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Dysfunctional Finance

Positive Shocks and Negative Outcomes

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Abstract

This paper shows how badly a market economy may respond to a positive productivity shock in an environment with asymmetric information about project quality: some, all, or even more than all the benefits from the increase in productivity may be dissipated. In the model, based on Bernanke and Gertler (1990), entrepreneurs with a low default probability are charged the same interest rate as entrepreneurs with a high default probability. The implicit subsidy from good types to bad means that the marginal entrant will have a negative-value project. An example is presented in which, after a positive productivity shock, the presence of enough bad types forces the interest rate so high that it drives all entrepreneurs out of the market. This happens in

an industry in which there are good projects that are productive. The problem is that they are contaminated in the capital market by bad projects because of the banks' inability to distinguish good projects from bad.

One possible explanation for the lack of development in some countries, is that screening institutions are sufficiently weak that impersonal financial markets cannot function. If industrialization entails learning spillovers concentrated within national boundaries, and if initially informational asymmetries are sufficiently great that the capital market does not emerge, then neither industrialization nor the learning that it would foster will occur.

This paper—a product of the Macroeconomics and Growth Team, Development Research Group—is part of a larger effort in the department to understand problems of financial markets and governance. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at khoff@worldbank.org.

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Dysfunctional Finance: Positive Shocks and Negative Outcomes

Karla Hoff*

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The problem of financial fragility has received a great deal of attention. It is well understood that a negative shock to wealth, prices, or beliefs can lead to the collapse of a financial market.¹ It is less well understood that markets can also become unstable after a positive shock. Here I show that a positive productivity shock can increase the extent of asymmetric information in the market as it draws in low-quality borrowers. It can even happen that a positive shock leads to a complete collapse of investment.

These points are made by analysis of the process of investment finance in Bernanke and Gertler (1990). They showed that their model has a “fragile” equilibrium in the sense that it can be greatly disturbed by a negative wealth shock. What I show here is that under some conditions, a positive productivity shock can also cause negative movements in the equilibrium, and possibly large movements. In the model, entrepreneurs who want to undertake investment projects know their probability of success, but financial intermediaries know only the average success probability of entrants, and the marginal entrant has the highest risk of failure. In this setting, the marginal entrant will have a negative-value project. The high-quality borrowers subsidize the low-quality borrowers. A positive shock that increases the success return to projects will attract a new set of high-risk, negative-value projects. This adverse selection process will erode the ability rents of the inframarginal borrowers. I present an example in which it destroys the market.

The results of this paper suggest a new reason why institutional change in the financial sector has often followed technological progress. The usual explanation is that an explosion of demand for funds can be met only by a widening of the financial market across group boundaries and geographic distance, which decreases trust and increases the extent of asymmetric information (*e.g.*, Zucker 1986 and Baskin 1988). The additional explanation suggested in this paper is that a productivity improvement in an industry can widen the divergence of interests between entrepreneurs and banks, which provides potentially large returns to improvements in institutions for economic governance. The returns can be as much as the entire value produced in the industry, which is at risk of dissipation from financing of negative-value projects.

¹ See, for example, Bernanke and Gertler (1990), Greenwald and Stiglitz (1993), and Morris and Shin (2008).

For instance, the first century of investment in railroads in the United States has been described as a “long story of defaults, reorganizations, frauds, and other pitfalls and mishaps [that] may give the impression that it was at best a question of avoiding losses instead of making profits” (Veenendaal, 1996, p. 175). The New York Stock Exchange (NYSE) emerged as the central market for railroad securities and devised a set of screening policies that became progressively more stringent after 1860. “Market screening undertaken by the New York Stock Exchange allowed certain firms to invest in costly signals to separate their securities from those of competing ventures....A NYSE listing itself became a signal to American investors of the ‘quality’ of an investment opportunity” (Davis and Cull, 1994, pp. 74-75). The literature on financial market development explains this change by the geographical expansion of the market. However, another factor that may have contributed to the recurrent need for improvements in screening was that technological progress widened the divergence of interests between entrepreneurs and banks, as entrepreneurs faced higher incentives to take long-shot gambles with other people’s money.

There are many markets in which the marginal entrant is the lowest quality type. For example, in markets in which quality is not observable at the time of purchase and firms differ in the marginal cost of producing quality, the lowest ability firms will choose to produce the lowest quality goods. In such a setting, Grossman and Horn (1988) show that high-ability firms will choose to build a reputation over time for high quality, and the lowest ability firms will choose to sell shoddy goods (which they can sell at the price of the average quality) and then exit. The marginal entrant will produce negative social value.

The surprising result that positive shocks may cause negative outcomes cannot, however, occur in the model in Akerlof’s seminal paper on the market for “lemons” (Akerlof 1970). As Akerlof writes of his model of the used car market, “The bad cars tend to drive out the good” (p. 489). There is always *too little* exchange in his model because the marginal seller, having the highest quality used car in the market, receives less than its true value. In contrast, I am concerned with the opposite problem, as were also de Meza and Webb (1987) and Grossman and Horn (1988). If exchange occurs at all, there is always *too much* of it because the marginal investor, having the worst project and the greatest risk, borrows at a better than fair interest rate. *The good types draw in the bad.* Under some conditions, a positive shock can worsen the problem of too much entry.

1. A model of the financial market in which good types draw in bad

A. *The agents and technology*

There are two groups of agents: entrepreneurs and financial intermediaries (“banks”). All agents are risk-neutral. An entrepreneur chooses whether or not to invest an indivisible level of effort at utility cost e to design a project. Each entrepreneur can design at most one project. A project is an independent draw from the distribution $H(p)$, where p is the probability that the project succeeds. A project pays off R if it succeeds and zero otherwise. A byproduct of designing a project is that the entrepreneur learns the probability of success of the project, which he then chooses whether or not to undertake. Undertaking it requires an investment of one unit of wealth. Entrepreneurs have a wealth endowment W that is strictly positive but less than one, so that they must obtain outside finance to undertake their projects. There are a large number of financial intermediaries, each with an unlimited supply of funds at gross interest rate r . r reflects the gross return on resources that are stored, rather than invested.

