Signal s_1 tells the investor that the state of the world is high and the entrepreneur is good. Similarly, signal s_3 says that the state of the world is low and the entrepreneur is bad. In sum, after observing either s_1 or s_3, the investor operates under perfect information.

Signal s_2 is more interesting. It indicates a bad entrepreneur in a high state of the world or a good one in a low state. Although the investor can use the signal s_2 to update her prior beliefs about the state of the world and entrepreneur's type, asymmetric information remains after observing such a signal. If the first loan applicant emits s_2, the investor must accept or reject the application without knowing the entrepreneur's type or she can gather more information by contacting another entrepreneur and comparing him with the first one. If the second entrepreneur emits s_1, the state of the world is necessarily high and the investor knows that the first entrepreneur is bad and the second entrepreneur is good. If the second entrepreneur emits s_3, the investor knows that the state of the world is low, the first entrepreneur is good and the second is bad. In such cases we assume that the investor can return to the first entrepreneur and grant him a loan. Thus if the signal of the second loan applicant is s_1 or s_3, the asymmetric information is eliminated and the investor can make her lending decision under perfect information.

If the second applicant also emits s_2, we still have asymmetric information. However, even in this case, seeking a second loan applicant and comparing with the first yields useful information, since the investor can update her beliefs about the state of the world and entrepreneur's type. Thus, although the investor still must make a lending decision under asymmetric information, she is better informed. Based on the new information, the investor can decide whether to grant a loan to either of the two contacted entrepreneurs, search for a third one, or not to lend. Since contacting a new loan applicant is costly, the investor encounters an optimal stopping problem each time she receives the signal s_2.

In sum, the signalling technology builds on two key properties. First, each signal is informative. Second, it is more informative to compare several entrepreneurs than just to observe the same entrepreneur over time. The second property follows from our assumption that signals can vary according to the state of the world. We could avoid signal variation by assuming that a single signal is uninformative except if compared to other signals. Although such an assumption would simplify the analysis, it would be highly unrealistic. On the contrary, it is easy to cite examples where signals depend on the state of the world:

- Business cycles distort the values of the signals. For instance, a good firm might earn good profits if the industry is booming or moderate profits if the industry is in recession, whereas a bad firm might earn moderate profits during a boom or fail in a recession. Hence, whether moderate profit indicates a good or a bad firm would depend on the stage of the industry cycle.

- The profitability of a firm varies with the industry equilibria. Efficient firms may, for example, earn supernormal profits if the firms collude and moderate profits if they compete. Less efficient firms may earn moderate profits if they collude or zero profits if the they compete. Moderate profits may signal an efficient firm if the firms compete or an inefficient firm if the firms collude.

- Technological cycles change the meanings of signals. The propensity to patent changes over time depending on the legal and technological environment. For example, it is known that innovations can come in waves: after a breakthrough invention it is easier to make follow up innovations. A successful innovative firm may possess dozens of patents after a breakthrough, having had only a handful before. A less innovative firm, having struggled to obtain one patent before the breakthrough, may easily obtain a handful of patents after the breakthrough. For an outsider, it is hard to know whether a handful of patents indicates an innovative or an unsuccessful firm.

- There are differences between business sectors. Financial ratios, for example, reveal information to investors. Some of this information is industry-specific. What is regarded as a good ratio of asset turnover, administration costs, gross profit or solvency will vary across industries. Consider three solvency ratios, $x_1 > x_2 > x_3$, and two sectors, A and B. In sector A, a firm is good if its solvency is x_1 and bad if the solvency is x_2. In sector B, a firm may be good if its solvency is x_2 and bad if its solvency is x_3. Hence, whether x_2 indicates a good or a bad firm, is a sector-specific matter.

- The values of signals vary by region. Wages and costs of business premises, for example, can vary from region to region. The same wage cost per employee may indicate a good, efficient firm in Area A, or a bad, inefficient firm in Area B.

2.3 The timing of events

First, the investor decides whether to incur cost c to contact an entrepreneur. Second, the investor receives a signal on the entrepreneur's type and updates her belief about type and state of the world. In the third stage, the investor faces three options. She can grant a loan to any of the entrepreneurs she has contacted or whether to invest c to acquire more information by comparing a new loan applicant with the previous ones, or she can refuse to lend.

3 Comparing with two loan applicants

In this section, we first consider a benchmark loan market with perfect information. We then further develop concepts in the context of a simple example where there is only one loan applicant in the economy, so that comparing is impossible. Finally, we introduce a second loan applicant and demonstrate the value of comparing.

3.1 Perfect information

Under perfect information the investor can separate good from bad firms and grant a loan to a good one. The following assumption ensures the establishment of a loan market.

Assumption. *Under perfect information, lending is profitable to the investor, ie*

$$g(Y-r)-c>0 \tag{3.1}$$

As explained, g in (3.1) is the probability of contacting a good entrepreneur. In such case the investor grants a loan at interest rate Y; r denotes the opportunity cost of invested capital and c the cost of a contact. In what follows, information is assumed to be asymmetric, but the Assumption is satisfied.

3.2 Asymmetric information with one loan applicant

If the economy consists of one just entrepreneur, comparing is impossible and the investor's problem is simple. She has to decide first whether to incur c and contact the entrepreneur and then whether to grant a loan to the entrepreneur given her updated belief about the entrepreneur's type. With probability hg, the signal is s_1. With this signal, the investor knows that the entrepreneur is good and she grants him a loan. With probability $(1-h)(1-g)$ the signal is s_3 and the investor knows that the entrepreneur is bad and she does not grant a loan. With probability $h(1-g)+(1-h)g$ the signal is s_2 and the investor can update her belief about entrepreneur's type, but information asymmetry remains. In such a case, the investor may or may not grant a 'risky loan', ie, a loan in the presence of uncertainty about the type of entrepreneur. Thus the value of a loan to the investor with one entrepreneur in the economy is given by

$$V_{N=1} = \max\{hg(Y-r)+[h(1-g)+(1-h)g]v_R(s_2)-c, 0\} \tag{3.2}$$

where subscript N=1 of V is the number of entrepreneurs in the economy and

$$v_R(s_2) = \max\{p(g|s_2)\ Y - r, 0\} \tag{3.3}$$

is the value of a risky loan, given the signal s_2. In (3.3)

$$p(g|s_2) = \frac{(1-h)g}{h(1-g)+(1-h)g} \tag{3.4}$$

is the conditional probability that an entrepreneur emitting s_2 is good. From (3.1) and (3.2) it is clear that asymmetric information reduces the value of the lending opportunity.

