An Economic Analysis of the Screening Industry

Jisoon Lee *

Utilizing a simple screening model, we explain how the provision of screening services alters equilibrium allocations of funds. For example, when screening services are available, banks tend to increase funding for risky projects and the equilibrium interest rate tends to fall. Indeed, the former is an increasing and the latter is a decreasing function of the extent of screening. These results accord well with our usual expectation. The proposed model, however, provides an unexpected result: It shows that having the screening industry run by a profit maximizing monopolist might be better than relying on many competing firms. This seemingly unusual result comes from the realization that, when many firms are competing, they produce essentially the same 'products' over and over again, resulting in serious information duplications. A monopoly can easily avoid information duplications. However, it results in deadweight losses. Separating information production businesses from information selling businesses seems to be a better option. We show that when the former is handled by a single public entity and the latter is handled by many competing firms, we can have better outcomes. This arrangement solves the information duplication problem. More importantly, the resulting equilibrium configurations could be made identical to competitive equilibrium outcomes.

Keywords: Screening services, Funding risky projects, Information duplications

JEL Classification: D83, G14, G24

* Professor, Department of Economics, Seoul National University, 599 Gwanak-ro, Gwanak-gu, Seoul 151-746, Korea, (Tel) +82-2-880-6476, (Fax) +82-2-886-4231, (E-mail) jisoon@snu.ac.kr. I am grateful to two anonymous referees and participants at 2009 Shanghai Forum for their useful suggestions and corrections. I also gratefully acknowledge the financial support from the Advanced Strategy Program (ASP) of the Institute of Economic Research, Seoul National University.
[**Seoul Journal of Economics** 2009, Vol. 22, No. 3]

I. Introduction

The main objective of this paper is to understand economics involved in financial screening activities. We think of screening as an activity to produce information that can be gainfully used by traders. Providing more accurate information on trading partners or on objects being traded is such an activity. Among many different kinds of screening activities, we will focus on the screening activities occurring in a small subset of financial markets. (A classic paper on screening is Spence (1974), which has theorized schooling as a signaling device. Another important contribution is Stiglitz (1975), which has developed similar hypothesis from the screening aspect. Our research is inspired by Spence (2002).)

The problem we consider is as follows. A large number of banks are competing in the business of providing funds for investment projects proposed by new startup firms. These firms (investors) do not have sufficient capital to finance the projects so that they must obtain funding from banks. The proposed projects are inherently risky, in that not all of them would succeed. Of the n projects that are funded, only pn of them will succeed. Of course, an investment project would either succeed or fail. However neither banks nor investors know ex ante which particular project will succeed.

Interactions among banks and investors would produce equilibrium outcomes. But depending on whether screening services are provided or not, we would in general have different equilibrium configurations. The presence of screening services, for example, may make the number of funded projects larger and interest rate lower. Or, it may not. This we must find out. And that is our first task.

Utilizing a very simple model, we show that the presence of screening services will indeed alter equilibrium configurations. (See Barcena-Ruiz & Rubio (2003), which deals with entry decision of firms with privately held information.) But more crucially, we find that depending on whether screening services are provided by many competing firms, by a public monopoly, or by a private monopoly, we would have very different outcomes. Here, whereas a public monopoly is required to fund the largest number of projects, a private monopoly is allowed to maximize profits.

In general, both the revenue and cost functions of a screening firm are increasing in the amount of screening services produced m. We generally expect the former to be a concave function, while the latter to be a convex function. This would lead the public monopolist to choose a much larger m than the profit maximizing monopolist. How about the competitive industry? Normally one expects the competitive equilibrium value of m to be larger than the profit maximizing monopolist's choice and smaller than the public monopolist's choice.

As far as a comparison between the two types of monopoly is concerned, the usual prediction turns out right: The profit maximizing monopolist's equilibrium value m is smaller than that for the public monopoly. However, it is no longer the case for the competitive equilibrium value m: It is smaller than the public as well as the private monopolist's choice. Why do we have this result? It is basically because the size of the market that a competitive firm faces is much smaller than that a monopolist would face. A monopolist deals with the entire market, whereas a competitive firm deals only with its share of the market. The much larger market size naturally induces a monopolist to choose a much larger m.

Here one may wonder that, whereas the amount produced by a single competing firm is small, the aggregate amount produced by the industry must be large. Indeed, it is usually the case that a competitive industry's total output is larger than the amount produced by a monopolist. However, that is not the case for our problem. To be sure each of the competing firms, say x, screens m projects, and consequently the industry as a whole appears to screen $x \cdot m$ projects. But it is not like that for our problem: what is going on is a repeated random sampling of size m by x firms. Thus the relevant amount produced in the industry is m, not $x \cdot m$.

Our model provides a clear ranking on the alternative forms of competition. In terms of (screening) costs, the model demonstrates that a profit maximizing monopoly is the best. The public monopoly comes next and, surprisingly, the competitive industry comes last. This is a rather 'unusual' outcome. Why do we have this outcome?

The key lies in the observation that what is being produced here is a piece of information. (Stigler (1961) has pioneered information economics.) A piece of information, being a non-rival good, needs to be produced only once, or, only by one. If more than one firm engages in its production, an essentially identical piece of information would be produced many times over. The result is a serious information duplication problem. A monopoly, be it public or private, solves this problem automatically. That is why a monopoly would incur smaller costs than a competitive industry. (For some related research, see Gehrig & Stenbacka (2006), which deals with the possibility of coordination failure when screening is decentralized, and Japelli & Pagano (2002), which deals with the pros and cons of information sharing in credit markets.)

Of course, one has to consider the benefits, too, in order to find out what would be the best option. Interestingly in our model, all three alternatives induce the same number of projects to be undertaken. In that sense all have the same benefits. Thus it suffices to compare costs alone. (In a more general setting,[1] the equilibrium number of funded projects n would also be a function of m. In that case a higher m may lead to a larger n. Then we have to consider benefits as well as costs.)

The reason why each of the competing firms separately produces the 'same' information and thereby creates a serious information duplication problem is essentially because they cannot solve the free riding problem. If we can find an arrangement that would solve the free riding problem, and at the same time maintain competition, then we can produce the competitive equilibrium value m with smallest possible costs.

We propose one such option. It is to separate the business of information production from the business of selling products based on the information. The former would be handled by a single entity, while the latter would be handled by a multitude of competing firms. A feasible solution is to establish a public entity (or, give a new mandate to our public monopoly) who would specialize in information production, and require it to produce the same level of information as one competing firm would have produced. It would then sell the information to a multitude of certificate-issuing firms. The price it would set for this is its costs divided by the number of issuing firms. That is, the issuing firms will equally share the screening costs. The issuing firms then sell certificates to project undertakers. These latter would submit certificates to obtain funding for their projects. This will produce the same outcome as the competitive industry we have originally considered, but only with a fraction of costs.

The finding that separating information producing from information selling is desirable can have wider applicability. It is clear that if the information concerned is of a low dimension, perhaps we would need a

[1] We get the 'particular' result mainly because we have used a quadratic cost function. With a general cost function, we might get more 'general' outcomes.

single entity specializing in its production. However, if the information is complex and of higher dimension, we may need several entities, each of which would specialize in a sub area. Finally, when the objects for which we want to draw inferences are not easily fathomable, we may need many competing firms providing different interpretations.

These remarks are the essence of our findings. In the remainder of the paper, we are going to elaborate how we have obtained those conclusions. Thus in Section II, a formal model of financial intermediation is proposed and solved. Here we derive equilibrium allocations under the assumption that no screening services are provided. Then in Section III, we will introduce screening activities into the picture, and derive new equilibrium allocations. There we find that our equilibrium configurations crucially depend on the amount of screening services provided. Thus in Section IV, we explain how the amount of screening services are determined. Naturally, it depends on the market structure of the screening industry. We consider three alternatives: a viable or contestable competition, a public monopoly, and a private monopoly. In Section V, we discuss implications of our findings. For example, we find, to our surprise, that a public monopoly with a proper mandate might produce better outcomes than those obtained under competition. More surprisingly, a profit maximizing monopoly may produce even better outcome. We explain why we have these seemingly strange results. It is essentially because the information obtained through screening activities is non-rival. Based on this finding, we propose several alternatives. We also show that our model can be applied to a wider class of problems. Section VI contains concluding remarks.

