Does Adverse Selection Justify Government Intervention in Loan Markets?

Jeffrey M. Lacker

Government involvement in loan markets in the United States is substantial. For example, federal government direct and assisted lending for 1980 through 1987 amounted to $1208.1 billion, or 25.3 percent of total net lending in nonfinancial credit markets over the period (Gale 1991). Only $115.5 billion of this amount represents direct federal lending; the rest is accounted for by guaranteed loans ($251.3 billion), lending through government-sponsored enterprises ($441.8 billion), and lending subsidized by tax-exemptions ($399.5 billion). Can such interventions be justified as welfare-improving corrections of market failures?

Some economists have argued that market failure is particularly likely in credit markets because of "adverse selection"—borrowers have unverifiable hidden knowledge about their likelihood of repayment.[1] There is a type of externality in loan offers, and this can sharply constrain loan market outcomes.

The author thanks Tom Humphrey, John Weinberg, Tony Kuprianov, and Tim Cook for helpful comments on earlier drafts. Some of the material in this article resulted from joint work with John Weinberg. The author is solely responsible for the contents of the article, and the views expressed do not necessarily reflect those of the Federal Reserve Bank of Richmond or the Federal Reserve System.

[1] "The Federal government has played a central role in the allocation of credit among competing uses. This paper illustrates that this sort of government program can under plausible conditions improve on the unfettered market allocation. A necessary condition for efficient government intervention is unobservable heterogeneity among would-be borrowers regarding the probability of default. The greater is such heterogeneity, the greater is the potential for default" (Mankiw [1986], p. 469). See also de Meza and Webb (1987), Gale (1990), Greenwald and Stiglitz (1986), Innes (1991), and Smith and Stutzer (1989).

For example, a good borrower may not receive ideal loan terms, since an otherwise indistinguishable bad borrower would have an incentive to apply for that loan as well, making it unprofitable. The market failure literature argues that government credit guarantees can ease these constraints by improving loan terms for less creditworthy borrowers. The resulting improvement in loan terms for good borrowers leaves them willing to fund the subsidy to bad borrowers.

In a separate literature, some economists have argued that adverse selection can help explain the role of financial intermediaries.[2] In their models, financial intermediaries often emerge endogenously as part of equilibrium arrangements, attaining allocations that cannot be attained through direct lending alone. One notable result from these models is that the resulting financial arrangement cannot be improved upon by government intervention; private financial arrangements do as well as any government scheme.

How can we reconcile these two contrasting approaches? As I show in this article, both are based on virtually identical economic environments. They differ, however, in how they predict outcomes for given economic environments; each adopts a different definition of equilibrium. In the models rationalizing government intervention, equilibrium is defined by the way agents play a specific multi-stage game. The rules of the game have strong implications for how agents rationally play and what outcome emerges. In contrast, models of financial intermediation are careful not to impose any institutional arrangement on the agents in the economy, so that institutional structure can emerge endogenously.

I argue in this article that the different definitions of equilibrium yield contrasting policy conclusions because the market failure approach imposes ad hoc restrictions that prevent mutually beneficial contractual arrangements. In the models of market failure, a seemingly reasonable implication of the game agents play is that each type of loan contract must break even. This condition prevents lenders from offering a menu of contracts that breaks even on average but involves cross-subsidies across contracts. In this case, government tax and subsidy schemes, such as credit guarantees, can bring about the cross-subsidization that private agents cannot. Thus government intervention can make all people better off, even though the government is subject to the same informational constraints as private agents.

The same equilibrium condition rules out endogenous financial intermediaries in the market failure models. Intermediaries arise in adverse selection environments to reap the benefits of cross-subsidy; by subsidizing one borrower the incentive constraints impeding a better borrower can be relaxed, making both types better off. Since financial intermediaries are a prominent feature

[2] See Miyazaki (1977), Boyd and Prescott (1986), Boyd, Prescott, and Smith (1988), and Lacker and Weinberg (1993).

of loan markets, it seems desirable to adopt a model that allows financial intermediaries to emerge when they have a role to play. This suggests that the adverse selection justification for government intervention in loan markets is based on an overly restrictive definition of equilibrium. I conclude that based on the models now available, adverse selection does *not* justify government intervention in loan markets.