3.3 Asymmetric information with two loan applicants

With two entrepreneurs, the investor can gather information by comparing. To begin with, she must decide whether to contact either of the entrepreneurs. If she contacts one of them, she has to decide whether to grant a loan to him or contact a second one and compare the two. If she also contacts a second entrepreneur, she must decide whether to grant a loan to either or neither of the two entrepreneurs. If the first signal is either s_1 or s_3, the investor's decision problem is straightforward so we first characterise them.

The first signal is s_1. If the signal from the first entrepreneur is s_1, the investor knows that he is good. There is no need to contact and compare with a second entrepreneur, and the investor grants a loan to the first entrepreneur, which yields $Y-r$ with certainty.

The first signal is s_3. If the first entrepreneur emits s_3, the entrepreneur is bad with certainty. If the second contact also yields s_3, the investor does not lend. If the second entrepreneur emits s_2, the investor can eliminate the asymmetric information problem by comparing signals. Because the first signal, s_3, reveals that the state of the world is low, the second entrepreneur, emitting s_2, must be good. Hence the second entrepreneur, emitting s_2, is a worthy borrower. Since the probability that the second entrepreneur emits s_2 is g, the value of a loan when s_3 is the first signal is given by $v(s_3) = \max\{g(Y - r) - c, 0\}$. As $g(Y - r) - c > 0$ by the Assumption, we obtain

$$v(s_3) = g(Y - r) - c > 0 \tag{3.5}$$

Note that the value of a loan stems entirely from the possibility of comparing the entrepreneurs.

The first signal is s_2. In this case the investor's problem is more complicated. If the second entrepreneur also emits s_2, the investor cannot be sure about the entrepreneurs' type and can only update her beliefs. The value of a risky loan when both signals are s_2 is given by

$$v_R(s_2, s_2) = \max\{p(g|s_2, s_2)Y - r, 0\} \tag{3.6}$$

where, analogously to (3.4),

$$p(g|s_2, s_2) = \frac{(1-h)g^2}{h(1-g)^2 + (1-h)g^2} \tag{3.7}$$

is the conditional probability that signal s_2 indicates a good entrepreneur after two observations.

If the second entrepreneur emits s_1, the investor knows that she is dealing with a good entrepreneur and grants a loan. If the second entrepreneur emits s_3, the investor knows that the state is low, the entrepreneur is bad and the first entrepreneur is good. The investor thus grants a loan to the first entrepreneur. When the first signal is s_2, the value of a loan can be written as

$$v(s_2) = \max\{v_R(s_2),\ t_2(Y - r) + (1 - t_2)v_R(s_2, s_2) - c\} \tag{3.8}$$

where $t_2 = p(h|s_2)g + [1 - p(h|s_2)](1 - g)$ is the probability that information asymmetry can be eliminated by using the second signal. Here

$$p(h|s_2) = \frac{h(1-g)}{h(1-g) + (1-h)g} = 1 - p(g|s_2) \tag{3.9}$$

is the conditional probability that the state is high when the investor observes signal s_2. As it stands, (3.8) shows the three choices faced by the investor if the first entrepreneur emits s_2. First, if $v(s_2)$ is negative, the investor does not lend at all. Otherwise, the maximisation problem on the right-hand side of (3.8) reflects the investor's choice of whether to contact the second entrepreneur. If the investor decides to grant a risky loan after contacting only one entrepreneur, her expected payoff is given by (3.3). From (3.8) we observe that the investor contacts the second entrepreneur if

$$t_2(Y - r) + (1 - t_2)v_R(s_2, s_2) \geq c + v_R(s_2) \tag{3.10}$$

In Appendix 1 we prove that the investor's optimal lending strategy after observing s_2 satisfies the following conditions:

Proposition 1. *Suppose that the first loan applicant's type is unknown (signal s_2). Then,*
i) if the contacting cost (c) is sufficiently low, the investor contacts a second loan applicant and compares him with the first one,
ii) if c is sufficiently high and if either the prior probability that a loan applicant has a good project (g) is sufficiently high or if the prior probability of a high state (h) is sufficiently low to render the net present value of a risky loan to the first loan applicant positive ($v_R(s_2) > 0$), the investor grants a risky loan to the first applicant.
iii) if c is sufficiently high and if either g is sufficiently low or h sufficiently high to render $v_R(s_2) \leq 0$, the investor does not lend at all.

Although the formal proof of the first part of the proposition is fairly tedious, the underlying tradeoff is clear from (3.10): The LHS of (3.10) shows the benefits of comparing: with positive probability (t_2) the second contact will probably eliminate the asymmetric information problem and, even if it does not, the investor can gather more information by comparing entrepreneurs and updating her beliefs. The cost of comparing is on the RHS of (3.10). Besides the cost of contacting, the opportunity cost of comparing stems from the possibility to grant a risky loan to the first entrepreneur. For the case $g > 1/2$, it is easy to see why part i) of Proposition 1 must be true, since then $Y - r > v_R(s_2, s_2) \geq v_R(s_2)$, ie, the payoff from comparing clearly exceeds the value of the risky loan. But it turns out that the same conclusion holds even for $g < 1/2$, so the benefits exceed the cost of comparing when the cost of monitoring is sufficiently low.

In the first case in Table 1 we give a numeric example where the investor optimally compares entrepreneurs when the first entrepreneur emits s_2. The parameter values of interest are $g = 0.25$, $h = 0.5$, and $c = 0.1$.[4] If the first entrepreneur emits s_1, the investor's profit is unity. If the first signal is s_3, the investor contacts the second entrepreneur and earns an expected return of 0.15. If the first entrepreneur emits s_2, the probability that he has a good project is relatively low (0.25) and a risky loan is unprofitable. Instead, the investor contacts a second entrepreneur, since that eliminates information asymmetry with probability 0.375. Although a risky loan remains unprofitable if information asymmetry is not eliminated, contacting is optimal because the cost of contacting is low ($c = 0.1$).

As part ii) suggests, the investor may prefer to grant a risky loan to the first entrepreneur over comparing entrepreneurs. This alternative is rational if the cost of contacting is sufficiently high. The risky-loan strategy may also be optimal with moderate or even with low contacting cost if the first entrepreneur is good with sufficiently high probability, that is, when $p(g|s_2)$ is close to one. As (3.4) shows, this possibility arises when g is close to one or h is close to zero. In such circumstances, asymmetric information causes a minor nuisance and the expected benefits of comparing do not cover the cost of contacting. Instead of wasting resources in comparing, the investor optimally grants the risky loan with positive expected return $(p(g|s_2)Y - r > 0)$.

A numerical example in which granting a risky loan to the first entrepreneur is optimal can be found in Case 2 of Table 1. Here $g = 0.75$, $h = 0.25$, and $c = 0.5$. Because the priors of a good entrepreneur and a low state are high (both 0.75), the first entrepreneur, emitting s_2, is good with a probability of 0.9. Together with relatively costly contacting ($c = 0.5$) this makes contacting a second entrepreneur unprofitable. The investor optimally grants a risky loan to the first entrepreneur, knowing that the loan will be defaulted with probability 0.1.