B. *The financial contract*

Contracts must be based on observables. The following assumptions restrict the set of observables in a way that introduces the problem of adverse selection into the financial market and ensures that no feasible contract can solve it.

Assumption 1. The distribution of p is known to all, but the specific realization of p is each entrepreneur’s private information.

Assumption 2. The entrepreneur's effort cannot be monitored.

Assumption 3. A bank cannot observe all the financial contracts that an entrepreneur enters into.

Together with limited liability, Assumption 1 creates a potential problem of adverse selection. Assumption 2 means that the problem cannot be solved by offering a fixed wage

contract to entrepreneurs, since under such a contract the entrepreneur would have no incentive to expend effort. Assumption 3 means that it is not feasible to mitigate the incentive of entrepreneurs to undertake bad projects by designing a contract in which a payment is made *from* the bank *to* the entrepreneur in the event that he does not undertake a project. To see this, notice that if an entrepreneur's success probability was so low that he did not wish to undertake his project, he would have an incentive to enter into such a contract with every intermediary and accept the grants. If, alternatively, his success probability was high enough that he wished to undertake his project, then he would have an incentive to sign a simple debt contract. Hence, a contract that provided for a payment to the entrepreneur when he did not undertake a project (thereby inducing the entrepreneurs with the worst projects to withdraw from the financial market) would not be self-sustaining.

Given these assumptions, the contract that maximizes each entrepreneur's expected income subject to the constraint that the bank breaks even is a pure debt contract with maximum self-finance. The proof follows the lines of Bernanke and Gertler (1990, proposition 2(i)). The intuition for maximum self-finance is that the unwillingness of a risk-neutral entrepreneur to invest in his own project would signal that it was of poor quality.

Under the equilibrium contract, the entrepreneur pays principal and interest if his project succeeds, and defaults if his project fails. Let i denote $1 +$ the interest rate. I will generally refer to i as —the interest rate,” for short.

C. Overview of the game and the equilibrium

Competition is modeled as a three-stage game:

In Stage 1, an entrepreneur decides whether or not to design a project.

In Stage 2, banks offer contracts to entrepreneurs.

In Stage 3, entrepreneurs decide whether or not to accept the offers.

Proceeding by backward induction, consider in Stage 3 an entrepreneur who has already designed a project and learned its success probability p . He will wish to undertake his project if it is at least as profitable as the alternative use of his wealth. This implies $p[R - i[1-W]] \geq rW$

or, equivalently, that projects with success probabilities equal to or above p^* are undertaken, where

$$(1) \quad p^* = \frac{rW}{R-i[1-W]} \cdot \text{Entrepreneurs' reservation success probability (RSP)}$$

In Stage 2, there is perfect competition in the lending activity. Financial market equilibrium occurs at an interest rate at which banks break even in expected value:

$$(2) \quad i = \frac{r}{\hat{p}} \quad \text{Banks' break-even locus}$$

where \hat{p} denotes the average success probability of entrepreneurs who borrow. If, for example, there are a continuum of types and no mass point at p^* , then

$$(3) \quad \hat{p} = E(p|p \geq p^*)$$

Thus, the contracts offered in Stage 2 depend on the banks' expectation of entrepreneurs' response in Stage 3.

Consider finally the entrepreneur's problem in Stage 1. He will find it worthwhile to invest effort to design a project if the expected return is positive:

$$(4) \quad y = \pi[\hat{p}R - r] - e \geq 0,$$

where π is the probability that an entrepreneur who designs a project will choose in Stage 3 to undertake it. This inequality implies a lower bound on wealth below which an entrepreneur loses access to credit.² I assume initially, by choice of parameters, that (4) is satisfied.

The process of investment finance described by equations (1) to (3) has the consequence

² The intuition is that the lower the entrepreneur's wealth, the lower his stake in his project and thus the lower the probability of success p^* at which he is willing to undertake a project. Hence, the lower is W , the lower the average quality of borrowers and the higher the interest rate. This rate may be so high that (4) is violated. Bernanke and Gertler (1990) prove the existence of a critical wealth level below which the market collapses. Without loss of generality, I consider in this paper only one wealth level. With a distribution of wealth levels across entrepreneurs, one would have a distribution of markets, each with its own interest rate. Point by point, the results in this paper would hold for each level of wealth.

that entrepreneurs are willing to undertake *negative* social value projects. The social return to the entrepreneur who is indifferent between undertaking his project, or not, is p^*R-r . p^*R-r is negative since

$$(5) \quad p^* = \frac{r}{R} \left[W + [1 - W] \frac{p^*}{\hat{p}} \right] < \frac{r}{R}$$

using (1) and (2) and the fact that $p^* < \hat{p}$. Thus, the good types draw in the bad to the financial market.

D. *The equilibrium with a discrete distribution of types*

In order to better show the intuition behind the results of this paper, in the text I will focus on the case of a discrete distribution of types. In the appendix, I will present the case of a continuous distribution of types.

I now assume that the probability of success for projects is either p_L or p_H , with $0 < p_L < p_H < 1$, and that the two types exist in proportions λ and $1-\lambda$, respectively. I will refer to an entrepreneur with a project success probability p_L (respectively, p_H) as the low (high) ability type.³