II. Funding for New Investment Projects When Screening Services Are Unavailable

A. The Set up of a Model

Consider a situation where a large number, y, of banks are competing in the business of financing risky investment projects proposed by borrowers (investors). As all the borrowers are ‘new’ on the market, banks do not know individual borrower’s credit worthiness. Likewise borrowers do not have track records to demonstrate their credit worthiness to banks. The number of borrowers will be determined on the market as banks make decisions on how many investment projects they would fund.

There exist in the economy N potential investment projects, where N is a very large number. An investment project requires a capital commitment of K. We assume that there are only two outcomes: a success or a failure. When it succeeds, an investment project yields S, which is much larger than K. When it fails, on the other hand, an investment project yields nothing. Nature reveals the outcome only after an investment project is actually undertaken.

In order to simplify our problem, we model the fundamental randomness as someone drawing a ball from an urn. The drawn ball is returned to the urn. The urn contains altogether N balls, of which Np are white and $N(1-p)$ are black. When an investor draws a white ball, his project would succeed for sure. But if he draws a black ball, it would surely fail.

An investor has his own capital of W, which is smaller than K. Hence an investor must borrow $K-W$ from a bank if he wants to undertake an investment project. An investor's own capital W is used as collateral, which is taken by the lending bank if the project fails. Let the borrowing-lending rate be R. We assume that investors have an opportunity to earn R^* on their own capital. The opportunity cost R^* is taken as an exogenously determined parameter. These lead to the following expected profit function for an investor:

$$E\pi_f = p[S-R(K-W)]-(1-p)W \tag{1}$$

A bank in our model is in the business of mobilizing funds from savers and allocating them to investors. Let n be the number of projects a typical bank is going to fund. The total amount of funds a bank lends out then will be $n(K-W)$. When an investment project succeeds, the lending bank will get $Rn(K-W)$ as a return on their loans. When an investment project fails, on the other hand, the lending bank can secure only the collateral nW. Banks mobilize the necessary funds by paying R^* on $n(K-W)$. In addition to this, banks have to incur costs of mobilizing, processing, and allocating funds. This cost of 'intermediation' is a strictly increasing and strictly convex function $G(\ )$ of the volume of intermediation $n(K-W)$. We take $G=F+1/2[n(K-W)]^2$ as our cost function, where F stands for a fixed cost. This function will enable us to derive an explicit solution.[2] Thus a

[2] The convexity of the cost function $G(\ )$ allows us to locate a unique equilibrium. If $G(\ )$ is linear, we would have either a degenerate equilibrium or

typical bank's expected profit function can be written as follows:

$$E\pi_b = p \cdot R \cdot n(K-W) + (1-p) \cdot nW - R^* \cdot n(K-W) - F - \frac{1}{2}[n(K-W)]^2 \quad (2)$$

B. Determination of Equilibrium

For a typical bank, the lending rate R is a given data. Its only choice variable is the number of projects n that it will fund. The first order condition for profit maximization is as follows:

$$pR(K-W) + (1-p)W - R^*(K-W) - n(K-W)^2 = 0 \quad (3)$$

From (4) we can immediately get the following solution:

$$n = \frac{pR + (1-p)\frac{W}{K-W} - R^*}{K-W} \quad (4)$$

Note that the number of projects a typical bank will fund is an increasing function of R, p, and W, and a decreasing function of K and R^*. Note that the fixed cost F does not enter (4). As far as the determination of n is concerned, the presence of a fixed cost seems to be immaterial. (We will show that this needs not be the only case.)

The number of projects n given in (4) is not yet an equilibrium quantity. We have to determine the equilibrium R in order to reach at the equilibrium n. How is the equilibrium interest rate R determined? Conceptually, it would be determined as a number in between the maximum rate $\bar{R}$ borrowers are willing to pay and the minimum rate $\tilde{R}$ banks are willing to charge. Let us now turn to the determination of $\bar{R}$ and $\tilde{R}$. (The two usually coincide and yield a unique value. But we cannot rule out the possibility that $\bar{R}$ turns out to be higher than $\tilde{R}$. If the latter is higher than the former, nobody would be willing to undertake projects.)

In order to find out $\bar{R}$, we need to consider the decision problem for an investor. An investor's expected profit function, Equation (1), indicates that all the variables contained in the equation are 'not' the decision variables for the investor. Is there nothing for the investor to

a continuum of equilibrium. Here we rule out increasing returns.

decide then? In fact the only decision an investor makes is whether to undertake a project. Since an investor can earn R^*W elsewhere, he will enter the market only when the following holds:

$$E\pi_f \geq R^*W \tag{5}$$

Note that the expected profits of the investor is a function of the borrowing rate R. Thus what the Equation (5) says is that an investment project will be undertaken when the borrowing rate charged by a lending bank is not so high as to violate the inequality. Now as long as the inequality given in (5) holds, investors will enter the market. As more investors enter the market, the borrowing rate will naturally rise. As the borrowing rate rises, the inequality given in (5) will eventually cease to hold. This means that, at a particular level of interest rate $\bar{R}$, the relationship given in (5) will hold as an equality. Solving for the particular interest rate $\bar{R}$, we get the following expression:

$$\bar{R} = \frac{S + W - \frac{(1+R^*)}{p}W}{K - W} \tag{6}$$

This is the 'maximum' borrowing rate that investors are willing to pay. It is the rate at which investors just break even, in the sense that they expect to earn just as much profits as they can earn from the best alternative.

Before we proceed, we want to show that $\bar{R}$ represents only a portion of the borrowing costs. Recall that an investor borrows $(K-W)$ and pays on average $p\bar{R}(K-W)+(1-p)W$ back to the bank. Thus the true cost of borrowing should be calculated as follows:

$$\frac{p\bar{R}(K-W)+(1-p)W}{K-W} = \frac{pS - R^*K}{K-W} \tag{7}$$

It is easy to see that the true cost would exceed R^* if $pS > R^*K$. This condition is equivalent to $(S/K) > R^*/p$. Thus as long as the 'real' rate of return on investment exceeds the risk adjusted opportunity cost of borrowing, investors would willingly pay a cost higher than R^*.

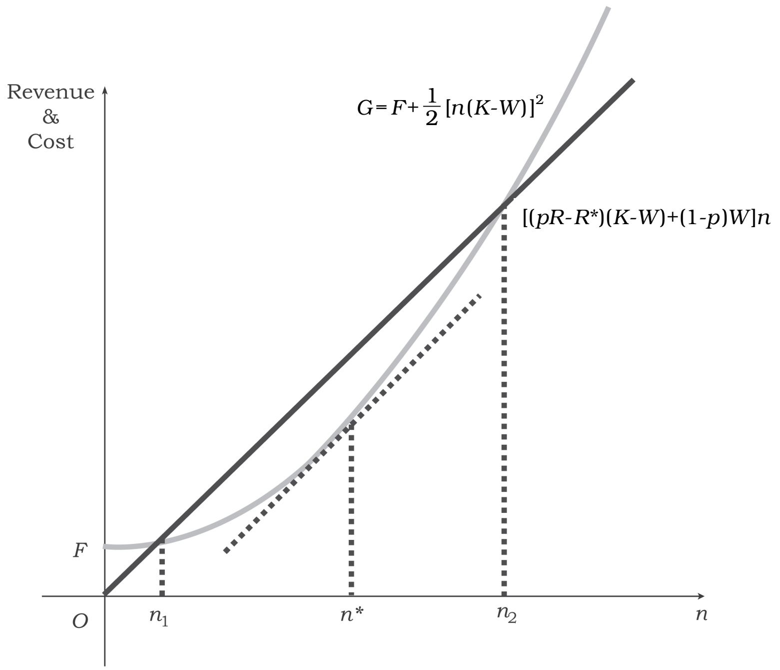


FIGURE 1

DETERMINATION OF n WHEN THE LENDING RATE IS GIVEN AS R

If the lending rate charged by banks turns out to be equal to the borrowing rate $\bar{R}$, then the number of projects that a bank would fund is determined as follows:

$$\bar{n} = \frac{pS - R^{*}K}{(K - W)^{2}} \tag{8}$$

Note that indeed $\bar{n}$ is independent of the fixed cost. Thus, when a bank can charge the maximum rate an investor is willing to pay, it can safely disregard the fixed cost, since it can earn much more than the fixed cost. Finally, as we want to have a positive $\bar{n}$, we should have $(S/K) > R^{*}/p$. But this is nothing but the condition that $\bar{R}$ is higher than R^{*}.

