# Too Much Investment: A Problem of Asymmetric Information

David De Meza; David C. Webb

# TOO MUCH INVESTMENT: A PROBLEM OF ASYMMETRIC INFORMATION*

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This paper shows that under plausible assumptions, the inability of lenders to discover all of the relevant characteristics of borrowers results in investment in excess of the socially efficient level. Raising the rate of interest above the free market level will restore optimality. This conflicts with generally held views and is contrasted with the Stiglitz-Weiss model. It is shown that the assumptions which yield overinvestment support debt as the equilibrium method of finance. However, under the Stiglitz-Weiss assumptions, used to derive an underinvestment result, equity is shown to be the equilibrium method of finance.

## Introduction

In this paper we examine the effects of asymmetric information on aggregate investment and on the financial structure of firms. Using a simple competitive model, we show that, under certain reasonable assumptions about the distribution of project returns, the inability of banks to discover the characteristics of entrepreneurs' projects leads to more investment than is socially efficient. This outcome is contrasted with the traditional underinvestment result implicit in Stiglitz and Weiss [1981] and other papers on credit rationing resulting from asymmetric information (see, for example, Jaffee and Russell [1976] and Ordover and Weiss [1981]). To highlight that our results are not due to the market clearing feature of our model, we show, paradoxically, that the underinvestment problem in the Stiglitz-Weiss model is more severe when their credit market clears.

The intuition for the underinvestment result is Akerlof's [1970] "lemons' principle." Asymmetric information gives rise to an adverse selection problem that causes projects which are poor from the banks' point of view to drive out good projects. In our model asymmetric information causes good projects to draw in bad. There is consequently too much investment, and a tax on interest income could restore social efficiency.

The structure of information also has implications for the method of finance. Entrepreneurs with projects that are attractive to banks attempt to choose financial structures that signal their characteristics. We are able to show that the assumptions which

yield the overinvestment result support debt as the equilibrium method of finance. Interestingly, however, under the Stiglitz-Weiss assumptions, equity rather than debt is shown to be the equilibrium method of finance. With equity finance the underinvestment property of the Stiglitz-Weiss model disappears, and social efficiency obtains.

The paper is in three sections. In the first section we derive the overinvestment result and show that an interest rate tax will restore social efficiency. The second section compares this result with the underinvestment outcome implicit in the Stiglitz-Weiss model. The third section examines equilibrium methods of finance. Finally, we draw some conclusions.

## I. THE BASIC MODEL

There is a continuum of entrepreneurs, each of whom is endowed with a project. All projects require the same initial investment, $K$. The return on the $i$th entrepreneur's project is the random outcome $\tilde{R}_i$. All projects yield the same returns, $R^s$ if successful and $R^f$ if a failure, with $R^s > R^f > 0$. What distinguishes projects is the probability of success, $p_i(R^s) \in [0,1]$. If $i$ and $j$ are two entrepreneurs, then if $p_i(R^s) > p_j(R^s)$, entrepreneur $i$ is said to have a "better" project than $j$. In what follows, the terms entrepreneur and project are used interchangeably.

Entrepreneurs have the same initial wealth, $W_i = W$ for all $i$, which is entirely invested either in their project or in a safe asset. The proof of maximum self-finance of projects is deferred to Section III. However, $W < K$, so that if a project is undertaken, additional finance must be raised. For the moment we assume that this is done by issuing debt and leave until later the question of whether this is optimal. The value of debt issued by the $i$th entrepreneur is $B_i = B = K - W$.

Finance is raised through a standard debt contract that has fixed repayment in nonbankruptcy states of $\tilde{D}_i = (1 + r_i)B$, where $r_i$ is the rate of interest, bankruptcy if $(1 + r_i)B > \tilde{R}_i$ and maximum recovery of debt in bankruptcy states in which $\tilde{D}_i = \tilde{R}_i$. Assume that $R^s > (1 + r_i)B > R^f$. Then with limited liability the return to entrepreneur $i$ on his project is

(1) $$\pi_i = \max [R^s - (1 + r_i)B, 0].$$

In the event of bankruptcy he gets nothing.[1] If the entrepreneur is risk-neutral, he wishes to maximize (expected) profit given by

(2) $$E\pi_i = p_i(R^s)(R^s - (1 + r_i)B).$$

He will accept the project if $E\pi_i \geq (1 + \rho)W$, where $\rho$ is the safe rate of interest. From (2) it follows that the magnitude of

(3) $$E\pi_i - (1 + \rho)W \geq 0$$

will be smaller, the lower the value of $p_i(R^s)$.