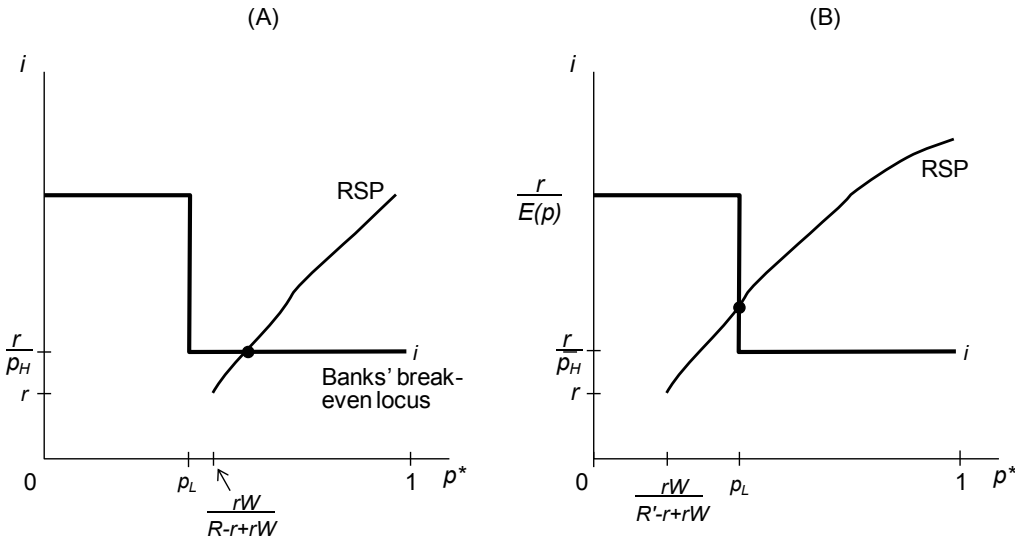
Figure 1 depicts the *banks' break-even locus* (equation (2)). With discrete types, the locus is a step function. For $p^* < p_L$, the interest rate is $r/E(p)$, where $E(p)$ is the unconditional expectation. For $p^* > p_L$, the interest rate declines to r/p_H . The banks' break-even locus shows how individual behavior aggregates up to the market interest rate.

Figure 1 also depicts the *entrepreneurs' reservation success probability* (RSP in equation (1)). The curve is upward sloping because at a higher interest rate, the entrepreneur requires a higher success probability to be willing to invest in his project.

FIGURE 1. Equilibrium with two types of entrepreneurs. In panel (A), the success return R is low and the marginal borrower is high ability. In panel (B), the success return is R' (with $R' > R$) and

³ The case of two types generalizes fully to an arbitrary number of discrete types. This can be seen by considering the average success probability of inframarginal types in equilibrium as the composite type " \bar{p}_H " and by considering the success probability of the next worst type as " \bar{p}_L ."

the marginal borrower is low ability.



Equilibrium occurs at the intersection of the two curves. If they intersect along a horizontal segment of the banks' break-even locus, a small shock will have no effect on entry. This case occurs if $p_L < p^*$ (only the high-ability type undertakes projects), as shown in panel (A), or if $p_L > p^*$ (all entrepreneurs undertake their projects, not shown in the figure).

In the alternative case, as shown in panel (B), the two curves will intersect along a vertical segment of the banks' break-even locus, where $p_L = p^*$. I will call this "the intermediate case." Given the result in (5), the intermediate case is one in which there are some entrepreneurs who should undertake their projects and some who should not, and the latter are at the margin of entry.⁴ Let $q \in [0,1]$ denote the fraction of low-ability entrepreneurs that undertake their projects.

With a discrete distribution of p , the average success probability of entrepreneurs that undertake their projects is a step function

$$(3') \quad \hat{p} = \frac{q\lambda p_L + [1-\lambda]p_H}{q\lambda + 1-\lambda} \quad \text{if } p^* = p_L \quad (\text{the intermediate case})$$

$$(3'') \quad \hat{p} = p_H \quad \text{if } p^* > p_L$$

$$(3''') \quad \hat{p} = E(p) \quad \text{if } p^* < p_L$$

⁴ This is indeed the *general* case for a continuum of types, presented in the Appendix.

(3') says that a fraction $q\lambda+1-\lambda$ of all entrepreneurs undertakes projects, and of these $q\lambda$ are low quality and $1-\lambda$ are high quality.

Equations (2) and (3') describe the Nash equilibrium for the intermediate case. Each entrepreneur's action is at least tied for his best response to the interest rate charged by the banks, and no bank has an incentive to deviate from that interest rate. To see why this is the Nash equilibrium, note that if more than this value of q entered the industry, the interest rate would rise. At that higher interest rate, $p^* > p_L$, so that all the low-ability entrepreneurs would exit, and banks would earn strictly positive profits. Thus, this cannot be an equilibrium. If less than this value of q entered, the interest rate would fall. At that lower interest rate, $p^* < p_L$. All the low-ability entrepreneurs would enter and so banks would suffer losses. This also cannot be an equilibrium.

Normalizing the number of entrepreneurs to one, y in (4) defines the *social surplus*. In the intermediate case, it is

$$(4') \quad y|_{p^*=p_L} = (q\lambda + 1 - \lambda) (\hat{p}R - r) - e.$$

The factor $\hat{p}R-r$ is, of course, the average income of entrepreneurs who undertake their projects. All entrepreneurs with high-quality projects undertake them, but as explained above, only a fraction q of the entrepreneurs who have low-quality projects do so. The first factor, $q\lambda + 1 - \lambda$, is thus the probability that an entrepreneur who designs a project chooses to undertake it. From this overall return, the cost of project design, e , must be subtracted.

$$\text{Evaluated at } p^*=p_L, (1) \text{ and } (2) \text{ imply that } R = \frac{rW}{p_L} + \frac{r}{\hat{p}} [1 - W].$$

Rearranging this equation gives a useful result:

$$(6) \quad \hat{p}R - r = rW \left(\frac{\hat{p} - p_L}{p_L} \right)$$

This means that in the intermediate case, any social surplus that is produced arises because the inframarginal type (the high-ability type) is producing enough *relative* to the marginal type (the low-ability type), and because there are enough of the high-ability type (*i.e.*, $1 - \lambda$ is large enough) to offset the design costs e . The next section will show that under some conditions, a

broadly beneficial productivity shock will erode this social surplus.

2. Technological progress

Technological progress, or a positive shock to productivity, potentially affects aggregate income in two ways: a *direct* income-increasing effect holding the composition of the industry fixed, and an *indirect* effect from the change in the set of entrepreneurs who enter the industry. With a discrete distribution of types, the second effect from a marginal shock will occur only in the ~~intermediate case,~~ because it is only in this case that there is a type at the margin of entry.