What would be the interest rate a lending bank charges? Would it be identical to $\bar{R}$ we have just derived? In order to find this out, let us first represent on a figure the choice of n for a given R. [Figure 1] does

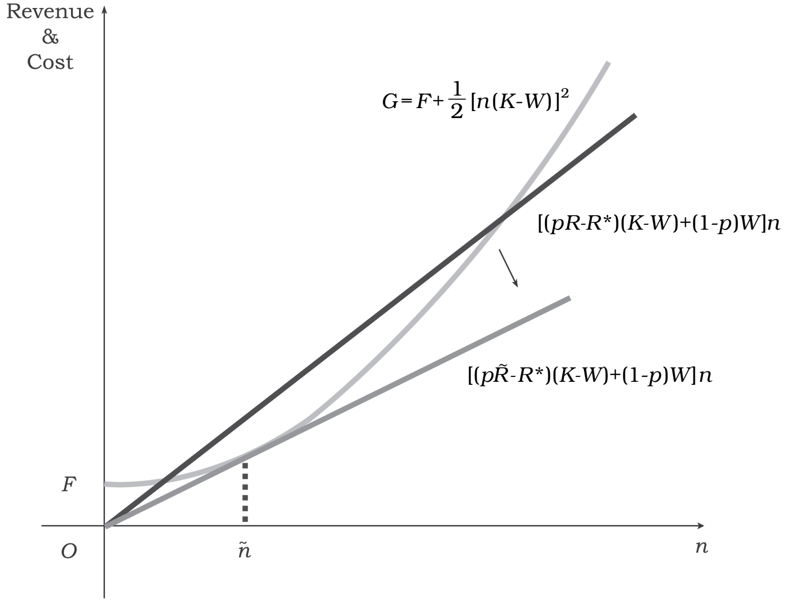


FIGURE 2
DETERMINATION OF n AND R WHEN ENTRY IS FREE

exactly that. The figure depicts the revenue and the cost of a typical bank, both as functions of n. The revenue is a linear function passing through the origin with a slope of $(pR-R^*)(K-W)+(1-p)W$. The cost is a hyperbola with an intercept F. Notice that the lending rate R enters the revenue function. But at this stage it is just a given data. Under the assumption that the slope of the revenue function is sufficiently large, we would then have the outcome depicted in [Figure 1]. As one can see, a lending bank would choose an $n^* \in [n_1, n_2]$, as its profit maximizing number of projects to fund. Needless to say, the choice n^* would be altered whenever R changes.

Note, however, that the lending bank makes positive profits at n^*. Apparently the lending rate is still 'too' high. The positive profits would induce additional banks to enter. As they do, then, the lending rate would surely fall. How far would it fall? The answer is given in the [Figure 2]:

As one can readily see from the figure, now the revenue line is just tangent to the cost curve. The tangency would occur when the lending rate goes down to $\tilde{R}$. When the lending rate falls to $\tilde{R}$, no additional banks would enter the market and all the incumbent banks would choose $\tilde{n}$ as their equilibrium number of projects to fund. We can easily derive the exact value of $\tilde{R}$ and $\tilde{n}$ from the given information. They are as follow:[3]

$$\tilde{R} = \frac{R^* + \sqrt{2F}}{p} - \frac{(1-p)W}{p(K-W)} \tag{9}$$

$$\tilde{n} = \frac{\sqrt{2F}}{K-W} \tag{10}$$

Note carefully that whereas $\tilde{n}$ in (10) is crucially dependent on the fixed cost F, $\bar{n}$ in (8) is not. Apparently, when a bank can charge the maximum a borrower is prepared to pay, it can determine the number of funded project independent of the fixed cost of intermediation. However, if it has to charge only the minimum rate it can bear, the fixed cost becomes critical for his decision.

$\tilde{R}$ is the minimum rate a lending bank is willing to accept and $\bar{R}$ is the maximum rate a borrower is willing to pay. In a usual model, both should coincide. But in our model they need not. Now if $\tilde{R}>\bar{R}$, no mutually agreeable transactions would occur: The minimum rate for a bank is simply too high for a borrower to bear. When $\bar{R}>\tilde{R}$, on the other hand, the equilibrium becomes indeterminate: The maximum rate a borrower is willing to pay is higher than the minimum rate a bank is willing to accept.

From Equations (6) and (9), we have the following relationship:

$$\bar{R} - \tilde{R} = \frac{(pS - R^*K) - \sqrt{2F}(K-W)}{p(K-W)} \tag{11}$$

The expression in (11) will be non-negative whenever $(pS-R^*K)-\sqrt{2F}(K-W)\geq 0$ holds. In what follows we assume this inequality. Of course, if $(pS-R^*K)=\sqrt{2F}(K-W)$, the two rates would coincide. However, the probability for that happening is rather slim.

Which is larger $\tilde{n}$ or $\bar{n}$? Note that the condition for $\bar{R}>\tilde{R}$ to hold, $(pS-R^*K)\geq\sqrt{2F}(K-W)$, suggests the following:

[3] For this, let the optimal choice represented in (4) be $\tilde{n}$, when $R=\tilde{R}$. Then substitute $\tilde{n}$ into (2) and find $\tilde{R}$ that would make a bank just breakeven.

$$\bar{n}(K-W)=\frac{pS-R^{*}K}{(K-W)}\geq\sqrt{2F}=\tilde{n}(K-W) \tag{12}$$

In (12) the first equality comes from (8) and the last equality comes from (10). Thus the condition for $\bar{R}>\tilde{R}$ to hold is also the condition for $\bar{n}>\tilde{n}$ to hold. That is, when $(pS-R^{*}K)\geq\sqrt{2F}(K-W)$ holds, $\bar{R}>\tilde{R}$ as well as $n>\tilde{n}$ hold, too.

When $\bar{R}>\tilde{R}$ holds, however, a new problem arises. We have argued that any number in $[\tilde{R}, \bar{R}]$ could be an equilibrium interest rate. But when the interest rate is so determined, either the banks or the investors (or both) would earn positive profits. This violates the free entry condition we have assumed for the two industries.

How to alleviate this problem? One, admittedly arbitrary, solution is to induce banks to charge $\bar{R}$ as the lending rate, and then tax away excessive profits. Another equally arbitrary solution is to induce borrowers to pay only $\tilde{R}$, and then tax away excessive profits it would make. Of course, by appropriately imposing taxation on both the banks and the borrowers, one can set the equilibrium rate to any number in $[\tilde{R}, \bar{R}]$.

But what would then be a desirable policy option? The answer depends on the policy goals. In passing we just note that the largest possible number of projects could be funded, if we let the banks charge $\bar{R}$ and then tax away their excessive profits in a lump sum manner. The tax revenue thus collected could be used for some other policy goals. Note that in this case our equilibrium would become $\bar{R}$ and $\bar{n}$, given respectively in (6) and (8).

C. Characteristics of the Equilibrium

Suppose in what follows that $\bar{R}$ and $\bar{n}$ are indeed our equilibrium. The Equation (6) indicates that $\bar{R}$ is increasing in S and p, but decreasing in K and R^*. It is quite natural for R to rise when the real yields S of an investment project becomes larger, *i.e.*, when the real return on investment S/K rises. It is also natural to expect for R to rise when an investment project becomes more probable to succeed.

On the other hand, if a larger K is required to undertake a project, the equilibrium interest rate would go down. (This is equivalent to a case when S/K falls.) Likewise, if the alternative becomes more attractive, R^* gets higher, the equilibrium rate goes down. When alternatives become more attractive, the investment opportunity under consideration becomes less attractive. This would lead to a fall in $\bar{R}$.

How about the effect of the investor's own capital W on $\bar{R}$? An increase in the own capital W would induce R to fall except for the case when the real (gross) rate of return on investment, S/K, is very high. When this rate is very high, competition among wealthier investors would raise $\bar{R}$.

The equilibrium number of projects a bank decides to fund $\bar{n}$ is an increasing function of S, W, and p. When the real yield on a project becomes larger, more projects would be funded. Likewise, as investors' own capital becomes larger, more projects would be funded. Finally, an increase in the success probability induces more projects to be funded.

On the other hand, as R^* or K becomes larger, the equilibrium $\bar{n}$ would decrease. Apparently, when alternatives become more attractive, fewer investment projects would be undertaken. Likewise, when the required capital K for a project gets larger, fewer projects would be undertaken. It is natural for that to occur, since the real rate of return becomes smaller, when K gets larger for a given S.