Part iii) of Proposition 1 can also be seen from (3.10). The investor prefers not to lend at all after signal s_2 if the expected return on a risky loan is not positive and the cost of contacting is sufficiently high to render a search for a second entrepreneur unprofitable. This possibility is illustrated by Case 3 of Table 1, with $g = 0.75$, $h = 10/11$, and $c = 0.65$. With these parameters, an average entrepreneur has a good project and the state is very likely high so that signal s_2 probably indicates a bad entrepreneur. Thus a risky loan upon observing s_2 is unprofitable. Nor is it profitable to seek a second entrepreneur and compare with the first, since contacting is so costly. As a result, the investor exits the loan market upon receiving signal s_2 from the first entrepreneur. Note that it is profitable to seek a first entrepreneur but not a second one: The probability that information asymmetry will be eliminated by contacting the first entrepreneur is fairly high $(hg + (1-h)(1-g) \approx 0.7)$. However, if asymmetric information obtains, the

[4] In all numerical examples we hold Y at 2 and r at 1 and vary g, h, and c.

probability that the problem will be eliminated by seeking a second entrepreneur is somewhat lower (below 0.64).

The value of a loan. We have above determined the conditional value of a loan for the three possible values of the first signal. The initial value of a loan – the investor's expected return before she has contacted either loan applicant – is then given by

$$V_{N=2} = hg(Y - r) + [h(1-g) + (1-h)g]v(s_2) + (1-h)(1-g)v(s_3) - c \tag{3.11}$$

In (3.11) $v(s_2)$ and $vs_3)$ are given by (3.8) and (3.5), and they give the values of a loan to the investor after she receives signals s_2 and s_3 from the first entrepreneur. The value of a loan when the first entrepreneur emits s_t is simply $Y - r$. These values of loans are weighted by the appropriate probabilities: with probability hg the signal of the first entrepreneur is s_1, with probability $[h(1-g) + (1-h)g]$ the signal is s_2, and with probability $(1-h)(1-g)$ it is s_3.

That the investor's optimal strategy under asymmetric information and comparing is feasible can be seen from (3.11). After contacting the first entrepreneur, the investor can gather more information by seeking a second entrepreneur and comparing with the first. If the signal from the first entrepreneur is 'better' than the signal of the second, the first proves to be worthy of finance and vice versa. If the contacted entrepreneurs emit identical signals, the investor can update her prior beliefs on the state of the world and types of entrepreneurs, but the asymmetric information problem remains. The investor will search for a second entrepreneur if the benefits outweigh the opportunity costs of comparing. If the cost of contacting is sufficiently large, the investor may want to grant a risky loan to the first entrepreneur without comparing, although there is higher risk of credit loss than for a risky investment after comparing. Alternatively, the investor will not grant a loan at all. If VN=2≥0 the loan market opens up. This occurs if c is not too high. If $V_{N=2} \geq 0$, the Assumption also holds, but not necessarily vice versa.

We summarise the benefits of comparing based on the above analysis as follows:

Proposition 2. *By comparing two loan applicants, the investor can gather more information and raise the expected return on her loan. If the applicants emit different signals, information asymmery is eliminated, and the investor can grant the loan to the good applicant. Even if both applicants emit the same signal (s_2) and asymmetric information obtains, the investor can update prior beliefs on state of the world and types of applicants.*

We give an example of the last point – the benefits of comparing when both loan applicants release s_2 – in Case 4 of Table 1. The parameter values are g = 0.25, h = 0.2, and c = 0.1. Now monitoring is cheap and the investor contacts the second entrepreneur if the first emits s_2 as predicted by part i) of Proposition 1. Upon observing the first entrepreneur emitting s_2, a risky loan appears to be profitable $(p(g|s_2)Y - r \approx 0.14)$. Yet, when the investor has contacted two entrepreneurs emitting s_2, she is no longer willing to grant a loan since $p(g|s_2, s_2)Y - r < 0$. Intuitively, since both the state of the world is likely to be low (h is low) and average entrepreneur is likely to be bad (g is low), the investor sees that one entrepreneur emitting s_2 is a good type with a relatively high probability $(p(g|s_2) \approx 0.57)$. Upon observing two entrepreneurs emitting s_2, however, the investor begins to put more weight on the possibility that the state is high and consequently on the possibility that an entrepreneur with s_2 represents a bad type $(p(g|s_2, s_2) \approx 0.31)$. Thus a loan applicant emitting s_2, who initially seemed to be promising, proves to be unattractive after more detailed analysis. Hence comparing provides valuable information even when the investor contacts only identical loan applicants emitting s_2 and the problem of asymmetric information remains.

In spite of all the benefits of comparing, the investor's lending decision is still less efficient than under perfect information. From (3.1) and (3.11), we see that four inefficiencies remain: i) With probability $(1-h)g$, the first entrepreneur is good, but his type is unobservable to the investor. The investor may waste resources by searching for a second entrepreneur or she may inefficiently exit the credit markets; ii) With probability $(1-h)g^2$, the investor encounters two good entrepreneurs emitting s_2, but the entrepreneurs' types remain unobservable. If $p(g|s_2, s_2)Y < r$, the investor makes a mistake and denies a loan; iii) With probability $h(1-g)$, the investor contacts a bad entrepreneur who signals s_2, while the entrepreneur's type remains unobservable. The investor inefficiently grants a loan, if c is sufficiently high and $p_2(g|s_2)Y > r$ (part ii) of Proposition 1); iv) With probability $h(1-g)^2$, the investor contacts two bad entrepreneurs with s_2. The investor grants a loan if $p_2(g|s_2, s_2)Y > r$. The loan results in a credit loss.

Table 1. **Four numerical examples with $N = 2$, $Y = 2$, and $r = 1$**

	CASE 1 g = 1/4; h = 1/2; c = 1/10	CASE 2 g = 3/4; h = 1/4; c = 1/2	CASE 3 g = 3/4; h = 10/11; c = 65/100	CASE 4 g = 1/4; h = 1/5; c = 1/10
$p(g\|s_2)$	0.25	0.9	0.23077	0.57143
$v_R(s_2)$	0	0.8	0	0.14286
$v(s_2)$	0.15	0.25	0.1	0.15
$p(g\|s_2,s_2)$	0.1	0.96429	0.47368	0.30769
$v_R(s_2,s_2)$	0	0.92857	0	0
t_2	0.375	0.3	0.63462	0.53571
$v(s_2)$	0.275	0.8	0	0.43571
$V_{N=2}$	0.21875	0.23438	0.03409	0.1925

3.4 Discussion of results

The model with one investor and two entrepreneurs is admittedly limited. In the subsequent sections we will allow for multiple entrepreneurs and financiers. However, the basic insight about the value of comparing does not change. To gain intuition for the upcoming results and illustrate the value of comparing, we revisit some of the examples of section 2.2. As mentioned in section 2.2, the signals have two core properties: each signal is informative and the value of the signal depends on the state of the world. Given the first property, it is the second property that underlies the value of comparing.