This section considers three kinds of technological change: (a) an increase in the return of projects that succeed, (b) an increase in the success probability of each type, and (c) an increase in the return of projects that fail. Consider first an initial equilibrium in which there is no type at the margin of entry. Then a marginal increase in R or in both p_L and p_H will not change the mix of types who undertake projects or the probability of entry (π in equation (4)). There is a simple outcome: owners of projects get a higher return. It is trivial to see that an increase in R or in both p_L and p_H must increase y . I will now show that in the intermediate case, *i.e.*, when the low-quality type is at the margin of entry, something very different happens.

A. An increase in the return, R

An increase in the success return lowers p^* at a given interest rate, which shifts RSP left in Figure 2. In the intermediate case, the social surplus is *invariant* with respect to a change in R , as can be seen by substituting (6) into (4'), to obtain an expression for y in which R does not appear:

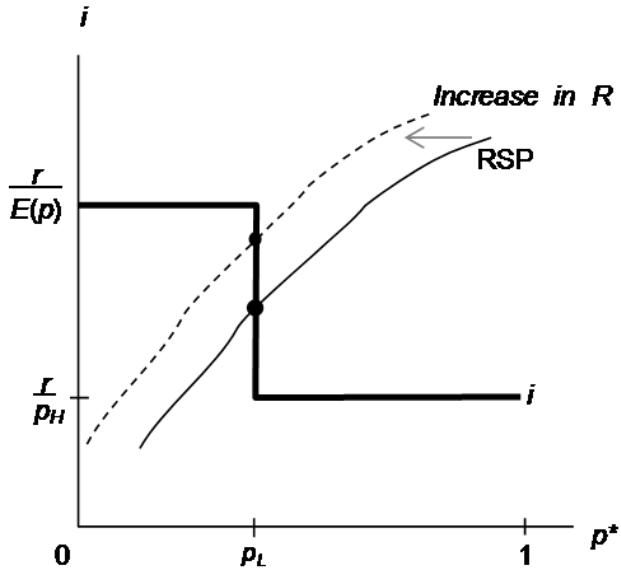
$$(7) \quad y_{|p^*=p_L} = rW \left\{ \frac{q\lambda p_L + [1-\lambda]p_H}{p_L} - [q\lambda + 1 - \lambda] \right\} - e$$

$$= rW[1 - \lambda] \left[\frac{p_H}{p_L} - 1 \right] - e$$

The reason for this invariance result is that when the low-ability type is at the ~~margin of~~ entry, an increase in R is exactly offset by a rise in the interest rate in response to the entry of more

low-ability types. The new entrants impose a cost on high-quality borrowers, which they do not take into account. As q rises from 0 to 1, the interest rate rises from r/p_H to $r/E(p)$. These effects are similar to externalities that occur when a market is missing.⁵

FIGURE 2. Comparative statics of an increase in the success return



The invariance of income to a general improvement in productivity is a new application of an old result, the “tragedy of the commons.” Gordon (1954) showed that if the supply of potential entrants to the commons, e.g. an open-access fisheries, was infinitely elastic, then the value of the commons would be exactly dissipated. The analogy to the commons in the model presented here are the ability rents to high-quality projects. *If banks do not distinguish low-quality from high-quality borrowers, then a part of the ability rents of high-quality borrowers becomes, in effect, a common-property resource subject to the tragedy of the commons.* Improvements in technology that increase R and thereby induce a larger fraction of the low-quality type to implement their projects will dissipate the gains from the improvement in technology.

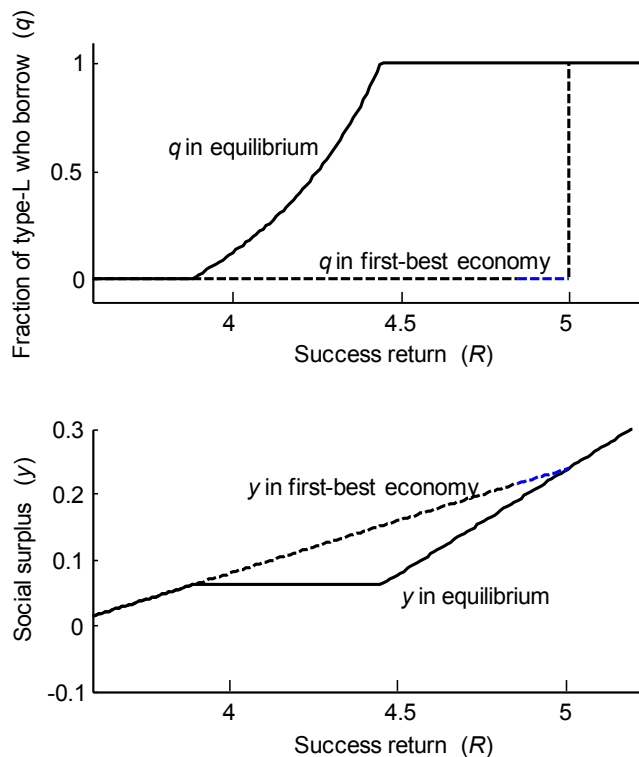
Gordon also showed that if the supply of potential entrants to the commons was *less* than

⁵ Greenwald and Stiglitz (1986) provide a general framework that recasts information inefficiencies in an externalities framework.

infinitely elastic, then the rents attributable to the variable factor, *e.g.*, the fish, would be only partly dissipated. The Appendix shows that this result also carries over to the investment process analyzed here.

Figure 3 illustrates the erosion of the potential gains from technological progress when the low-ability type is at the margin of entry. In this example⁶, $r = 1$, $W = 0.7$, $e = 0.36$, $p_L = 0.2$, $p_H = 0.8$, and $\lambda = 0.8$. The upper panel plots q against R .

FIGURE 3. Effect of an increase in R on entry and the social surplus



The lower panel plots y against R . The figure shows that in equilibrium, when q is increasing, y is flat: over this range, all potential gains from the increase in R are eroded.⁷ These curves can be contrasted with the dotted curves for a first-best economy (in which banks can distinguish between good and bad types).