This completes our discussions on how the problem of funding risky investment projects proposed by new start up firms is handled. Under a condition that can be easily met in real life, we find that both the market clearing interest rate and the accompanying equilibrium number of projects are 'indeterminate.' There exists a range $[\tilde{R}, \bar{R}]$ such that any $\underline{R}$ in $[\tilde{R}, \bar{R}]$ could be an equilibrium rate. The corresponding $\underline{n}$ also lies in $[\tilde{n}, \bar{n}]$. Of course, $\tilde{R}$ might turn out to be equal to $\bar{R}$. But the probability for this occurring is rather small. The indeterminacy is a disappointing feature of our model. However, as we have already suggested, it can be alleviated with a judicious choice of policies.

We have so far assumed that the fundamental randomness inherent in our model economy is something beyond one's influence. This assumption seems to be too strong: There may appear an agent or agents who might alter the nature of the randomness. For instance, someone might engage in screening or credit evaluation activities, and thereby raise the probability for a project to succeed. Let us now turn to that case.

III. Funding New Investment Projects When Screening Services Are Available

A. The Extended Model

Suppose now that there exists in the economy, in addition to banks and investors, a firm (or firms) who offers screening services. We model a screening firm as someone who 'buys' a right to visit our urn and reconfigure it so that the probability for a project succeeding improves. What the firm does is to buy a right to draw m-balls from the urn. Of the m-balls drawn, the screener returns only the white balls back to the urn. The black balls are eliminated from the urn. As a result of this operation, the urn is now reconfigured. Originally it contained N balls, of which Np were white and $N(1-p)$ were black. Now it contains altogether $N-(1-p)m$ balls, of which Np are white and $(N-m)(1-p)$ are black. If anyone randomly draws a ball from the reconfigured urn, the probability for that ball to be white is now given by the following:

$$p(m) = \frac{Np}{N-(1-p)m} \tag{13}$$

Obviously, m must be in between 0 and N. Indeed, we have $p(0)=p$ and $p(N)=1$. Furthermore, it is easy to see that $p(m)$ is a strictly increasing in m. The more balls a screening firm 'previews,' the higher it can make the success probability.

In order to draw m-balls from the urn, a screening firm incurs costs $c(m)$. These are what we call screening costs. In general these costs would consist of many things. However, we will lump them together and make costs only function of m. The cost function $c(m)$ is assumed to be non-negative, strictly increasing and strictly convex.[4]

The screening firm (or firms), who has thus reconfigured the urn, issues 'certificates' that guarantee to their holders a higher probability $p(m)$. Since $p(m)$ is higher than p, investors would have an incentive to buy the certificates. The lending banks do also know that projects undertaken by investors with the certificates have a higher probability of success. In this case, banks might want to provide funds only for the investors with certificates. That is, the certificates might be valuable

[4] For our purpose all that is needed is that the marginal cost of screening is non-decreasing.

to banks, too.

Whether an investor actually buys a certificate, of course, would depend on how much it has to pay for it. Likewise, whether a bank actually decides to give a priority to an investor with a certificate would depend on how much the bank should pay for the superior information. Though there is no a priori reason, we will assume that the cost of a certificate would be borne by an investor.[5]

Let the price of a certificate be $q(m)$. How would it be determined? A potential investor knows that his chance to obtain the needed fund is virtually zero unless he submits a certificate to the lending bank. When an investor pays $q(m)$ to obtain a certificate, its expected profit would be revised as follows:

$$E\pi_f = p(m)[\mathrm{S} - R(m)(K-W)] - (1-p(m))\mathrm{W} - q(m) \tag{14}$$

We know that an investor would actually undertake a project only if the expected profit given in (15) is larger than or equal to its best alternative. Therefore, the maximum price an investor would be willing to pay for a certificate is determined as the following:

$$q(m) = p(m)[S - R(m)(K-W)] - [1-p(m)]W - R^*W \tag{15}$$

The price of the certificate $q(m)$ in (15), which contains an endogenous variable $R(m)$, is not yet an answer we are seeking. It just indicates the maximum price an investor would be willing to pay for a certificate, knowing that it has to pay $R(m)$ for the borrowed fund.

How is $R(m)$ determined? In order to find this out, we must consider the decision problem of a bank. The presence of screening services will not alter the structure of a bank's decision problem other than the fact that now the probability of the funded project succeeding is $p(m)$. The revised expected profit function of a bank is then given by the following:

$$\begin{aligned} E\pi_b &= p(m)R(m)n(m)(K-W) \\ &\quad + [1-p(m)]n(m)W - R^*n(m)(K-W) - F - \frac{1}{2}[n(m)(K-W)]^2 \end{aligned} \tag{16}$$

[5] We would get the same results, even when we let the banks bear the cost of certificates.

Except for the fact that p, R, and n are replaced with $p(m)$, $R(m)$, and $n(m)$, (16) is essentially the same as (2).

For an individual bank, $R(m)$ is a given data to be determined when the entire industry is in equilibrium. Its decision variable is $n(m)$, the number of projects to fund. As before, an individual bank would choose $n(m)$ so as to maximize its expected profits. The choice would naturally be a function of $R(m)$. We get the following from the first order condition for profit maximization:

$$n(m) = \frac{p(m)R(m) - R^* + \frac{[1-p(m)]W}{K-W}}{K-W} \tag{17}$$

Again, this is essentially the same as (4). This is not yet a final answer: We should know the value of $R(m)$. How is $R(m)$ determined? As before, it is determined at a level at which no more banks would enter the market. That is, it is determined so that all the incumbent banks would just break even with that particular lending rate.

When we solve the first order condition and the zero profit condition simultaneously, we get the following result:

$$\tilde{n} = \frac{\sqrt{2F}}{K-W} \tag{18}$$

Interestingly enough, this is exactly the same $\tilde{n}$ given in (10). Remember that this was the number of projects, when no screening services were available, a bank would fund when it could charge the minimum rate $\tilde{R}$.

When we substitute (18) into (17), we get the following:

$$R(m) = \frac{R^* + \sqrt{2F}}{p(m)} - \frac{[1-p(m)]W}{p(m)(K-W)} \tag{19}$$

This is the equilibrium lending rate. Of course, it is also the equilibrium borrowing rate for our investors. (Borrowers may want to pay higher rates, but they do not have to.)

Now we can go back to (15) to find out the price of a certificate that an investor (a buyer) is willing to pay. For this substitute $R(m)$ from (19) into (15) to get the following:

$$q(m)=p(m)S-R^*K-\sqrt{2F}\,(K-W) \tag{20}$$

This is the maximum price of a certificate that guarantees to its holder that the investment project it would undertake would succeed with probability $p(m)$. Recall that an investment project without a guarantee would succeed only with probability p.

B. Characterization of the (as yet partial) Equilibrium

When screening services are available, the equilibrium configurations are altered, some only superficially, but others fundamentally.

Note first that our equilibrium is not yet the end result, because the number of balls drawn m, *i.e.*, the extent of screening activities, is not yet determined. For this we have to consider the screening industry. We leave the task for next section.

The most fundamental change is the fact that now the equilibrium is uniquely determined. Remember that, when screening services are unavailable, the model as we have specified has an indeterminacy problem. We have found that any number $\underline{R}$ in $[\tilde{R}, \bar{R}]$, and its accompanying counterpart $\underline{n}$ in $[\tilde{n}, \bar{n}]$ can be an equilibrium pair. But when we introduce screening services for a pay, the indeterminacy problem vanishes: We now get a unique equilibrium pair.[6]

What is the economic rationale for this change? Before virtually everyone can become an investor provided that he is willing to bear the borrowing cost. But a bank would fund only a limited number of projects. As a result fierce competition would arise among potential investors. This competition pushes up the borrowing rate way above the rate that competing banks would be willing to charge. Hence was the indeterminacy. However, now a potential investor has to pay an upfront cost, an entry or a fixed cost so to speak, to apply for a loan. That is, he has to purchase a certificate to enter into the business. Competition among the potential investors now bid up the price of the certificate, and there would be no room for them to bid up the interest rate. (In any case, banks do not have a power to make R higher than $R(m)$ given in (19).)

Another important change has to do with the determination of $\tilde{n}$.

[6] Alternatively the indeterminacy problem may disappear, if banks themselves enter into the screening businesses. Studying implications of the vertical integration is beyond the scope of this paper, however.