Outside financiers, subsequently called banks, are identical competitive, risk-neutral (expected) profit maximizers. They have no prior information on the characteristics of individual entrepreneurs, but they do know the distribution of characteristics of the population of entrepreneurs. The distribution of success probabilities is $F(p_i(R^s))$, with density function $f(p_i(R^s))$. The banks obtain their funds from depositors at the safe rate of interest $\rho$.

The investment market is competitive in the sense that all agents are price takers. As in Stiglitz and Weiss, with fixed principal and risk-neutral agents, it is easily shown that a separating equilibrium does not exist. Henceforth, we only consider pooling equilibria. In a pooling equilibrium the loan contract $(B, r)$ earns the bank an expected profit of

(4) $$E\pi_B = (1 + r)B \int_{\bar{p}}^{1} p_i(R^s) f(p_i)dp_i$$
$$+ R^f \int_{\bar{p}}^{1} (1 - p_i(R^s))f(p_i)dp_i - (1 + \rho)B,$$

where $\bar{p}$ is the success probability of the marginal project (that is, the project for which (3) holds with equality).

PROPOSITION 1. An equilibrium must be market clearing.

*Proof of Proposition 1.* Suppose, to the contrary, that an interest rate $r'$ is set at which some entrepreneurs, for whom $E\pi_i > (1 + \rho)W$, are denied credit. In the presence of such an excess supply of bonds (an excess demand for credit), a bank can maintain

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1. In our model entrepreneurs have liquid funds to invest, but can offer no collateral security. Stiglitz and Weiss assume the reverse. However, a collateral requirement is similar in its economic effects to a rise in $W$ and as such does not affect the results we obtain. This point is recognized by Stiglitz and Weiss in their footnote 8 on page 402, where what they call equity is the same as what we call self-finance (retained equity). In our later presentation of the Stiglitz-Weiss model, we again, without affecting the results, substitute self-finance for a collateral requirement.

its initial volume of loans if it makes a small rise in the rate it charges borrowers. Now a necessary condition for a credit rationing equilibrium is that at $r'$, $dE\pi_B/dr = 0$. But this condition is not satisfied. If $r$ rises, then from (2) and (3) $\bar{p}$ must rise. As $r$ increases, revenue from successful projects rises, and in addition, the higher $\bar{p}$ means that there is a greater chance that an applicant entrepreneur's project will be successful. It follows that $dE\pi_B/dr > 0$. So, a credit-rationing equilibrium cannot exist.

The possibility that there may be an excess demand for bonds (an excess supply of credit) may be ruled out on familiar competitive grounds. If the rate of interest were above the zero-profit market-clearing level, then, because $dE\pi_B/dr > 0$, banks would expect to make positive profits on each contract. A bank that then undertook a small interest rate cut would make slightly lower profits per contract, but would be able to expand its loan volume indefinitely. A large enough expansion in loan volume would always offset the slightly lower profit per loan, and so the interest rate must fall to the zero-profit market-clearing equilibrium value.     Q.E.D.

We now compare the equilibrium investment level with the first-best solution. The first-best solution corresponds to the full-information competitive equilibrium. It is immediate that for social efficiency all projects should be undertaken which satisfy

$$(5) \qquad p_i(R^s)R^s + (1 - p_i(R^s))R^f \geq (1 + \rho)K.$$

That is, all projects which have expected returns at least as high as the safe return should be undertaken.

PROPOSITION 2(A). If the supply of funds to the banking system is not decreasing in the rate of return on deposits, at the competitive equilibrium investment exceeds the first-best level.