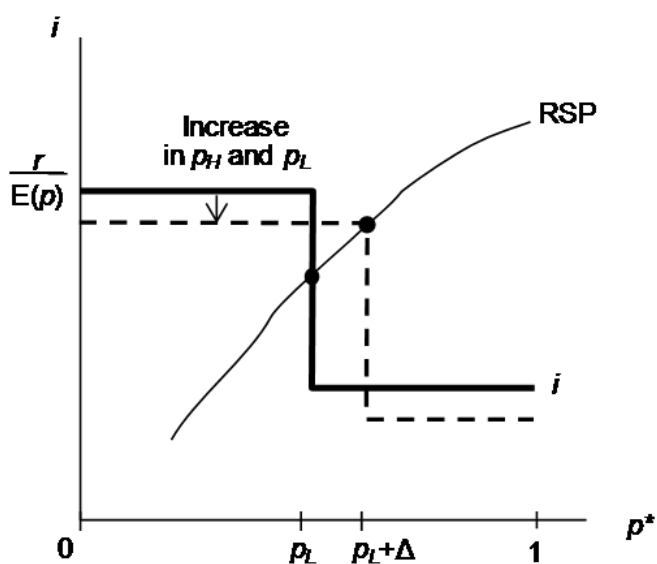
⁶ The Matlab programs to produce Figures 3 and 5 are at www.econ.worldbank.org/staff/khoff.

⁷ The same kind of analysis shows that if the innovation in the success returns of projects R is biased toward type L , then social surplus may fall as a result of the innovation. There are many instances in which firms at the margin are different from the best firms, and so a non-uniform technological change is natural. For example, in the trucking business the marginal firms may be those whose entrepreneurs have the lowest ability to repair trucks. In that case, the marginal firms will benefit the most from technological change in the form of an improvement in publicly provided roads.

B. An increase in the probabilities of success

Next consider a technological innovation in the form of a rightward shift in the distribution from $\{p_L, p_H; \lambda, 1-\lambda\}$ to $\{p_L+\Delta, p_H+\Delta; \lambda, 1-\lambda\}$. The innovation causes the banks' break-even curve to shift *down* (entrepreneurs are more likely to repay) and *right* (at any value of p^* , the set of types for which $p \geq p^*$ weakly increases). See Figure 4. In the intermediate case, the new equilibrium entails a higher interest rate, since more low-ability types enter the market (just as they did in response to an increase in R).

FIGURE 4. Comparative statics of an increase in the probabilities of success



To assess the impact on y , it is useful to decompose y into three terms: (a) the income earned by low-quality borrowers, plus (b) the income earned by high-quality borrowers, less (c) the design cost, as follows:

$$(8) \quad y_{|p^*=p_L+\Delta} = \lambda q \left\{ (p_L + \Delta)[R - i(1 - W)] - rW \right\} \\ + (1 - \lambda) \left\{ (p_H + \Delta)[R - i(1 - W)] - rW \right\} - e$$

If the low-quality type is on the margin, then $R - i[1-W] = rW/[p_L + \Delta]$. This fact implies that the expression for (a) is equal to zero. A marginal productivity change that increases the success probability of the low-ability type makes this type no better off (although it increases the fraction of this type who implement their projects as compared to the case in which the low-ability type had a probability of success p_L). Using the above fact to rewrite the expression for (b), (8) becomes

$$(9) \quad y_{|p^*=p_L+\Delta} = (1 - \lambda)rW \left\{ \frac{p_H - p_L}{p_L + \Delta} \right\} - e .$$

(9) means that the surplus y is *strictly decreasing* in Δ in the intermediate case. The intuition is easy to explain. A rise in the interest rate for all borrowers that would hold constant the net income of the low-quality type, who has only a low probability of actually repaying his loan, would entail a decline in the net income of the high-quality type, who has a high probability of repaying his loan. Formally, the indifference curves of the low- and high-quality types satisfy a single-crossing property in the space of i and Δ .

Differentiating (9) with respect to Δ gives

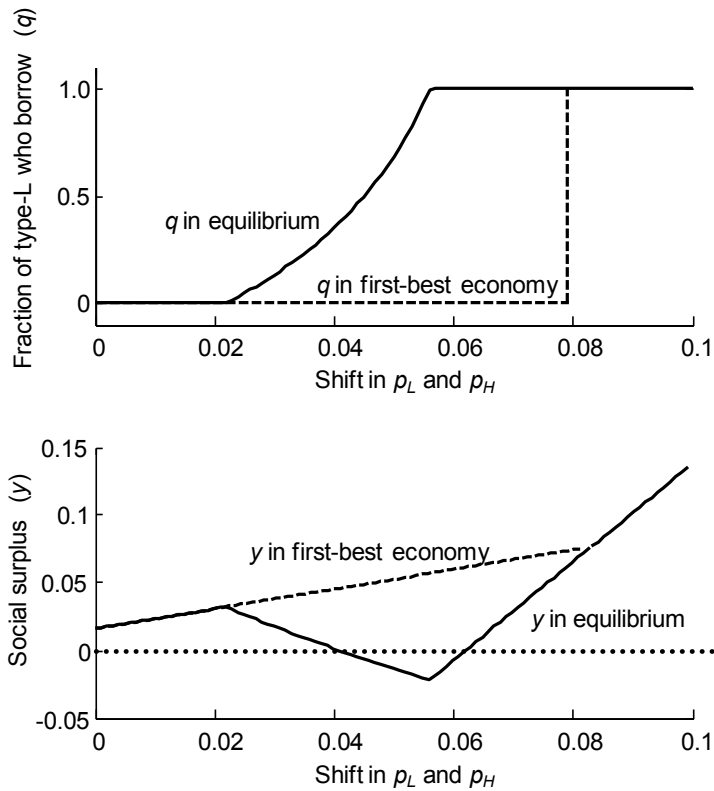
$$(10) \quad \frac{dy}{d\Delta}_{|p^*=p_L+\Delta} = - (1 - \lambda)rW \frac{p_H - p_L}{(p_L + \Delta)^2} < 0 .$$

The absolute value of $dy/d\Delta$ is increasing in the level of debt finance (rW), in the fraction of good projects ($1 - \lambda$), and in the gap in success rates between good and bad types ($p_H - p_L$). Each of these factors contributes to the rents that the low-quality types dissipate when they enter the market. The absolute value in (10) is also larger the lower the success probability of the low-quality type, $p_L + \Delta$. The lower this probability, the greater the externality that the low-quality type imposes on others.