The equilibrium we have reached at, Equation (18), shows that the number of project an individual bank would fund is only a function of the fixed cost of the banking business F and the size of a loan $(K-W)$. In particular, in our model neither the lending rate $R(m)$, the probability of success for a project $p(m)$, nor the best alternative R^* matter for the determination of $\tilde{n}$. All of these crucially enter into the determination of $R(m)$, though. It appears that $R(m)$ completely absorbs the influence of $p(m)$ and R^* so that they do not affect $\tilde{n}$.[7]

The revised lending rate $R(m)$ is almost identical to R except for the fact that now $p(m)$ enters in place of p. Note that $R(m)$ is decreasing in $p(m)$, unless investors posses relatively large wealth. A sufficient condition of $R(m)$ decreasing in $p(m)$ is an investor's wealth W is smaller than or equal to one half of the needed investment K. Since $p(m)$ is increasing in m, whenever $W<(1/2)K$ holds, $R(m)$ decreases with m. In this case then we will have $R(m)\leq R(0)\equiv\tilde{R}$, for all $0\leq m\leq N$. In general an investor's own capital W would be very much smaller than the required investment K. Thus we can conclude that the presence of the screening industry would lower the economy's lending rate. This happens because the banking industry lowers the lending rate when they encounter loan applications with higher probability of success.

IV. Determination of Screening Activities

A. How to Model the Screening Industry?

We have demonstrated in Section III that the presence of a screening industry would substantially alter the characteristics of financial transactions. In order to complete the analysis, we have to understand how the screening activities are determined in equilibrium. For us this amounts to understanding how m is determined.

We have learned so far that, when screening services are available, i) the probability for a project succeeding goes up to $p(m)$, ii) a bank would fund $\tilde{n}$ investment projects, iii) the interest rate is $R(m)$, and iv) investors would pay $q(m)$ to buy a certificate issued by a screening firm. The remaining task is to find out how m is determined.

Suppose now that altogether y banks are in business. (The number

[7] This is mainly due to the linearity of the marginal cost curve (a quadratic cost function).

of banks is taken as given. Its determination is beyond our concern.) Since each of these banks would fund $\tilde{n}$ projects, the total number of projects that would be undertaken in the economy would be $y \cdot \tilde{n}$. We know that only those investors who possess a certificate would get loans from the bank. Therefore, the total number of certificates the screening industry can sell is also $y \cdot \tilde{n}$. Since the price of the certificate is $q(m)$, $y \cdot \tilde{n} \cdot q(m)$ is the aggregate revenue for the screening industry.

In Section III, we have already introduced a screening cost function $c(m)$, which encompasses all the costs incurred by a screening firm. Recall that we have assumed $c(m)$ to be a strictly increasing strictly convex function.

With revenue as well as cost thus described, it seems to be a simple matter to find out how the equilibrium m is determined. However, the problem is not that simple. Depending on how many firms are in the screening industry, we might have different outcomes. For example, a competitive allocation would surely differ from a monopoly allocation. (Of course, this must also true for the banking or the investment industry. But our main concern in this paper is to understand the nature of screening activities. Thus we have limited our analysis of the banking and investment industries only to the case of perfect competition.) Of diverse market structure, we consider three alternatives: *de facto* perfect competition (not necessarily a textbook version), a public monopoly, and a private monopoly.

B. Equilibrium When Many Screening Firms Are in Competition

Suppose that altogether x screening firms are competing in the market. (Again, we assume x to be a given data.) Each screening firm buys a right to reconfigure our hypothetical urn. What it does is to draw m-balls from an urn and eliminate black balls: White balls are returned back to the urn. For convenience, just imagine that there exist in the economy a large number of homogenous urns. Anyone who pays $c(m)$ can reconfigure one of the urn. It can sell to the investors a right to draw a ball from the reconfigured urn.

When there are x competing firms, each of them would have a market share of $(y/x)\tilde{n}$. Thus its profit function is given by the following:

$$E\pi_s = \frac{y}{x} \cdot \tilde{n} \cdot \bar{q} - c(m) \tag{21}$$

Here the price of the certificate $\bar{q}$ is determined in equilibrium. As such it is not a choice variable for an individual screening firm. Neither the number of certificates it can sell, $(y/x)\cdot\tilde{n}$, is a choice variable. All that it can control is m and hence $c(m)$. Here one may wonder why the number of certificates a screening firm sells is not a choice variable. But notice that once a firm produced m, marginal cost of issuing certificates becomes zero. As a result the optimal choice for the issuing firm is to sell as many certificates as it can. Note that this latter is determined by banks in our model.

How would a competing firm determine m, then? It would determine m so that the Equation (21) would equal to zero, (*i.e.*, all competing firms earn zero profits). Let the solution be $\bar{m}$. It satisfies the following:

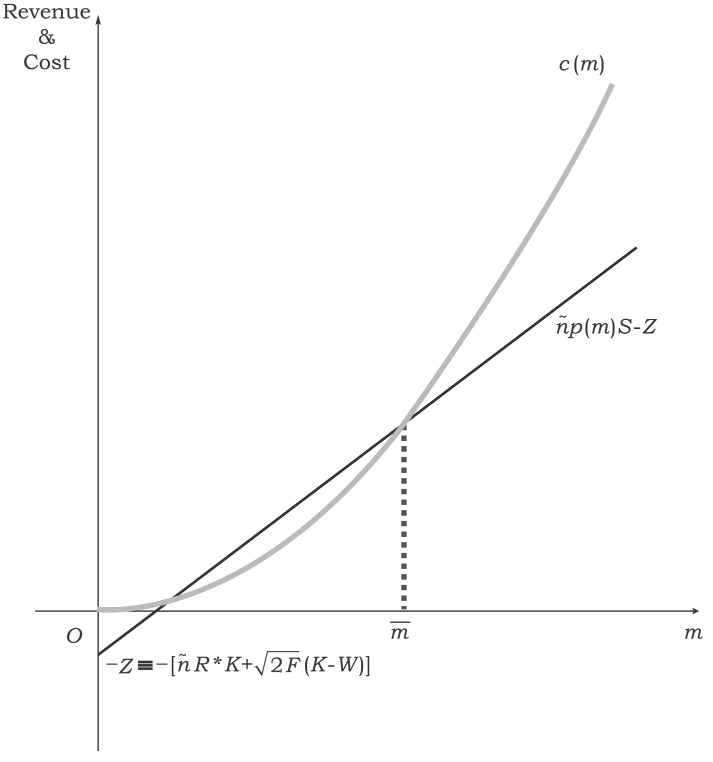
$$\frac{y}{x}\cdot\tilde{n}\cdot\bar{q} = c(\bar{m}) \tag{22}$$

As one can see very easily, a solution for (22) would be a function of y/x, where y stands for the number of banks and x stands for the number of screening firms. Since we are not primarily concerned with how y or x is determined, both y and x are treated as exogenous variables in our model. As such they can take any value. In particular y can be equal to x. Let us assume in what follow that is the case.

For an individual screening firm $\bar{q}$ is a given data, but for the screening industry as a whole it is not: It must be determined as an outcome of the equilibrating process. This means that the following must hold in equilibrium, where we have substituted $q(m)$ given in (20) for $\bar{q}$, with m replaced with $\bar{m}$:

$$\tilde{n}\cdot q(\bar{m})=\tilde{n}\cdot[p(\bar{m})S-R^{*}K-\sqrt{2F}\,(K-W)]=c(\bar{m}) \tag{23}$$

The competitive equilibrium can be represented in a figure as follows: As the [Figure 3] shows, when the parameters of the model have suitable values, there exists a unique competitive equilibrium $\bar{m}$. Once $\bar{m}$ is determined in this manner, we can immediately determine equilibrium values for R and q, too. For this, just substitute $\bar{m}$ into (20) and (21). Then $\{\bar{m}, R(\bar{m}), \tilde{n}, q(\bar{m}), p(\bar{m})\}$ constitute the equilibrium configurations we have been seeking for the case of the competitive screening industry.