*Proof of Proposition 2(A).* Suppose, to the contrary, that investment were at or below the first-best level. The banks would therefore require the same or a lower volume of deposits, and so $\rho$ could not be higher than at the socially efficient solution. Moreover, with less investment the success probability of the worst project undertaken must be greater than that of the worst project accepted at the social optimum. So, for the worst project in the proposed competitive equilibrium,

$$(6) \qquad p_i(R^s)R^s + (1 - p_i(R^s))R^f \geq (1 + \rho)K.$$

This marginal project earns the entrepreneur a zero expected profit, and thus

(7) $$p_i(R^s)(R^s - (1 + r)B) = (1 + \rho)W.$$

From (6) and (7) and the fact that $B = K - W$,

(8) $$p_i(R^s)(1 + r)B + (1 - p_i(R^s))R^f \geq (1 + \rho)B.$$

According to (8), a bank would expect to make profits on the marginal project. Hence, it would also expect to make profits on all the intramarginal projects. It follows that (6) is inconsistent with a zero-profit banking equilibrium. Hence, in the competitive equilibrium, investment must exceed the first-best level.    Q.E.D.

In the above Proposition we assume that the supply of funds to the banking system is not decreasing. It may, however, be backward-bending, and then we have the following proposition:

PROPOSITION 2(B). If the supply of funds to the banking system is backward-bending, equilibrium investment may fall short of the efficient level.

*Proof of Proposition 2(B).* At a social optimum (6) holds with equality for the worst acceptable project. But if investment were reduced, $\rho$ now increases and the inequality in (6) may hold in the reverse direction. The inequality in (8) would then also be reversed, and so at a sufficiently low level of investment it is possible that at a social optimum the banks would expect losses on the marginal project. If so, there must exist a competitive equilibrium with investment below the first-best level.    Q.E.D.

Since the competitive equilibrium investment level will generally be socially inefficient, we now propose a simple policy that achieves a first-best allocation whatever the shape of the supply curve of funds.

PROPOSITION 3. A tax on interest income can achieve social efficiency.

*Proof of Proposition 3.* If $r$ is chosen to yield a socially optimal level of investment, (6) holds as an equality for the marginal project financed. Moreover, by definition of a marginal project, (7) also holds. Conditions (6) and (7) together imply that (8) holds with equality. That is to say, the banks expect to break even on the marginal project. But the marginal project is the least profitable of all those the banks accept. Thus, banks' expected profits are positive at the social optimum. A tax on interest income will raise the gross $\rho$ banks must pay to attract the volume of deposits required to finance the optimal level of investment and thereby

eliminate these profits. Hence, such a tax can be used to support a competitive equilibrium that is also efficient.                    Q.E.D.

## II. COMPARISON WITH THE STIGLITZ-WEISS MODEL

Stiglitz and Weiss examine credit market equilibrium when entrepreneurs with projects requiring the same investment $K$, but with different risks, seek outside finance. The story sounds very similar to that investigated above. The crucial difference is that in Stiglitz and Weiss all projects have the same expected return but the dispersion of returns is different, whereas in our model the expected returns differ between projects. To keep matters simple while capturing the essence of the Stiglitz-Weiss argument, suppose that each entrepreneur's project yields a random outcome $\tilde{R}_i$ of $R_i^s$ if successful and $R_i^f$ if a failure. All projects satisfy

$$(9) \qquad p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R_i^f = \text{a constant}, \qquad \text{for all } i,$$

where $p_i(R_i^s) \in [0,1]$ is the success probability of the $i$th project. For present purposes and without loss of generality, assume that $R_i^f = R^f$ for all $i$. Project $i$ is said to be riskier than project $j$ if, given that (9) is satisfied, $p_i(R_i^s) < p_j(R_j^s)$.