Figure 5 presents an example in which the adverse selection problem leads to a collapse of investment by reducing below zero the entrepreneur's expected return y to designing a project. The values of the fixed parameters, including the initial values of $p_L = 0.2$ and $p_H = 0.8$, are the same as in Figure 3, and the value of R is now fixed at 3.6. The upper panel plots q against a uniform shift (Δ) in p_L and p_H . The lower panel plots y against Δ . The figure shows that when q is strictly increasing, the surplus is strictly decreasing. That is, the entry of the low-quality type erodes more than 100 percent of the potential gains from the increase in success probabilities. These curves can

be contrasted with the dotted curves for the first-best economy, in which types are observable to banks. The paths diverge at the point where the low-ability type first enters the market. The curves meet again at the point at which Δ is sufficiently great that the low-ability type produces positive social value (in this example, at $\Delta \approx 0.08$). y dips below zero in the interval $\Delta \in (0.04, 0.06)$. Within this interval, in a rational expectations equilibrium, entrepreneurs would be unwilling to design projects that would be financed at an interest rate that banks would be willing to offer. The pres-

FIGURE 5. Effect of an increase in the probabilities of success



ence of enough bad types forces the interest rate so high that it drives all entrepreneurs out of the market. This happens in an industry in which there are good projects that are productive. The problem is that they are contaminated in the capital market by bad projects because of the banks' inability to distinguish good projects from bad.

C. An increase in the returns to projects if they fail

Up to now I have assumed that a project either succeeds and pays off R , or fails and pays off zero. Suppose now that a technological change occurs in the form of an increase in the return when a project fails. Assume that this return is less than $r[1-W]$. Then if a given project fails, the bank will receive this return. In contrast to the preceding cases, this technological change reduces the externality imposed by low-ability entrepreneurs on high-ability entrepreneurs. Thus, the technological change unambiguously increases the surplus. This can be seen diagrammatically in Figure 1 (A and B) by noting that this kind of technological change would shift down the banks' break-even locus, lowering i . At the lower interest rate, each entrepreneur who would have undertaken his project absent the innovation is made strictly better off; a new set of entrepreneurs may undertake their projects and can be no worse off; and the banks break even.

3. Discussion

The results have been developed in the context of specific model of the investment process. They can be generalized to a wider set of models. The results depend on three key assumptions. The first is a specific assumption about asymmetric information: among a class of borrowers who know their distribution of future returns but who are indistinguishable to banks, borrowers can be ranked by *first-order stochastic dominance* (as in Black and de Meza 1994). The second is that there is perfect competition among financial intermediaries, with an infinitely elastic supply of funds. The third is an assumption about technology: there is a fixed cost of designing a project and evaluating its success probability. The first two assumptions mean that an entrepreneur would be willing to undertake a negative-value project, since the downside risk is borne partly by others whereas he benefits fully from the upside risk; but that borrowers as a whole will fully bear the costs of the defaults. The last assumption means that if externalities

from the bad projects are sufficiently great, there will be no incentive to design and evaluate any project, and so investment will collapse.

An episode from U.S. history provides an example in which the emergence of new institutions to reduce the extent of asymmetric information may have been causally related to major technological changes that widened the gap between the highest and lowest quality types in the market. The railroad gave rise to a vast increase in the demand for capital that could be met only in a national or international financial market. The capital used in the U.S. railroad industry increased from \$0.3 billion in 1850 to \$9-\$10 billion in 1890 and to \$21.1 billion in 1916 (Mitchie 1987, p. 222). The New York Stock Exchange, a cartel of traders with fixed commission rates, emerged as the central market for railroad securities by the 1870s. In an effort to reduce informational asymmetries, the NYSE devised a set of screening policies that became progressively more stringent after 1860 (Mitchie, p. 198). The most obvious ones were its vetting procedure, which required potential listings to meet high minimum standards in terms of size of capital, number of shareholders, and proven track record. Listing on the NYSE was voluntary and provided a signal to investors of the quality of an investment opportunity, enabling firms to build a national market for their securities. Despite competition from other market exchanges with lower standards, the price of a seat on the NYSE rose from about \$20,000 to \$80,000 between 1880 and 1910 (Davis and Cull, 1994, p. 74). What the NYSE did is to bestow labels. With technological progress that increased rents to high ability, defining and establishing rights to those labels became especially valuable.

This idea can be formalized in a simple way. Suppose there exists a screening technology such that banks can perfectly identify a project's success probability at a fixed cost c per project screened. Then an entrepreneur with success probability p_j would wish to be screened if

$$(11) \quad [1-W]r + c < p_j [1-W] \frac{r}{\hat{p}}$$

The left-hand side is the expected cost of principal plus interest if he is screened, plus the cost of screening. The right-hand side is the expected cost of principal plus interest if he is not screened. A positive technological change that causes the set of entrants to extend deeper into the distribution of potential entrants reduces \hat{p} , which increases the right-hand side of (11) for any given value of p_j . Thus, the change can shift the economy from a no-screening equilibrium to a screening equilibrium, in the language of Stiglitz (1975).

The success of the NYSE rested upon the self-interest of its members and of the entrepreneurs who sought capital. By 1912 it is estimated that 45 percent of the \$58 billion of securities in circulation in the U.S. were to be found on the NYSE. The provision of this secondary market made an enormous difference to the willingness of investors to buy and hold securities of firms listed on the exchange, facilitated the movement of capital within the U.S. and internationally, and by reducing asymmetric information about the value of securities, made possible an enormous expansion of lending based on stocks and bonds as collateral (Mitchie, pp. 168, 235).

4. Conclusion

In this paper, I showed how badly a market economy may respond to a positive productivity shock in an environment with asymmetric information about the quality of projects: some, all, or more than all of the possibilities of an increase in wealth may run to waste, and investment may even collapse. These results have close parallels to the “tragedy of the commons.” In a commons with an infinitely elastic supply of entrants, the rents to the common-property resource are fully dissipated. The saying that “everybody’s property is nobody’s property” captures the idea. In the model of this paper, banks cannot distinguish good projects from bad. Thus the entrepreneur with a good project financed partly by debt cannot fully appropriate the surplus produced by his ability. The result is a pattern of entry of entrepreneurs in response to positive productivity shocks that, under some conditions, will dissipate the promised gains from the technological improvement. This is the “tragedy.”