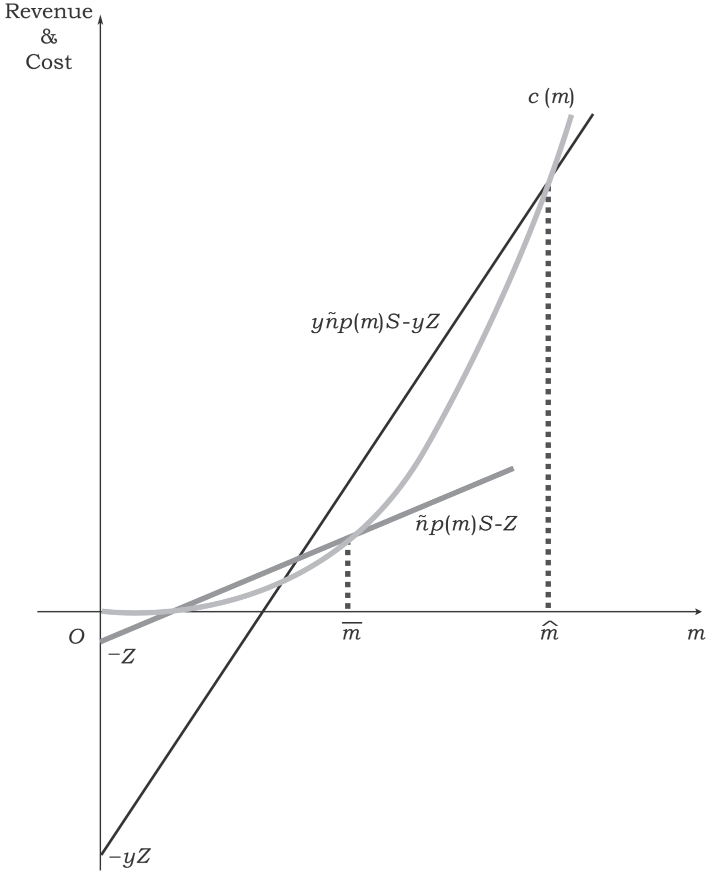


Note: The 'line' representing revenues is not really a line. It should be a strictly increasing convex curve, too.

FIGURE 3
DETERMINATION OF THE SCREENING INTENSITY m
WHEN MANY FIRMS COMPETE

C. Equilibrium When the Screening Industry Is Monopolized by a Public Entity

When the screening industry is monopolized by a public entity, how would the outcomes change? The answer depends on the mandate(s) given to the monopoly firm. There could be many reasons why a government wants to monopolize screening businesses. For instance, it may want to provide funds for the largest number of investment projects, thinking that it would foster economic growth. Or, it may imagine that screening businesses are subject to market failures when



Note: The intercept of the dark black 'line' must be way below the intercept of the red 'line,' as it is y times Z. Its slope is also n-times steeper than the red 'line.'

FIGURE 4

DETERMINATION OF SCREENING INTENSITY m UNDER A PUBLIC MONOPOLY

left to unfettered competition, and opts for a government monopoly. And so on. Of these, we will consider the case of maximizing the number of funded projects, subject to a condition that the monopoly should not incur losses.

The mandate for the public monopoly can be implemented when the following condition holds:

$$y \cdot \tilde{n} \cdot q(m) - c(m) = 0 \tag{24}$$

Here $y \cdot \tilde{n}$ denotes how many certificates the monopolist can sell. Of course, it is also the aggregate number of projects the entire banking industry would provide funding. In a more general setting, the number of project n that a single bank would fund should be dependent on m. However, for our particular model, $\tilde{n}$ is invariant to a choice of m.[8]

The equilibrium condition for the public monopoly given in (24) looks almost identical to the condition (23) that would hold for a competitive industry. One may thus conclude that the public monopolist would choose the same m, the equilibrium for the competitive industry. Of course, this is a wrong conclusion.

A crucial difference comes from the presence of y in (25). Whereas a firm in the competitive industry has a market share of $\tilde{n}$ (under the assumption that $y=x$), the monopolist has a market share of $y \cdot \tilde{n}$, *i.e.*, the monopolist has the entire market. As we assume a competitive banking industry, the number of banks y must be a fairly large number. Thus the number of customers a monopolist would deal with, $y \cdot \tilde{n}$, should be much larger than the number of customers a competitive firm would deal with, $\tilde{n}$. This suggests that the optimum choice of $\hat{m}$ for the public monopolist with the said mandate would be much bigger than $\bar{m}$.

The [Figure 4] shows a public monopolist's choice when it needs only to break even. Notice that now the revenue function is given by $y \cdot \tilde{n} \cdot q(m)$, not by $(y/x) \cdot \tilde{n} \cdot q(m)$. As long as $x>1$, the former is much bigger than the latter. Thus the value $\hat{m}$ at which the public monopolist just breaks even would be much larger than $\bar{m}$. When m is so determined, then we would have $R(\hat{m})$, $q(\hat{m})$, and $p(\hat{m})$ as new equilibrium values. But n would still be $\tilde{n}$.

In sum, we get equilibrium configurations $\{\hat{m}, R(\hat{m}), \tilde{n}, q(\hat{m}), p(\hat{m})\}$ when the screening industry is run by a public monopolist with a mandate to induce funding for the maximum number of projects.

D. Equilibrium under a Profit Maximizing Monopoly

Suppose now that the screening industry is run by a monopoly who seeks maximum profits. Needless to say, a private monopoly would surely try to maximize its profits. But a public monopoly would behave

[8] Recall that this result is due to the linearity of the marginal cost of screening.

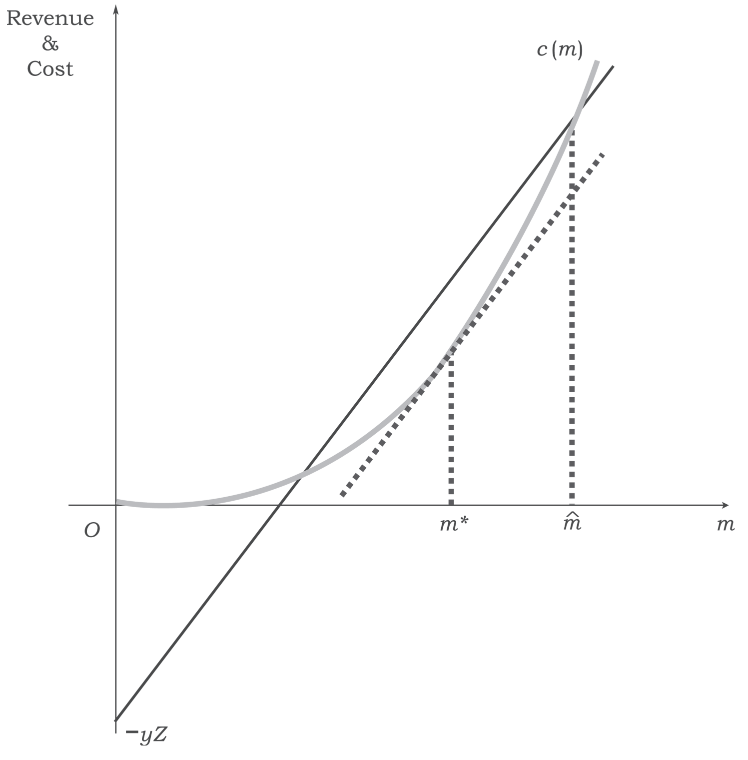


FIGURE 5
DETERMINATION OF m UNDER A PROFIT MAXIMIZING MONOPOLY

the same, if the government imposes a mandate to earn as much as possible. In either case, when there is only a single screening firm, its profit function takes the following form:

$$\pi_s = y \cdot \tilde{n} \cdot q(m) - c(m) \tag{25}$$

The profit maximizing monopolist's choice of m is given by the solution to the following first order condition:

$$y \cdot \tilde{n} \cdot q(m^*)' = c(m^*)' \tag{26}$$

As one can see from [Figure 5], the profit maximizing monopolist's choice of m, m^*, is smaller than the public monopolist's choice of m, $\hat{m}$. Of course, this must be the case, since the formers to obtain positive profits, but the latter tries only to break even.

In sum, we get equilibrium configurations $\{m^*, R(m^*), \tilde{n}, q(m^*), p(m^*)\}$ when the screening industry is run by a profit maximizing monopolist.

V. Implications

A. Competition vs. Monopoly in Information Production

It is quite natural for different forms of competition to produce different equilibrium configurations. For example, we generally expect a profit maximizing monopoly to produce a smaller quantity than a competitive industry would. Likewise, we generally expect a profit maximizing monopoly to charge a higher price than a competitive industry would. How is it about the public monopoly that has a mandate to maximize 'outputs'? Here normally one expects a public monopolist to produce a larger quantity than a profit maximizing monopoly would. On the other hand, one normally expects a public monopoly to charge a higher price than a competitive industry would.

In the case of the screening activities under considerations, however, we have different results. Remember that we have $\bar{m}$, m^*, and $\hat{m}$ for the three cases, where $\bar{m}<m^*<\hat{m}$ holds. A public monopoly produces a largest amount of screening services, a profit maximizing monopoly comes next, and the competitive industry produces the smallest amount. In terms of the price of a certificate, we have $q(\hat{m})>q(m^*)>q(\bar{m})$, since $q(m)$ is monotone increasing in m. Thus a public monopoly would charge the highest, a profit maximizing monopoly comes next, and competitive industry charges the lowest. In terms of the borrowing-lending rate, we have $R(\bar{m})>R(m^*)>R(\hat{m})$. Thus R turns out to be the lowest when a public monopoly runs the screening industry and the highest when it is run by many competing firms. A profit maximizing monopoly induces it to come in between the two.