- Variation of signals across sectors: As mentioned, financial ratios reveal valuable information to investors, but a part of this information is sector-specific. That is, even when the financial ratios of a sector are fixed in time, the critical values of financial ratios differ across sectors. Hence, if an investor who has no previous experience in the sector evaluates a firm, the firm's financial ratios do not reveal its true financial condition to the investor. To gather credible information and evaluate the firm properly, the investor must compare the financial ratios of the firm with the financial ratios of the other firms in the very same sector. Only after studying sufficiently many firms, will the investor understand the meaning of financial ratios in the sector and be able to use them in lending decisions.

- Variation of signals over time: The investor may have previous experience in the sector, but the signal value fluctuates over time, making the information value of a single signal modest. For instance, the profit of a copper mine may appear to be moderate. Yet, a detailed comparison may uncover that the whole sector has been booming and the profit of the mine is relatively poor.

The incipient recession is likely to hit the mine hard. Without comparing, the investor might make a serious mistake by financing the copper mine.

- Variation of signals across regions: Production costs and market potential differ from one region to another. To be able to evaluate the competitiveness of a firm in its local region, the investor needs to compare the firm's cost and customer structure with its local competitors.

- Variation of signals in research and development: The progress of research and development is stochastic almost by definition. At first glance, the prototype of an entrepreneur may seem to be promising. However, careful comparison with the other entrepreneurs in the sector may reveal that the prototype is lagging. Financing the first entrepreneur is likely to be a mistake since its product will hardly be commercially viable.

- Variation of signals according to the equilibrium of the game. Multiple equilibria are pervasive in network industries. A network firm's profit may be negative, but contrasting the firm with other firms in the industry may reveal that the firm has a relatively large customer base, and that the firms are engaged in fierce competition for clear dominance where all firms are making losses. It is likely that the firm will win the competition and obtain a dominant position in the market. Once in the dominant position, the firm will be able to raise its price and make substantial profits. Denying the firm finance would probably be a mistake.

4 Comparing with N loan applicants

So far we have assumed that the investor can contact at most two firms. This leaves open the robustness of the results with respect to the number of entrepreneurs. In this section we briefly consider a more general case where the number of entrepreneurs is, $N \in Z^{+}$. Although a complete analysis of the case is beyond the scope of this study, our brief analysis confirms that the insights gained from the two entrepreneur case apply for a larger pool of loan applicants.

We first show how information asymmetry can be eliminated with certainty when the number of compared entrepreneurs approaches infinity. Recall that asymmetric information obtains only if the investor receives signal s_2, because then the state can be high and the entrepreneur bad, or the state can be low and the entrepreneur good. Since each entrepreneur is good with probability g and bad with probability $1-g$, the numbers of good and bad entrepreneurs is binomially distributed. Consequently, when the number of compared entrepreneurs grows, asymmetric information still obtains after n contacts only with probability $(1-h)g^n + h(1-g)^n$. With probability $1-h$ the state is low and with probability g^n the investor has contacted only good entrepreneurs. With probabilities h and $(1-g)^n$ the state is high and the investor has compared only bad entrepreneurs. Because probabilities g^n and $(1-g)^n$ are decreasing in n, the probability that asymmetric information obtains approaches zero, when $n \to \infty$. Moreover, the probability that asymmetric information obtains falls rapidly fast when n increases. For example, with $h = \frac{1}{2}$, $g = \frac{1}{3}$ and n = 2, the probability is 5/18 ≈ 0.28 but, if n = 10, the probability is only $\frac{1}{2}\left(\frac{1+2^{10}}{3^{10}}\right) < 0.01$. In words, information asymmetry can be virtually eliminated by ten contacts.

Even if the investor has not received two different signals over the first n first contacts, and asymmetric information in theory remains, comparing can in practice render the remaining information asymmetry insignificant. To see this, consider the nth entrepreneur who, like all previous $n-1$ entrepreneurs, emits s_2. The probability that the entrepreneur is good is

$$p(g|S_{2,n}) = \frac{(1-h)g^n}{(1-h)g^n + h(1-g)^n}$$

or

$$p(g|S_{2,n}) = \frac{1}{1+\frac{h}{1-h}(\frac{1}{g}-1)^n} \tag{4.1}$$

where $S_{2,n} = [s_{2,1}, s_{2,2}, ..., s_{2,n}]$ is the vector of signals s_2 emitted by n entrepreneurs. From (4.1) it is evident that if $g < \frac{1}{2}$, the probability that signal s_2 indicates a good entrepreneur is decreasing in n. And it is decreasing rapidly: for example, values $g = \frac{1}{3}, h = \frac{1}{2}$, and $n = 10$ result in $p(g|S_{g,10}) = \frac{1}{1025} < 0{,}01$, ie, the entrepreneurs emitting s_2 are bad almost with certainty. Similarly, if $g > \frac{1}{2}$, the probability that entrepreneurs emitting s_2 are good is rapidly increasing in n. In the limit when n approaches infinity, informational asymmetry is removed with certainty: If $g < \frac{1}{2}$, $\lim_{n->\infty} p(g|S_{g,n}) = 0$, and if $g > \frac{1}{2}$, $\lim_{n->\infty} p(g|S_{g,n}) = 1$. We summarise the above observations in the following result.

Proposition 3. *Information asymmetry can be rendered insignificant by comparing sufficiently many loan applicants. When the number of compared loan applicants increases, the investor either eventually contacts two different loan* *applicants, which eliminates the asymmetric information problem, or updates her prior belief about type of loan applicant, which ultimately results in the same outcome.*

As Proposition 3 suggests, comparing works through two different channels. The first exploits differences in signals. Sooner or later the investor will encounter a signal that differs from the previous signal or signals. This immediately removes information asymmetry. The second channel exploits the absence of differences in signals. If the entrepreneurs continue to emit the same signal, the investor can simply update her beliefs about state of the world and type of entrepreneur. With sufficiently many observations, the investor should be quite confident about the meaning of the signal. The latter channel illustrates how comparing comes close to experimentation or learning in the more traditional context, with a slight difference: comparing requires only one signal from one entrepreneur and can in principle occur within one time period, whereas experimentation and traditional learning require many observations on the same entrepreneur over time.

The above discussion dismisses the costs of comparing. If the investor contacts n firms, the total cost of contacting amounts to nc. It is not clear whether the benefits of comparing cover the costs. We next investigate the investor's optimal choice of how much to invest in information gathering, taking into account the costs.