Entrepreneurs have identical initial wealth, $W_i = W$ for all $i$, but as $W < K$, additional finance must be sought. As in Stiglitz and Weiss, it is assumed that if entrepreneurs undertake a project, they issue debt to the value $B = K - W$. A standard debt contract is issued with fixed repayment in nonbankruptcy states of $\tilde{D}_i = (1 + r_i)B$, bankruptcy if $(1 + r_i)B > \tilde{R}_i$, and maximum recovery of debt in bankruptcy states in which $\tilde{D}_i = \tilde{R}_i$. Assume, as before, that $R_i^s > (1 + r_i)B > R^f$. With limited liability, the return to the $i$th entrepreneur is

$$(10) \qquad \pi_i = \max [R_i^s - (1 + r_i)B, 0].$$

A risk-neutral entrepreneur is willing to undertake project $\tilde{R}_i$, financed with a debt contract if

$$(11) \qquad E\pi_i = p_i(R_i^s)(R_i^s - (1 + r_i)B) \geq (1 + \rho)W.$$

From (9), since a higher $p_i(R_i^s)$ is associated with a lower $R_i^s$, the left-hand side of (11) is decreasing in $p_i(R_i^s)$.

Once again banks are identical risk-neutral (expected) profit maximizers. They do not know the characteristics of individual entrepreneurs, but they do know the distribution of the characteristics of the population of entrepreneurs. The distribution of success

probabilities is $G(p(R_i^s))$ with density function $g(p_i(R_i^s))$. In a pooling equilibrium with competition the debt contract $(B, r)$ earns an expected profit of

$$(12) \quad E\pi_B = (1 + r)B \int_0^{\bar{p}} p_i(R_i^s)g(p_i)dp_i$$

$$+ R^f \int_0^{\bar{p}} (1 - p_i(R_i^s))g(p_i)dp_i - (1 + \rho)B,$$

where $\bar{p}$ is the success probability of the marginal project. If, in equilibrium, credit is not rationed, then all projects satisfying (11) are financed. However, as we know from the Stiglitz and Weiss article, in this model some entrepreneurs for whom (1) holds may be denied credit. Below we review their main result.

PROPOSITION 4. A credit-rationing equilibrium may exist.

*Proof of Proposition 4.* Suppose that at the equilibrium interest rate $r'$ there exist entrepreneurs for whom $E\pi_i > (1 + \rho)W$ who are denied credit. A necessary condition for this to be an equilibrium is that at $r'$, $dE\pi_B/dr = 0$, for banks will then lose profit if they raise interest rates to clear the market. Now if $r$ were to increase, banks' revenues from successful projects would rise, but since from (11) $\bar{p}$ falls, the average success probability falls. Hence, $dE\pi_B/dr \gtreqless 0$, depending upon whether the revenue effect is greater or less than the offsetting adverse selection effect. It is therefore possible to find an $r'$ at which $dE\pi_B/dr = 0$.

Suppose further that when banks charge $r'$ to borrowers, their expected profits are zero if they pay depositors $\rho^*$. Moreover, at $\rho^*$ the supply of deposits is less than loan demand. A credit-rationing equilibrium therefore exists. Q.E.D.

The equilibrium level of investment will now be compared with the first-best solution. Social efficiency requires that projects are financed if and only if their expected gross return is at least as high as the safe return. That is, all projects must satisfy

$$(13) \quad p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R^f - (1 + \rho)K \geq 0.$$

In fact, since all projects have the same expected gross return, at an optimum (13) must hold as an equality for all $i$.

PROPOSITION 5(A). If the supply of funds to the banking system is not decreasing in the rate of interest on deposits, at the competitive equilibrium investment falls short of the first-best level.

*Proof of Proposition 5(A).* If total investment equals or exceeds the first-best level, then the total expected return on each project must be less than or equal to the safe return:

$$(14) \qquad p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R^f \le (1 + \rho)K.$$

Since the safest project that applies for finance at the equilibrium interest rate $r$ earns the entrepreneur a zero expected profit, it is easily checked that if (14) holds, then the banks would expect to break even or experience losses on this marginal project. All other projects applying for finance have a higher bankruptcy probability than does the marginal project, and so on these the bank would definitely expect losses. In equilibrium, therefore, investment must be less than the first-best level.                     Q.E.D.