In terms of the projects that would be actually funded, the three alternatives produce an identical outcome: Regardless of the forms of competition, n is always determined as $\tilde{n}$. This result seems to come from our assumption that marginal cost of screening is linear. A more general cost function would most likely produce $n(\hat{m})>n(m^*)>n(\bar{m})$, reflecting the fact that $\hat{m}>m^*>\bar{m}$. Finally, since the probability for a project succeeding p is an increasing function of m, we have $p(\hat{m})>$

$p(m^*) > p(\bar{m})$. Thus when the screening industry is run by a public monopoly, a project would have a highest probability of succeeding. On the hand, a project would be least likely to succeed, when screening services are provided by many competing firms. On this account, a profit maximizing monopoly comes again in between.

Is a high $q(m)$ better than a low $q(m)$, or vice versa? Is a high $R(m)$ better than a low $R(m)$, or vice versa? Our model does not provide any guidance in this regard, so we cannot say which is better. Is a large n better than a small n? Since n is the number of investment projects that would be undertaken, perhaps we can conclude that a large n is better. (It might make senses to argue for increased investment from, say, growth perspectives. But it would be difficult to argue the same for R or q.) But here we have a problem. As we have seen in the above, our model produces the same $\tilde{n}$ for the three alternatives. Thus we cannot differentiate them with n, either.

When it comes to the amount of screening services produced m and the accompanying costs $c(m)$, we have different pictures. Recall that we have $\hat{m} > m^* > \bar{m}$, so it must be the case that $c(\hat{m}) > c(m^*) > c(\bar{m})$. In terms of screening costs, 'a' competitive firm incurs the least, a profit maximizing monopoly the next, and a public monopoly the most. Therefore, it seems that we must judge the competitive industry to be the best option. The conclusion accords very well with our usual predilection toward free competition.

However, this conclusion is totally wrong in our case. What we have is a reverse ranking: We find that a profit maximizing monopoly is the best, and perfect competition is the worst. The public monopoly comes in between. This conclusion is based on the observation that, in terms of screening costs, the competitive screening industry incurs the most and the profit maximizing monopoly the least. A public monopoly costs more than a profit maximizing monopoly, but less than a competitive industry.

Note that, a single competing firm's screening costs are $c(\bar{m})$. We know that this $c(\bar{m})$ is much smaller than $c(m^*)$, a profit maximizing monopolist's screening costs. This in turn is smaller than $c(\hat{m})$, a public monopolist's screening costs. Thus one may conclude that a competitive industry would incur the least amount of screening costs. However, $c(\bar{m})$ is only a single firm's cost. As there are altogether x screening firms, the total industry costs are $x \cdot c(\bar{m})$. Thus we must compare this with $c(m^*)$ and/or $c(\hat{m})$. Which is bigger, $x \cdot c(\bar{m})$ or $c(\hat{m})$?[9] To be sure $c(\bar{m}) < c(\hat{m})$, but $x \cdot c(\bar{m})$ can easily exceed $c(\hat{m})$, when

x is a large number. Remember x stands for the number of firms competing in the screening industry. As such it should indeed be a large number. In sum, a competitive screening industry would incur larger costs than either form of monopoly.

B. Is Information Duplication a Necessary Cost to Avoid Free Riding?

How can a monopoly be better than a (perfect) competition? Here we must pay attention to the crucial fact that what is being produced is a piece of information. When a screening firm 'visits' our ultimate urn and successfully 'reconfigures' it, it produces a knowledge or a piece of information that whoever draws a ball from the reconfigured urn, he or she would draw a white ball (a success) with a higher probability $p(\bar{m})$. $c(\bar{m})$ is the costs that a screening firm pays to get such a knowledge.

Needless to say, a piece of information or knowledge is fundamentally different from other types of goods and services in that it is non-rival in usage. As such it needs to be produced only once, and once produced it can be used by many. It is better, therefore, that when there are x competing firms, only one produces the said information and share it with others. Because of the free riding possibility, however, this would almost never occur. Indeed, if the information is something a finder cannot exclusively use, no one would be willing to produce it. On the other hand, if a finder can use the information exclusively for himself, then everyone has to produce it. That is, each one of the x firms should engage in screening businesses: Each would produce '$p(\bar{m})$' and each would incur costs $c(\bar{m})$. This makes the industry wide costs be $x \cdot c(\bar{m})$. Note that to 'produce' $p(m)$, we need screening activities only once. However, in reality all would engage in screening activities. This way, a serious information duplication problem emerges in the competitive screening industry. This is a cost the firms are paying in order to avoid the free riding problem.

Let us summarize what we have learned here. When many firms are in competition, $p(\bar{m})$ is produced at the cost of $x \cdot c(\bar{m})$. When a public entity monopolizes the industry, $p(\hat{m})$ is produced at the cost of $c(\hat{m})$. Since $\hat{m} > \bar{m}$, $p(\hat{m}) > p(\bar{m})$. Even though $c(\hat{m}) > c(\bar{m})$, what is relevant is a comparison between $c(\hat{m})$ and $x \cdot c(\bar{m})$. The latter can easily surpasses the former. When that happens, the competitive industry would incur larger costs only to produce inferior information than what a public

[9] Recall that when $x \cdot c(\bar{m}) > c(\hat{m})$, so is $x \cdot c(\bar{m}) > c(m^*)$.

monopoly would do. Of course, in our model the gains for the society are measured by the aggregate number of projects that would be undertaken, not by $p(m)$. We have already pointed out that both the competitive industry and the public monopoly support the same number of projects. In this regard, neither is superior to the other. But since it is highly likely that $x \cdot c(\bar{m}) > c(\hat{m})$, a public monopoly is superior to (perfect) competition. Whereas a public monopoly can solve both the free-riding problem and the information duplication problem, perfect competition can only solve the free-riding problem.

How should we evaluate the choice that a profit maximizing monopolist makes? Note that we have $c(m^*) < c(\hat{m})$, since $m^* < \hat{m}$. The profit maximizing monopolist would engage in even fewer screening activities than the public monopolist. This way it saves screening costs and makes a positive profit. Note that in our model, the number of investment project that would be funded is invariant to a choice of m. The same number of projects would be funded, but a profit maximizing monopolist does it with smaller costs than a public monopoly does. The latter produces too much screening services. Thus from the society's view points, if for some reason the screening industry is to be monopolized, it is better to have a profit maximizing entity.

C. The Business of Producing and Selling Information Can Better Be Separated

However, there is a better option. The option is to have a public monopoly exclusively produce screening services. However, this time a new mandate is given to it. The mandate is to provide screening services only in the amount $\bar{m}$, the same amount of screening a competing firm would have made. This would produce a piece of information $p(\bar{m})$ at costs $c(\bar{m})$. Once the information is produced, then the public monopoly is required to sell to x issuing firms a privilege to use the information. The price of the right is set to $c(\bar{m})/x$, *i.e.*, all the issuing firms equally share the costs. Each issuing firm would then sell $(y/x) \cdot \tilde{n}$ certificates to the investors at a price $q(\bar{m})$.

Note, however, that now the certificates issuing firms earn positive profits, since each earns the same $\tilde{n} \cdot q(\bar{m})$ as before, but with a much smaller cost $c(\bar{m})/x$. How should we eliminate these excess profits? One option is to tax them away in a lump-sum fashion. Another option is to let the market solve the problem. In this case, however, the outcome would be identical to that obtained when we had our original public monopoly. The only difference is that, whereas previously a single entity undertook both production and sales of information, now those two activities are separated.

Note that both options would induce $y \cdot \tilde{n}$ projects to be undertaken. In that regard they are not different from other schemes. However, the first option now costs only $c(\bar{m})$, which is smaller than $c(m^*)$, which is in turn smaller than $c(\hat{m})$. Of course, $c(\bar{m}) < x \cdot c(\bar{m})$. Apparently the proposed scheme is the least costly method to provide screening services. Furthermore, it brings out the same equilibrium configurations $\{\bar{m}, R(\bar{m}), \tilde{n}, q(\bar{m}), p(\bar{m})\}$ as those for competitive equilibrium.