The initial value of a loan can be written analogously to (3.11) as

$$V_N = hg\left(Y - r\right) + \left[h(1-g) + \left(1-h\right)g\right]v_N(s_2) + \left(1-h\right)(1-g)v_N(s_3) - c \tag{4.2}$$

where subscript N denotes the total number of entrepreneurs. As in the case of two loan applicants, the investor immediately stops comparing and grants a loan if the signal is s_1. This possibility is captured by the first term in the right-hand side of (4.2). The second and third term arise from the cases where the first signal is s_2 or s_3.

The first signal is s_3. As discussed in the previous section, if the first signal is s_3, the investor knows that the state is low and the entrepreneur is bad with certainty. If the second entrepreneur releases s_2, the investor can eliminate information asymmetry by comparing signals. If the second contact also yields s_3, the investor does not lend and may or may not continue comparing. Thus the value of a loan when there are N potential entrepreneurs and when the first signal is s_3 can be written as

$$v_N(s_3) = \max\left\{g(Y-r) - c + (1-g)v(s_3, s_3), 0\right\} \tag{4.3}$$

where $v(s_3,s_3)$ is the value of a loan after two observations of s_3. Note that $v(s_3,s_3)$ cannot be negative, as the investor can always stop comparing and decide not to grant a loan at all. Since also $g(Y-r)-c>0$ by the Assumption, the investor continues comparing if the first signal is s_3. Because the investor's problem is stationary, we can easily solve (4.3) recursively. This yields

$$v_N(s_3)=\left[g(Y-r)-c\right]\left[\frac{1-(1-g)^{N-1}}{g}\right] \tag{4.4}$$

In words, (4.4) suggests that if the first signal is s_3, the investor continues comparing the loan applicants until she encounters signal s_2. The value of the loan is increasing in the total number of loan applicants in the economy. As the total number of loan applicants increases, it becomes increasingly likely that the investor will find a good applicant and can grant a loan.

The first signal is s_2. As in section 3, if the first signal is s_2, and the second signal is different (either s_1 or s_3), information asymmetry is eliminated and the investor can make an optimal lending decision. However, if the second signal is also s_2, the investor updates both the probability that signal s_2 indicates a good entrepreneur and that information asymmetry can be eliminated by the next contact. With more than two loan applicants, the investor encounters three choices at this juncture. She can grant a loan to either of the entrepreneurs emitting signal s_2, she can decide to exit the credit market without lending, or she can proceed to compare a third loan applicant. If she takes the last option, she will be in a similar but not identical position as after the second contact: either the information asymmetry is eliminated or she can update her beliefs.

In general, after the investor has encountered $n-1$ entrepreneurs who have emitted s_2, the value of a loan can be written as

$$v(S_{2,n-1})=\max\left\{v_R(S_{2,n-1}),\, t_n\left(Y-r\right)+(1-t_n)\,v(S_{2,n})-c\right\} \tag{4.5}$$

where $v_R(S_{2,n-1})=\max\left\{p(g|S_{2.n-1})Y-r,0\right\}$ is the value of a risky loan after $n-1$ s_2 signals and where $t_n=p(h|S_{2,n-1})g+\left[1-p(h|S_{2,n-1})\right](1-g)$ is the probability that information asymmetry will be eliminated by the nth contact. Here $p(h|S_{2,n-1})=\dfrac{h(1-g)^{n-1}}{h(1-g)^{n-1}+(1-h)g^{n-1}}=1-p(g|S_{2,n-1})$ is the conditional probability that the state is high when all $n-1$ previous entrepreneurs have emitted signal s_2.

The value of the loan (4.5) could be solved backwards, beginning with the termination payoff $v_R(S_{2,N})=\max\left\{p(g|S_{2.N})Y-r,0\right\}$. Because the problem is non-stationary, however, solving (4.5) completely is a messy exercise and does not yield substantial insights. Nonetheless, a few general results can be obtained from (4.5). The first of them is proved in Appendix 2.

Proposition 4. *If the net present value of a risky loan to the first loan applicant is negative ($v_R(s_2) \leq 0$) and the prior probability that a loan applicant has a good project is less than one half ($g < ½$), the investor continues to contact and compare new loan applicants until the problem of asymmetric information is eliminated.*

To understand Proposition 4, recall from (4.1) that $p(g|S_{2,n})$ is decreasing in n when $g < \frac{1}{2}$. Thus, if granting a risky loan to the first entrepreneur emitting s_2 is unprofitable $(p(g|s_2)Y < r)$, it will remain unprofitable for all subsequent entrepreneurs emitting s_2. This leaves the investor with two choices: either she should compare entrepreneurs until information asymmetry is eliminated or stop comparing and exit the market. It turns out that an exit, yielding zero payoff is not optimal if $g < \frac{1}{2}$. In the case of $g < \frac{1}{2}$ the probability that a new contact eliminates information asymmetry exceeds g and, thus the expected return from each new contact exceeds $g(Y - r) - c > 0$ (recall the Assumption). The investor thus compares entrepreneurs until information asymmetry is eliminated. With bad luck, the investor may end up comparing entrepreneurs forever if $N = \infty$. Under the parameter values of Case 1 of Table 1, the investor operates as predicted by Proposition 4.

If $g > \frac{1}{2}$, the investor's behaviour is different. In such circumstance the optimal number of comparisons is always finite, as verified by the following proposition.

Proposition 5. *If $g > ½$, the investor stops comparing new loan applicants even if information asymmetry remains.*

We give a heuristic argument here (the formal proof is in Appendix 3). On the one hand, $p(g|S_{2,n})$ is increasing in n by (4.1), if $g > \frac{1}{2}$. The probability approaches unity when n is large enough, and the expected return from a risky loan, $p(g|S_{2,n})Y - r$, approaches $Y - r$. On the other hand, the expected return from contacting a new loan applicant is always lower than $Y - r - c$. Thus, when n is large enough, the investor prefers granting a risky loan to contacting and comparing a new loan applicant, and the number of compared loan applicants is finite.

An implication of Proposition 5 is that granting a risky loan can be optimal already to the first entrepreneur, as in the two-entrepreneur economy of section 3.3. That is, if the type of the first entrepreneur is unknown (signal is s_2), the investor optimally grants a loan to him instead of contacting more loan applicants. It is easy to see that such a risky loan strategy is optimal if the first loan applicant is good with a sufficiently high probability or if the contacting is sufficiently costly. For example, this investment strategy is optimal under the parameter values of Case 2 in Table 1. In that case, the risky loan yields $p(g|s_2)Y - r = 0.9 \cdot 2 - 1 = 0.8$, whereas the maximal return that the investor can obtain by contacting more loan applicants is lower than $Y - r - c = 2 - 1 - 0.5 = 0.5$. Since 0.8 > 0.5, the investor grants a loan to the first firm.