Note that this Proposition holds true irrespective of whether or not the market clears. We also have the following proposition, the proof of which is analogous to that of Proposition 2(B).

PROPOSITION 5(B).  If the supply of funds to the banking system is backward-bending, equilibrium investment may exceed the first-best level.

Again, however, a simple policy is available to achieve social efficiency.

PROPOSITION 6.  A subsidy on interest income can achieve social efficiency.

*Proof of Proposition 6.* From the proof of Proposition 5(A) banks expect losses at the social optimum. A subsidy on interest income will reduce the gross $\rho$ banks must pay to attract the volume of deposits required to finance the optimal level of investment. Hence, such a subsidy can be used to support a competitive equilibrium that is also efficient.                     Q.E.D.

It might be thought that the reason the model of the previous section yields overinvestment, whereas the Stiglitz-Weiss assumptions imply underinvestment, is because in their model some entrepreneurs may be refused loans. However, this is not the reason for the different result. This is established by showing that if credit rationing occurs in their model, the volume of lending is actually higher than it would be at a market-clearing interest rate.

PROPOSITION 7.  If $\rho$ is increasing in the volume of bank borrowing, then investment is higher in a credit-rationing equilibrium than at the market-clearing interest rate.

*Proof of Proposition 7.* If there is a credit-rationing equilibrium at interest rate $r'$, then the banks' expected return per loan must be higher than at the market-clearing interest rate of $\hat{r}$. Under competition, a market-clearing interest rate implies zero profits for the banks. Hence profits would be positive at $r'$ if the level of bank deposits were the same or higher than at $\hat{r}$, for then $\rho$ would be at or below its market-clearing value. This is inconsistent with equilibrium because with positive profits each bank has an incentive to expand its lending. This forces $\rho$ up until profits are zero at $r'$. The volume of loans is therefore higher than under market clearing.

Q.E.D.

Propositions (5) and (7) immediately imply.

COROLLARY 1. Prohibiting credit rationing yields an efficiency loss.

For both the Stiglitz-Weiss model and our model, equilibrium involves entrepreneurs with high-success probabilities subsidizing low-success probability investments. However, there is a crucial difference between the two models in this regard. In our model the marginal project financed has the lowest success probability of those financed, while in the Stiglitz-Weiss model it has the highest. This, of course, explains the asymmetry in the relationship of the respective equilibrium levels of investment to the respective first-best levels.

## III. THE FORM OF CONTRACTS

So far it has been assumed that entrepreneurs put up as much finance themselves as they can and raise outside finance by selling debt. The assumption of maximum self-finance is easily justified. Omitting a formal proof, the reason is that in both models asymmetric information means that in equilibrium cross-subsidization takes place. In the first model better projects subsidize poorer projects, and in the Stiglitz-Weiss model low-risk projects subsidize high-risk projects. In both models entrepreneurs with higher than average success probabilities can supply finance to themselves on better terms than they can obtain in the market and hence will put up $W$. Realizing this, banks will require maximum self-finance as part of contracts. Failure of entrepreneurs to put up $W$ would signal that their projects are worse than average and hence disqualify them from the contract.

We now consider whether the equilibrium method of raising

outside finance is a debt contract. To do this, we compare debt with equity finance for both models. The proofs suppose that firms must be either wholly equity financed or wholly debt financed. However, this restriction does not affect the substance of our results.

First consider the model of Section I.

PROPOSITION 8. For the model of Section I, equilibrium requires that all firms are debt financed.