The analogy to the tragedy of the commons helps explain why positive productivity shocks can dramatically increase both the social and private returns to screening. An entrepreneur whose type is identified would appropriate all the rents to his ability; this would remove the commons problem. Conventional wisdom has it that the gains to better firms from screening are largely *at the expense* of the firms with which they would otherwise be grouped; and thus the *social* returns to screening are ambiguous. However, in this model, before actually developing a project, every entrepreneur has the same potential to develop a good or bad project and so to be a high- or low-quality entrepreneur. There are no *ex ante* distributional consequences of screening. What screening does is to discourage entry by entrepreneurs who

learn that they have negative-value projects—and who by implementing them would expect to receive gains less than the costs (the externalities) that they would impose on other borrowers in the market. The social returns to screening are thus unambiguously positive.

The creation of screening mechanisms has, however, historically been a slow, difficult process. There are many possible routes that institutional change can take. They include not only stock exchanges that serve as screens, but also innovations in guarantees, bankruptcy laws, and governance structures within firms. For example, Acemoglu (1998) argues that the separation of ownership from control may have occurred in part as a remedy to the kinds of distortions in entrepreneurs' incentives that are analyzed here. The dynamics between technological change and institutional change is a central aspect of economic development. There is a two-way causal relationship. Good institutions for economic governance enable a country to deploy its resources in high-value projects, which can spur technological progress. Technological progress may exacerbate adverse selection and lead to a crisis (an investment collapse), which can spur improvements in economic governance.

One possible explanation for the lack of development in some countries is that screening institutions are sufficiently weak that impersonal financial markets cannot function. If industrialization entails “self-discovery”—the discovery of opportunities for profit—and of innovation with spillovers concentrated within national boundaries (see *e.g.*, Hoff 1997, Hausman and Rodrik 2003, and Greenwald and Stiglitz 2006), and if initially informational asymmetries are sufficiently great that the capital market does not emerge because of the tragedy of the commons, then neither industrialization nor the learning that it would foster will occur. If the process of developing better screens also entails knowledge spillovers concentrated within national boundaries, then an economy may be trapped in an inefficient non-screening equilibrium, with no industrialization and no screening.

Appendix: A Continuous Distribution of Types of Entrepreneurs

The text established two surprising results for the special case of a discrete distribution of types when the low-ability type is at the margin of entry: $dy/dR = 0$ and $dy/d\Delta < 0$. The appendix shows that these effects are also possible in the case of a continuum of types, but other outcomes (that are not perverse) are possible, too.

Let p be distributed according to the continuously differentiable distribution function $H(p)$ with density function $h(\cdot) > 0$ if $p \in [0, p_u]$, and $h(\cdot) = 0$ otherwise. Thus p_u is the upper bound.

The model is set out in equations (1)-(5) in the text. Given p^* , the mean success probability of borrowers in (3) and the social surplus in (4) are

$$\hat{p}(p^*) = \frac{\int_{p^*}^{p_u} p dH(p)}{1-H(p^*)}$$

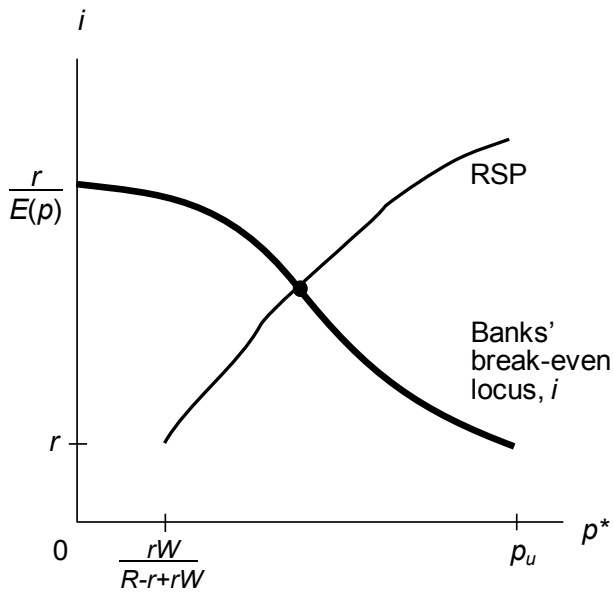
and

$$y = [1 - H(p^*)](\hat{p}R - r) - e.$$

Henceforth, to simplify the notation, let H^* denote $H(p^*)$ and h^* denote $h(p^*)$.

Figure 1-A illustrates the equilibrium. It differs from Figure 1 in that the banks' break-even curve is not a step function but instead slopes down everywhere. This means that anything that shifts the RSP curve will change p^* and, by implication, \hat{p} and i . These three variables are jointly determined. There is no possibility of the kind of outcome analyzed in the text in which p^* does not change when the RSP curve shifts.

FIGURE 1-A. Equilibrium with a continuous distribution of types



RESULT 1. Let p be distributed according to the continuously differentiable distribution function $H(p)$. Then $dy/dR \geq 0$, with strict equality in the limit as $h(p^*) \rightarrow \infty$.

PROOF OF RESULT 1. Differentiating y with respect to R gives

$$(1-A) \quad \frac{dy}{dR} = \frac{\partial y}{\partial R} + \frac{\partial y}{\partial p^*} \frac{dp^*}{dR} = \quad [1-H^*] \hat{p} \quad + \quad h^* [p^* R - r] \frac{p^*}{D}$$

Direct effect
of the
innovation

Effect of entry of
bad projects

where $D = R - i [1-W] - p^*[1-W] \frac{di}{dp^*} > 0$.

(1-A) expresses dy/dR as the sum of two terms. The first is the gain holding the composition of the industry fixed. The gain is the probability of undertaking a project multiplied by the average success rate of projects that are undertaken. The second term is the loss due to the change in the composition of the industry. This term is proportional to the social loss on the marginal entrant (p^*R-r).