5 Multiple investors and financial intermediation

Sections 3 and 4 show how comparing is beneficial even if there is only one investor in the credit market. If there are multiple investors, however, an arrangement wherein each investor separately collects information has many shortcomings: If an investor contacts one loan applicant who emits s_2, the investor operates under asymmetric information. If the investor grants a loan, she may finance a bad firm. If she does not grant a loan, she may deny a good entrepreneur a loan. The investor can gather more information by comparing several loan applicants. But this is costly. Each investor needs to contact several loan applicants even if each investor can grant only one loan. Each loan applicant is then contacted several times although each time the monitoring provides the very same information. Moreover, an investor cannot be sure ex ante that comparing several entrepreneurs will eliminate information asymmetry. In this section we show how investors can overcome these shortcomings by establishing a financial intermediary.

For brevity, we focus on the case where there are equally many entrepreneurs and investors. Suppose that the investors establish a financial intermediary. Each investor first invests her endowment in the intermediary and contacts one loan applicant. Then, the investors exchange information. It is simply assumed that investors cooperating within the intermediary can monitor each other at no cost. This kind of an intermediary reminds us of that in Ramakrishnan and Thakor (1984) and Milton and Thakor (1985), except that our intermediary accepts funds for investment.[5] By exchanging information, the investors can reap the benefits of comparing without duplication of contacting cost. If the investors have encountered two different signals, the investors learn the state of the world and can separate good from bad loan applicants. The intermediary can then grant loans to all good loan applicants, while investing the rest of the funds at the risk-free

[5] Alternatively, we could follow Diamond (1984) in assuming that investors choose one among them to carry out contacting and comparing loan applicants.

interest rate r. Even if all signals are alike, the intermediary can update beliefs about state of the world and types of loan applicants. All this can be achieved by contacting each loan applicant only once.

As the financial intermediary grows, it becomes increasingly likely that the intermediary will have two different types of loan applicants, which eliminates information asymmetry. Even if all its loan applicants are similar, the intermediary becomes increasingly confident about the true state of the world and types of its loan applicants. In the limit, when the financial intermediary is sufficiently large, the information asymmetry will be eliminated with certainty (Proposition 3), and the number of monitored loan applicants is equal to the units of the funds invested. To put it differently, a sufficiently large financial intermediary achieves the very same optimal solution that is achieved under perfect information. A conclusion follows:

Proposition 6. *If the investors join together and establish a financial intermediary, each loan applicant is contacted only once and the duplication of contacting cost is avoided. When the intermediary is sufficiently large, information asymmetry will be removed with certainty.*

This result resembles that of Diamond (1984). In both models, a financial intermediary is bank-like and eliminates the duplication of information provision, thereby cutting the costs of lending. Nonetheless, the models differ in some important aspects: In Diamond (1984), centralised information provision is profitable, since a single investor can finance only a small fraction of a project. Thus many investors are needed to finance the whole project. If each investor monitored the project, the cost of monitoring would be duplicated. The duplication can be eliminated by establishing a financial intermediary, which monitors the project only once. On the contrary, in our model, centralised information provision is profitable even if a single investor finances the whole project. Although a single investor finances only one project, she should contact numerous loan applicants to gather information. With multiple investors, the same loan applicants would be contacted by several investors and the cost of contacting would be duplicated. Useless duplication can be avoided by establishing a centralised intermediary, which contacts each loan applicant only once.

Another difference versus Diamond (1984) arises if we take the time dimension seriously. Suppose each investor can contact only one entrepreneur in a period. For an investor operating in isolation, it takes many periods to compare several entrepreneurs and gather information. But if the investors form a financial intermediary, they can compare all entrepreneurs in one period. In other words, even if there are no contacting costs other than the opportunity cost of time, comparing is conducive to centralised financial intermediation.

Finally, note that investors have no incentive to form a coalition to dampen the interest rate competition, since by assumption they can extract all the surplus from entrepreneurs. The tendency towards centralised financial intermediation arises solely from economics of scale in comparing.

Pushing the argument for centralised financial intermediation to the limit, we can also determine the deposit rate in the credit market. Let Π denote the total profit of the intermediary. If the intermediary has N investors (as well as loan applicants), $\frac{1}{N}\Pi$ is the profit share of a single investor.

Proposition 7. *A sufficiently large intermediary can pay to an investor-member a fixed return, of* $r_D \equiv \lim_{N \to \infty} \frac{1}{N}\Pi = gY + (1-g)r - c$.

The result follows from the law of large numbers. We can also interpret r_D as the deposit interest rate for the credit market, because the left-over funds are invested in the outside option at interest rate r. At the beginning of period, each investor deposits her unit in the intermediary, which invests a share g of the funds in good projects and puts the rest in the outside option. At the end of the period, the loans yield a net return of $N(gY - c)$ and the outside option yields $N(1-g)r$. The intermediary can then pay a return of r_D per deposit unit. Hence both the lending interest rate, Y, and deposit interest rate, r_D, are determined in the model. From the assumed market structure, it follows that depositors gain the full project surplus, whereas entrepreneurs and the intermediary earn zero profit.[6]

6 Conclusion

In this paper we study comparing as a source of information in financial markets. Comparing is a simple instrument of learning. It has many features common with other forms of learning such as learning by doing, experimentation and imitation. The other forms of learning, however, require many observations on the same entrepreneur over time whereas comparing exploits the differences between entrepreneurs. We show how comparing reduces information asymmetry. By comparing sufficiently many entrepreneurs, an investor can separate good from bad loan applicants. The optimal number of compared entrepreneurs is inversely related to the cost of contacting and directly related to the magnitude of the asymmetric information problem.

[6] Following Ramakrishnan and Thakor (1984) we abstract from costs of the information exchange within the intermediary. Obviously, internal monitoring in the intermediary is hardly costless as argued by Millon and Thakor (1985). However, proper analysis of information utilisation within the intermediary would require careful modelling of information exchange along the lines of Pagano and Japelli (1993) and is left for future research.

Even the extreme cases of no comparing and comparing all entrepreneurs irrespective of the total number turn out to be rational. On the one hand, if the initial probability of encountering a good entrepreneur is sufficiently high, asymmetric information is not an important problem. If also contacting is sufficiently costly, the benefits of comparing do not offset its costs, and the investor grants a loan without comparing entrepreneurs. On the other hand, if the problem of asymmetric information is severe (low initial probability that a randomly selected entrepreneur has a good project) and comparing is cheap, it may be optimal to compare entrepreneurs until information asymmetry is eliminated.

If every investor invests in comparing, information gathering will be inefficient, since loan applicants are compared several times with zero information gain. To prevent the useless duplication of comparing, the investors optimally join together and establish a financial intermediary, which contacts each loan applicant only once. If the intermediary can grow without bound, the problem of asymmetric information can be eliminated with certainty without further investment in information acquisition. This provides a novel rationale for centralised financial intermediation.