*Proof of Proposition 8.* Suppose, to the contrary, that in equilibrium both debt and equity are issued. Let $\alpha$ be the proportion of equity retained by entrepreneurs who finance with equity and $(B, r)$ the debt contract for entrepreneurs who finance with debt. In equilibrium there must then exist an entrepreneur who is indifferent between debt and equity finance. Denoting the success probability of this entrepreneur by $\hat{p}$, it follows that for $p_i = \hat{p}$:

$$(15) \quad \alpha(p_i(R^s)R^s + (1 - p_i(R^s))R^f) = p_i(R^s)\,(R^s - (1 + r)B).$$

This implies that

$$(16) \quad (1 - \alpha)\,(p_i(R^s)R^s + (1 - p_i(R^s))R^f = p_i(R^s)\,(1 + r)\,B$$
$$+ (1 - p_i(R^s))R^f.$$

Therefore, the rate of return to the bank is the same whether this project is financed by debt or equity. From (15) those entrepreneurs with projects with $p_i > \hat{p}$ prefer to issue debt, and those with $p_i < \hat{p}$ prefer equity. This is established by noting that while both sides of (15) are increasing in $p_i$, the right-hand side is more sensitive to changes in $p_i$. Banks know that projects choosing equity finance have $p_i \leq \hat{p}$ and debt-financed projects have $p_i \geq \hat{p}$. Hence, on debt-financed projects the banks expect higher profits than yielded by the marginal project, while on equity-financed projects profits will be lower than yielded by this project. Therefore, an equilibrium with debt and equity is impossible.

Now suppose that, contrary to the Proposition, all firms choose equity finance. Given the equilibrium $\alpha$, let a bank offer a debt contract with interest rate $r^*$ that attracts projects with a success probability of $p^*$ and above. On the project with success probability $p^*$, the bank will do as well as it would with the equity contract. Suppose that $r^*$ is set sufficiently high that the $p^*$ project is one on which a bank would earn a positive expected profit with equity finance. Then, when it offers a debt contract to which the worst project attracted has success probability $p^*$, expected profit must

be strictly positive. Hence, all firms choosing equity finance is inconsistent with equilibrium.

Using similar reasoning, it can be shown that if all firms choose debt finance, there can be no gain to a bank from offering to buy equity. By doing so, a bank will attract all the worst projects. All projects being debt financed is thus consistent with equilibrium. Moreover, as long as the expected return on the best project exceeds the lowest interest rate at which savers will supply funds, it follows that an all-debt equilibrium exists.                    Q.E.D.

Stiglitz and Weiss do not formally consider the possibility that, rather than issuing debt, entrepreneurs sell equity to investors. On pages 407–08 they mention that moral hazard problems may arise if equity is sold and that default risk is a drawback of debt. They suggest that, as a result, both forms of finance may be observed. However, in the absence of moral hazard considerations, it can be shown that equity is the equilibrium method of finance in the Stiglitz-Weiss model.

PROPOSITION 9. For the model of Section II, the equilibrium method of finance is an equity contract.

The proof of this Proposition is analogous to that of Proposition 8.

It is interesting to note that if all equity finance obtains in the Stiglitz-Weiss model, the first-best solution is achieved. The reason is clear. Since all projects have the same expected returns, with equity finance they are all equally attractive to investors. Hence, there can be no adverse selection problem. More formally, with equity finance all projects are undertaken for which

$$(17) \qquad \alpha(p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R^f) \geq (1 + \rho)W$$

and

$$(18) \quad (1 - \alpha)(p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R^f) \geq (1 + \rho)(K - W).$$

Using (18), (17) may be written as

$$(19) \qquad p_i(R_i^s)R_i^s + (1 - p_i(R_i^s))R^f \geq (1 + \rho)K,$$

which is the same as the first-best condition given in (13).

## IV. CONCLUSION

This paper has shown how, in the presence of asymmetric information, the financial structures of firms and the efficiency

properties of the level of investment depend upon the distribution of project returns. If all projects offer the same expected returns but differ in their risks, then equity is the favored means of finance, and social efficiency obtains. If, for some reason, only debt finance is feasible, there will be too little investment, and an interest rate subsidy would be appropriate. This is true whether the equilibrium involves credit rationing or is market clearing, but the underinvestment problem is less severe under credit rationing. If the expected returns on projects differ, then debt is the equilibrium financial contract, and a socially excessive level of investment results. An interest rate tax would therefore be the appropriate policy to restore efficiency. The overinvestment possibility is novel. It is precisely contrary to the usual view that if the credit market fails, the direction of the bias is that investment falls short of the socially efficient level.

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