The density of projects h^* enters twice into the last term in equation (1-A): once through $\partial y/\partial p^* = -h^*[p^*R-r]$ (as shown), and a second time (not shown explicitly) through $dp^*/dR = -p^*/D$. The greater is h^* , the greater the reduction in y due to a marginal change in p^* . However, through its effect on the interest rate, the greater is h^* , the less the composition of the industry will change as a result of an increase in R . This can be seen by writing D explicitly:

$$(2-A) \quad D = \frac{R}{\hat{p}} \left\{ \hat{p} - \frac{r}{R} [1-W] + \frac{h^*}{1-H^*} [\hat{p}-p^*] \frac{p^*}{\hat{p}} \frac{r}{R} [1-W] \right\}$$

using $di/dp^* = -\frac{i}{\hat{p}} \frac{d\hat{p}}{dp^*}$ and $d\hat{p}/dp^* = \frac{h^*}{1-H^*} [\hat{p}-p^*]$.

Substituting (2-A) into the right-hand side of (1-A) and rearranging gives

$$(3-A) \quad \frac{dy}{dR} = \frac{R}{D} [1-H^*] \left\{ \hat{p} - \frac{r}{R} (1-W) + \frac{h^* p^*}{1-H^*} \left[\frac{r}{R} (1-W) \left(1 - \frac{p^*}{\hat{p}} \right) - \frac{r}{R} + p^* \right] \right\}.$$

The last term inside the large square brackets is p^* . Rewriting that term using (5), it can be checked that the entire expression inside the large square brackets is zero, so (3-A) is equivalent to

$$\frac{dy}{dR} = \frac{1}{D} [1-H^*] [\hat{p}R - r(1-W)] > 0$$

which also means (since $D \rightarrow \infty$ as $h^* \rightarrow \infty$) that $\lim_{h^* \rightarrow \infty} dy/dR = 0$.

RESULT 2. *Let p be distributed according to the continuously differentiable distribution function $H(p)$ on $(0, p_u)$. Then $dy/d\Delta$ is ambiguous in sign.*

PROOF OF RESULT 2. The result is proved if $dy/d\Delta$ is shown to be ambiguous in sign for any continuously differentiable distribution function of p . I will prove the result for a uniform distribution of p . Clearly, allowing a non-uniform distribution of types (in which case the density for the marginal type could be arbitrarily small or large) would greatly expand the conditions under which $dy/d\Delta$ was ambiguous in sign.

But assume here that the density is uniform on $[0, p_u]$. This means that after a productivity shock that shifts the success probability of every type by Δ , the density is

$$h(p) = \frac{1}{p_u} \equiv \bar{h} \quad \text{for } p \in [\Delta, p_u + \Delta]$$

and $h(\cdot) = 0$ otherwise. For a given value of p^* , it follows that

$$\hat{p} = \frac{p^* + p_u + \Delta}{2},$$

$$i = \frac{2r}{p^* + p_u + \Delta}$$

and

$$y = \bar{h} \int_{p^*}^{p_u + \Delta} (pR - r) dp - e.$$

Differentiating y with respect to Δ gives, as usual, a positive effect for a fixed composition of projects and a negative effect from the adverse change in the composition of projects that are undertaken.

$$(4-A) \quad \frac{dy}{d\Delta} = \frac{\partial y}{\partial \Delta} + \frac{\partial y}{\partial p^*} \frac{dp^*}{di} \frac{di}{d\Delta}$$

$$(5-A) \quad = \bar{h}[(p_u + \Delta)R - r] \quad (\text{Direct effect of the innovation})$$

$$(6-A) \quad + \bar{h}[p^*R - r^*] \frac{[1-W]p^*}{R-i[1-W]} \frac{i}{2\hat{p}} \quad (\text{Effect of entry of bad projects})$$

The direct effect in (5-A) is determined by differentiating y at a fixed value of p^* . The direct effect is the expected return on the highest-quality project multiplied by the density at that point.

The indirect effect in (6-A) can be explained as follows. Moving from right to left, an increase in Δ lowers the interest rate (by $-r/2\hat{p}^2$), which, in turn, lowers p^* . (These effects are determined, respectively, by differentiating (2) with respect to Δ and differentiating (1) with respect to i .) The first factor in expression (6-A) is obtained by differentiating y with respect to p^* . From (5), $p^*R - r < 0$, and so the indirect effect is negative.

I now evaluate the net effect (the sign of (4-A)) in two cases. In the first case, $W \rightarrow 1$. It is easy to see that in this case, (6-A) approaches zero and so $dy/d\Delta > 0$.

In the second case, $W < 1/3$ and R is arbitrarily large. Recall that the constraint that $y \geq 0$ implicitly defines a minimum lower bound on \hat{p} . This bound approaches zero as R becomes arbitrarily large (using (4)). Since $0 < p^* < \hat{p}$, it follows that $p^* \rightarrow \hat{p}$ as R becomes arbitrarily large. Recall from (1) that $R-i(1-W) = rW/p^*$. Using this fact, (4-A)-(6-A) imply that

$$\frac{dy}{d\Delta|_{\Delta=0}} < 0$$

if

$$\frac{p_u R - r}{p^* R - r} < \frac{1 - W}{2W} \left(\frac{p^*}{\hat{p}} \right)^2.$$

As R becomes arbitrarily large, the left-hand side approaches $\frac{p_u}{p^*}$ (by l'Hôpital's rule) and the squared expression on the right-hand side approaches one. For $W < 1/3$, the first factor on the right-hand side is more than one. Thus, the inequality is satisfied by choice of the parameter p_u sufficiently small (so $p_u/p^* < [1-W]/2W$). Intuitively, this case corresponds to a scenario in which the upside risk (R), from which the entrepreneur gains, is extremely large; whereas he bears little of the downside risk because his stake in his own project, W , is small. In these circumstances, the *ex ante* surplus from investment, y , will be near zero and a marginal change in Δ , by increasing adverse selection, will reduce the surplus further. If the positive productivity shock reduces y below zero, then, of course, the shock will destroy the market.

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