The second option, on the other hand, produces the same outcome as our original public monopoly. Its desirability should then be determined by whether the business of information sales is handled better by a competitive industry than a monopoly. Our model has nothing to differentiate each.

The finding that an information good is better produced by a single firm to avoid duplications, but the services based on it are better sold by competing firms can be applied more widely. Note, however, this conclusion does not imply that all the information production activities should be handled by a single firm. All that it suggests is that we should avoid producing the same information over and over again. When the objects are amenable to segmentation, then having many information producing firms each engaging in one particular segment could be better. For example, a screening firm for IT related ventures, another for construction companies, and still another for small and medium sized exporting firms, and so on. For very complex objects, many firms providing their own interpretations could be better. For example, many competing news medium providing diverse interpretations for human activities is much better than a single media monopolizing the news businesses. Still, examples such as AP, Reuters, or YTN suggest that we do not need to have many firms reporting on fundamentally the same events.

The strategy of letting a single firm monopolize information production has a potentially serious drawback. A monopolist is in most cases shielded from threat of competition, and as such it might have weaker incentives to do the best: It could become too complacent. In some cases, therefore, many firms competing in information production may bring out better outcomes, especially in a dynamic sense. If that is the case, then waste stemming from information duplications can be viewed as a rightful price for gains in efficiency.

D. Applications to Other Activities

Our model is admittedly too simple to deal with complex financial behaviors. For example, it does not address the information asymmetry issue. An upside, however, is that it can be applied to areas other than financial markets. The desirability, for example, of avoiding unneeded information duplications can be applied to many phenomena. Let us provide a few such examples.

Each year we spend enormous resources to 'screen' students. Think about how much parents, students, schools, and the entire education system are spending in order to assign students to universities and colleges. For this we utilize many diverse screening devices managed by many screening 'firms.' For some of these no one quite understands what they are doing. Since screening students is not that complex, perhaps all that we need is to have a single agent produce report cards on students. For example, a series of nationally administered tests could be a very cost effective screening device. Of course, this could well be supplemented with some other relevant information.

How about assigning, say, college graduates to jobs? Again a series of nationally administered job placement tests can be a very cost effective screening device. In fact we are already relying on similar schemes to select high ranking officials, lawyers, doctors, and so on. Firms, which would require quite different types of workers, can supplement the test scores with other relevant information, too.

Similar logic can be applied to the 'marriage market,' too. However, here we may need several screening firms for easily divisible subgroups. For example, one specializing for college graduates, another specializing for foreign spouses, another for re-marriage candidates, and still another for old age singles, and so on.

Indeed the logic can be applied to all goods and services that are non-rival. For instance, the same can be applied to idea generation or knowledge creation. An idea or a piece of knowledge needs to be produced only once or by one agent. Public goods and services need to be produced only once in a given period, too. For example, there is no need for different agents to separately produce national defense services. In fact, due to non-exclusion, it should be produced by a singly public entity, *i.e.*, by a government.

The open source platforms such as Linux and Wikipedia can also be viewed as attempts to reduce unneeded information duplications. In the case of Linux, many smart people are independently trying to write essentially the same codes out of ignorance of what other people are doing can be avoided. In the case of Wikipedia, once the best explanation of an item is entered, others would voluntarily move onto other items, thereby naturally reducing information duplications.

Are university lectures and textbooks amenable to the same logic? Should each lecture be 'produced' by a single superstar professor, and be delivered by many professors? (Of course, we would need many superstar professors to produce lectures for extremely diverse subjects.) Isn't it desirable to have only the best textbook for each subject? Why do we need so many principles of economics textbooks, for example? Is it so because there are many different versions of principles? Perhaps it is so for economics. But why do we have so many textbooks for seemingly non-controversial principles such as mathematics or physics? Lectures and textbooks may be different: They are more of selling than of producing information or knowledge.

VI. Concluding Remarks

Utilizing a very simple, and admittedly somewhat primitive, model, we have studied the economics of screening. The problem we have studied is 'How would competing banks decide to fund inherently risky investment projects proposed by a group of new firms? And what would the equilibrium outcomes look like?' We have considered two cases, one without and the other with a screening industry.

The fundamental uncertainty for our problem arises from the fact that a certain portion of the funded projects will fail. This fact is known to all the participants. As such the usual asymmetry of information is not an issue for us. The problem is that neither the lending banks have means to differentiate loan applicants, nor the borrowers have means to convey their credit worthiness. In fact none of them know which project would succeed: They know only that on average a funded project would succeed with a probability p.

The probability p can be changed, however, when 'screening' costs are incurred. An increase in p would in general be welcome by banks as well as investors. If someone 'sells' the service of 'raising p,' they might well be willing to buy such services. On the other hand, this someone may earn some profits through production and sales of the said services. That is, a screening industry might emerge.

The screening industry we consider is not perfect: It does not know whether a particular project would succeed or fail. All that it can do is to raise the success probability p through screening activities. (Of course, if it is prepared to incur 'unlimited costs,' it may perfectly discern whether a project would succeed or not.)

When screening services are provided, p is raised. This would in general alter the lending rate R and the number of funded projects n. Of course, the price of the screening service and the amount of screening activities would also be endogenously determined. The provision of the screening services would in general make n larger: More projects would be undertaken when screening services are provided.

The equilibrium amount of screening activities is differently determined depending on whether the screening industry is run by i) many competing firms, ii) a public monopoly with a mandate to maximize the number of funded project, or iii) a profit maximizing monopoly. We find that, in our particular model, all three alternatives would result in funding the same number of projects. But the screening costs each of them would incur are very different. We find that, contrary to usual expectations, a profit maximizing monopoly incurs the smallest costs. The public monopoly is next: It incurs costs larger than the profit maximizing monopoly, but smaller than the competitive industry.

The finding that a competitive screening industry is the most costly option appears at first to be very odd. However, when we understand that what is being produced by a screening industry is a piece of information, and information is non-rival in usage, we can see why many firms competing to produce its own outputs are 'wastes.' The information needs to be produced only once. However, unless the free riding problem is skillfully handled, we cannot avoid a serious duplication problem in information production. That is why a competitive screening industry could well be the most costly option. (The exact result depends on how many firms are competing and how rapidly the screening costs rise with the extent of screening activities.)

Note that the fundamental problem we face here is two: How to avoid duplications and how to avoid free riding. A monopolist, be it public or private, solves both of them simultaneously. However, a public monopolist would provide too much screening services and thereby incur unnecessarily large costs. A profit maximizing monopolist, on the other hand, can provide the needed services at smaller costs. But it earns excess profits in doing so. (It is not immediately clear whether the excess profits are 'bad.') A competitive industry solves the free riding problem, but leaves the duplication problem unsolved. That is why it would most likely incur larger costs than a monopolist.

It is true that the costs incurred by a single competing firm are very small. Still it produces a very valuable piece of information, which can be easily used by many. Other screening firms do not need to produce essentially the same thing over and over again. This suggests that there may be a better alternative. Indeed we have proposed one such scheme. In order to avoid information duplications, it is better for a monopoly to produce the relevant information. The information thus produced would then be sold to issuing firms, which would in turn sell certificates based on the information to the investment undertakers. The price paid by a issuing firm for the information is its share of the total screening costs incurred by the information producing entity. This way the screening firm would produce the same information that a competing firm would produce, and the information is produced only once. Its benefits to the society would be the same as before, but its costs are only a tiny fraction of others.

(Received 4 March 2009; Revised 4 September 2009)

References

Barcena-Ruiz, J. C., and Rubio, J. "Private Information and Endogenous Entry." *Seoul Journal of Economics* 16 (No. 3 2003): 491-500.

Gehrig, T., and Stenbacka, R. Decentralized Screening: Coordination Failure, Multiple Equilibria and Cycles. HECER Discussion Paper No. 190, 2006.

Japelli, T., and Pagano, M. "Information Sharing, Lending and Defaults: Cross-Country Evidence." *Journal of Banking & Finance* 26 (No. 10 2002): 2017-45.

Spence, M. "Job Market Signaling." *Quarterly Journal of Economics* 87 (No. 3 1974): 355-74.

__________. "Signaling in Retrospect and the Informational Structure of Markets." *American Economic Review* 92 (No. 3 2002): 434-59.

Stigler, G. "The Economics of Information." *Journal of Political Economy* 69 (No. 3 1961): 213-25.

Stiglitz, J. "The Theory of 'Screening,' Education, and the Distribution of Income." *American Economic Review* 65 (No. 3 1975): 283-300.