An implication of our model is that financial institutions such as banks can become dominant financiers of an industry by exploiting scale economies in comparing. Once a bank has gathered information about firms in the industry by comparing them, it is difficult for new financial institutions to enter the market for finance of the industry. The entrants should start the process of comparing from the beginning whereas the established financiers know the firms and the signals. Thus, even if the incumbents and entrants observe the same information about funding applicants, the incumbents may have an information advantage since they are able to interpret the information correctly. Only in new industries, will old and new financiers compete on equal footing. In such circumstances the efficient use of comparing can be the crucial determinant of financial institutions' successes and failures.

Indeed, although we have emphasised the role of comparing in credit markets and that the intermediary arising from our analysis is bank-like, comparing is perhaps even more relevant for venture capital financiers and other entities that focus on financing new high-tech industries. As carefully documented by Gompers and Lerner (2004), such venture financiers frequently encounter ideas for businesses in areas where there is little available information. The lack of track records for applicants or business area does not lead to the collapse of markets for innovation finance, since venture capitalists seek many applications from the same narrow area. In comparing applications, it becomes evident that funding should be denied to some business ideas. More promising ideas are extensively scrutinised by means of both formal studies of the technology and market strategy and informal assessments of potential entrepreneurs' human capital and credibility. The most promising projects receive the first stage financing. The success of financed firms is intensively monitored by the venture capitalists. After a new round of comparing, only the most successful firm can obtain second stage financing. The next logical step is to endogenise the form of financial contract so as to enable assessment of the relative benefits of comparing in private equity and debt finance. That and many other intriguing issues are left for future work.

References

Bergemann, D – Hege, U (1998) **Venture capital financing, moral hazard, and learning.** Journal of Banking & Finance 22, 703–735.

Bergemann, D – Hege, U (2002) **The Value of benchmarking.** In McCahery, J and Renneboog, L (eds.) Venture Capital Contracting and the Valuation of High Tech Firms. Oxford University Press, Oxford.

Bester, H (1985) **Screening vs rationing in credit markets with imperfect information.** American Economic Review 75, 401–405.

Broecker, T (1990) **Credit-worthiness tests and interbank competition.** Econometrica 58(2), 429–452.

Cerasi, V – Daltung, S (2000) **The optimal size of a bank: costs and benefits of diversification.** European Economic Review 44(9), 1701–1726.

de Meza, D – Webb, D (1987) **Too much investment, A problem of asymmetric information.** Quarterly Journal of Economics 102, 281–292.

Diamond, D (1984) **Financial intermediation and delegated monitoring.** Review of Economic Studies 51, 393–414.

Freixas, X – Rochet, J-C (1997) **Microeconomics of Banking.** The MIT Press, Cambridge, Massachusetts.

Hellwig, M (2000) **Financial intermediation with risk aversion.** Review of Economic Studies 67, 719–742.

Holmström, B – Tirole, J (1997) **Financial intermediation, loanable funds and the real sector.** Quarterly Journal of Economics 112, 663–691.

Gombers, P – Lerner, J (2004) **The Venture Capital Cycle.** The MIT Press, Cambridge, Massachusetts, 2nd Edition.

Gorton, G – Winton, A (2003) **Financial Intermediation.** In Constantinides, G, Harris, M, and Stultz, R M (eds.) Handbook of The Economics of Finance. Elsevier, North Holland, Amsterdam.

Krasa, S – Villamil, A (1992) **Monitoring the monitor: An incentive structure for a financial intermediary.** Journal of Economic Theory 57, 197–221.

Millon, M – Thakor, A (1985) **Moral hazard and information sharing: A model of information gathering agencies.** Journal of Finance 40, 1403–1422.

Niinimäki, J-P (2001) **Intertemporal diversification in financial intermediation.** Journal of Banking and Finance 25(5), 965–991.

Pagano, M – Jappelli, T (1993) **Information sharing in credit markets.** Journal of Finance 48, 1693–1718.

Ramakrishnan, R – Thakor, A (1984) **Information reliability and a theory of financial intermediation.** Review of Economic Studies 51, 415–432.

Stiglitz, J – Weiss, A (1981) **Credit rationing in markets with imperfect information.** American Economic Review 71(3), 393–410.

Von Thadden, E-L (1995) **Long-term contracts, short-term investments and monitoring.** Review of Economic Studies 62(4), 557–575.

Appendix 1

Proof of proposition 1

Proof of part i): In the proof we use the following observation frequently

$$h(1-g)+(1-h)g-g(1-g)=(1-h)g^2+h(1-g)^2 \qquad (A1.1)$$

Given (3.3), (3.6), and (3.10), it is profitable to contact the second applicant if

$$t_2(Y-r)+(1-t_2)\text{Max}\{p(g|s_2,s_2)Y-r,0\}\geq \text{Max}\{p(g|s_2)Y-r,0\}+c \qquad (A1.2)$$

The inequality is obviously satisfied if $p(g|s_2)\ Y\leq r$ for sufficiently low c. Hence, we can focus on the case where $p(g|s_2)\ Y>r$. There are then two possibilities, depending on whether $p(g|s_2,s_2)\ Y-r$ is positive or negative. Using (3.9), we rewrite $t_2=p(h|s_2)g+[1-p(h|s_2)](1-g)$ as $t_2=\frac{g(1-g)}{h(1-g)+(1-h)g}$. As a result, if $p(g|s_2,s_2)\ Y<r$, (A1.2) simplifies to $\frac{g(1-g)}{h(1-g)+(1-h)g}(Y-r)\geq\frac{(1-h)g}{h(1-g)+(1-h)g}Y-r+c$ or, using (A1.1), to

$$r[(1-h)g^2+h(1-g)^2]+gY(h-g)\geq[h(1-g)+(1-h)g]c \qquad (A1.3)$$

Adding and subtracting $Y(1-h)g^2$ in the LHS of (A1.3) yields

$$r[(1-h)g^2+h(1-g)^2]-Y(1-h)g^2+Ygh(1-g)\geq[h(1-g)+(1-h)g]c \qquad (A1.4)$$

Since $p(g|s_2,s_2)\ Y<r$ implies $(1-h)g^2Y<[(1-h)g^2+h(1-g)^2]r$, the LHS of (A1.4) is positive. Hence, (A1.4) holds if the cost of contacting is sufficiently low.

Now assume $p(g|s_2,s_2)\ Y>r$ (A1.2) simplifies to

$$Y[t_2-p(g|s_2)\ +(1-t_2)p(g|s_2,s_2)]\geq c \qquad (A1.5)$$

Since $1-t_2=\frac{(1-h)g^2+h(1-g)^2}{h(1-g)+(1-h)g}$ by (A1.1), (A1.5) can be further simplified to

$$\frac{(1-g)gh}{h(1-g)+(1-h)g} \geq \frac{c}{Y} \tag{A1.6}$$

which is true if the cost of contacting is sufficiently low.

Proof of part ii): From (A1.2) we see that a necessary condition for the optimality of a risky loan to the first entrepreneur is $p(g|s_2)\, Y - r > 0$. This holds when $p(g|s_2)$ is sufficiently large, which is true when g is sufficiently large or h is sufficiently small (see (3.9)). When $p(g|s_2)\, Y - r > 0$, (A1.2) implies that the risky loan is optimal if

$$p(g|s_2)Y - r \geq t_2(Y-r) + (1-t_2)\text{Max}\{p(g|s_2,s_2)Y - r, 0\} - c \tag{A1.7}$$

Because the RHS of (A1.7) is smaller than $Y - r - c$, a sufficient condition for optimality of the risky-loan is that the LHS of (A1.7) exceed $Y - r - c$. As a result, a sufficient condition for part ii) of Proposition 1 to hold is

$$c \geq (1 - p(g|s_2))Y \tag{A1.8}$$

Sufficient condition (A1.8) is true if c is sufficiently large or if $p(g|s_2)$ is almost equal to one, which occurs when g is close to one or h is close to zero.

Proof of part iii): Clearly, if $p(g|s_2)\, Y - r < 0$, the investor does not want to grant a risky loan to the first entrepreneur. Thus, if the contacting cost is so high that (A1.2) does not hold, the investor does not grant a loan.

QED

Appendix 2

Proof of proposition 4

The proof consists of three steps.

Step 1: We show that $t_{n+1} < t_n$ for all n. Rewrite t_n as

$$= \frac{h\ A^{n-1}g + (1-h)(1-g)}{hA^{n-1} + (1-h)} \tag{A2.1}$$

where $A = \frac{1}{g} - 1$. Without loss of generality, we assume that n is continuous. As a result, we can differentiate (A2.1)

$$\begin{aligned}\frac{dt_n}{dn} &= \frac{1}{\left[hA^{n-1} + (1-h)\right]^2} \left\{hg\,(hA^{n-1} + 1 - h)A^{n-1}\ln A - \left[hA^{n-1}g + (1-h)(1-g)h\right]A^{n-1}\ln A\right\} \\ &= \frac{hA^{n-1}\ln A}{\left[hA^{n-1} + (1-h)\right]^2} \left[g\,(hA^{n-1} + 1 - h) - (hA^{n-1}g + (1-h)(1-g)\right] \\ &= \frac{hA^{n-1}\ (1-h)\left(2g-1\right)\ln A}{\left[hA^{n-1} + (1-h)\right]^2} < 0\end{aligned} \tag{A2.2}$$

Step 2: We next verify that $\lim_{n\to\infty} t_n = g$. Using (A2.1), it is easy to show that

$$\lim_{n\to\infty} t_n = \lim_{n\to\infty} \frac{h\ g + \dfrac{(1-h)(1-g)}{A^{n-1}}}{h + \dfrac{1-h}{A^{n-1}}} = \frac{hg}{h} = g \tag{A2.3}$$

Step 3: Since we assume that $p(g|s_2)Y < r$ and since $p(g|S_{2,n})$ is decreasing in n (recall (4.1)), $p(g|S_{2,n})Y < r$ for all n. Given $p(g|S_{2,n})Y < r$, the value of a risky loan is zero for all n, ie, $v_R(S_{2,n-1}) = 0$. Thus, (4.5) can be concisely written as

$$v(S_{2.n-1}) = \max\left\{0, t_n\left(Y - r\right) + (1 - t_n)\, v(S_{2,n}) - c\ \right\} \tag{A2.4}$$

If $v(S_{2,n})$ is positive for all n, the investor will contact and compare loan applicants until asymmetric information is eliminated, which occurs when she receives either s_1 or s_3. The RHS of (A2.4) is strictly positive since $t_n > g$ (steps 1 and 2) and

$g(Y - r) - c > 0$ by the Assumption. Hence, after contacting the first loan applicant, the investor optimally seeks the second loan applicant and compares him with the first one, and continues the process until asymmetric information is eliminated.

QED

Appendix 3

Proof of proposition 5

We need to show that if $g > \frac{1}{2}$, the optimal number of compared entrepreneurs is finite. Since $p(g|S_{2,n})$ is increasing in n if $g > \frac{1}{2}$, and approaches 1 and when n→∞ (see (4.1)), there exists a $\underline{p} < 1$, such that $\underline{p}Y - r = Y - r - c > 0$. The last inequality follows from the Assumption. Let k denote the smallest number of contacted loan applicants that satisfies $p(g|S_{2,k}) \geq \underline{p}$.

Equation (4.5) implies that the investor contacts a new loan applicant if

$$v_R(S_{2,n-1}) \leq t_n(Y - r) + (1 - t_n)v(S_{2,n}) - c \qquad \text{(A3.1)}$$

where $v_R(S_{2,n-1}) = \max\{p(g|S_{2.n-1})Y - r, 0\}$ and $v(S_{2.n}) = \max\{v_b(S_{2,n}), t_{n+1}(Y - r) + (1 - t_{n+1})v(S_{2,n+1}) - c\}$. When $n - 1 \geq k$, (A3.1) can be written as

$$p(g|S_{2.n-1})Y - r \leq t_n(Y - r) + (1 - t_n)(p(g|S_{2.n})Y - r) - c \qquad \text{(A3.2)}$$

because
$p(g|S_{2.n})Y - r > p(g|S_{2.n-1})Y - r \geq Y - r - c > t_{n+1}(Y - r) + (1 - t_{n+1})v(S_{2,n+1}) - c$.
Subtracting $Y - r - c$ from both sides of (A3.2) yields

$$p(g|S_{2.n-1})Y - r - (Y - r - c) \leq -Y(1 - p(g|S_{2.n}))(1 - t_n) \qquad \text{(A3.3)}$$

In (A3.3) the LHS is positive since $n - 1 \geq k$, and the RHS is negative. As a result, the inequality is not satisfied, and it is not optimal to go on comparing. Thus, the optimal number of compared entrepreneurs is finite.

BANK OF FINLAND RESEARCH
DISCUSSION PAPERS

ISSN 0785-3572, print; ISSN 1456-6184, online

1/2006 Juha-Pekka Niinimäki – Tuomas Takalo – Klaus Kultti **The role of comparing in financial markets with hidden information.** 2006. 37 p.
ISBN 952-462-258-0, print; ISBN 952-462-257-2, online.

Suomen Pankki
Bank of Finland
P.O.Box 160
FI-00101 HELSINKI
Finland

. 2343