In this article I focus solely on situations of adverse selection, in which agents have relevant private information ex ante, that is, *before they first meet*. Situations of ex post private information, in which agents obtain hidden information *after* they first meet, do not present the same possibilities for market failure. It is well known that the standard theorems on the optimality of competitive equilibria continue to hold under ex post private information (Prescott and Townsend 1984). As a consequence, adverse selection has received far more attention as a potential source of market failure. There remain, of course, possible justifications on redistributive grounds, but these are beyond the scope of this article.[3]

1. AN ADVERSE SELECTION CREDIT ECONOMY

In this section I describe a simple economic environment with borrowing and lending under adverse selection. The central feature of the environment is that borrowers have private information about the risk and return on their investment projects. Lenders do not know as much as borrowers, but try to infer as much as they can from the repayment promises borrowers issue. Lenders' beliefs and borrowers' actions are linked in a delicate interdependence that is the hallmark of adverse selection environments. In order to make this interdependence manageable and understandable, I will work with a drastically simplified economy. Various versions of adverse selection credit economies have been studied by economists. However, there is a basic structure shared by virtually all adverse selection environments, and my argument carries over to more general settings.

The economy I examine contains one feature that is not standard in adverse selection credit market models. I assume that borrowers are able to costlessly hide the return to their project. This feature, along with the properties of the collateral good, implies that borrowers' repayment promises must take the form of collateralized debt, as I showed in an earlier paper (Lacker 1991). In most of the literature on adverse selection in credit markets, either debt contracts are

[3] Some government credit programs might be justified to ameliorate the effects of other government regulations that inhibit diversification by private financial intermediaries, such as legal restrictions on bank branching (Williamson 1993). The best solution, however, is to eliminate the legal restrictions themselves. Lang and Nakamura (1993) argue that lending can generate an informational externality via publicly disclosed appraisals.

imposed by the theorist or the equilibrium contracts are not debt at all.[4] This feature does not alter my argument in any way, but it makes the predicted financial arrangements somewhat more realistic and demonstrates that the argument does not depend on the ad hoc imposition of debt contracts.

To begin then, there are two periods and all consumption takes place in the second period. There are a large number of borrowers, each with a single investment project that requires exactly one unit of input in the first period and yields a random return in the second period. The return can take on one of two values: either R units of output (the "good state") or zero (the "bad state"). Borrowers' returns are independent of one another. In addition, each borrower has an amount K of a collateral good in the second period. This good is more valuable to the borrower than it is to any other agent. One interpretation of the collateral good is chattels—portable personal property such as clothing or furniture.

Borrowers are risk-averse. They have identical utility functions over second-period consumption, given by $u(c_1 + c_2)$, where c_1 is second-period consumption of output and c_2 is consumption of the collateral good. I assume that the function u is strictly concave.

There are two types of borrowers—good and bad. The good borrowers have a high probability of a good return, p_g, and the bad borrowers have a low probability of a good return, p_b. I assume $0 < p_b < p_g < 1$. A borrower's type is known only to that borrower; borrowers are observationally indistinguishable to all other agents. The number of good borrowers is N_g, and the number of bad borrowers is N_b, both of which should be thought of as large.

There are a large number of lenders, more than the number of borrowers. Each lender has one unit of input good in the first period. Like borrowers, lenders only desire to consume in the second period. Unlike borrowers, however, lenders have linear, risk-neutral utility functions. Their utility is given by $c_1 + \beta c_2$, where c_1 is second-period consumption of output and c_2 is consumption of a borrower's collateral good. I assume that the preference parameter β is positive but strictly less than one. This reflects the assumption that a collateral good is more valuable to a borrower, relative to the payment good, than it is to any lender. The difference in valuations could represent a special match between the borrower and the collateral good or the resource costs of transferring the good.

Lenders have an alternative investment opportunity available to them that yields ρ units of output in the second period for every unit of input good invested in the first period. Because they only want to consume in the second period, lenders will want to lend or invest all of their first-period input goods. Because of their alternative investment opportunity, a loan to a borrower will

[4] An exception is Boyd and Smith (1993).

have to provide at least as much expected utility as ρ. Because there are more lenders than there are borrowers, there will always be an elastic supply of loans on terms that provide lenders with at least as much expected utility as ρ.

A *loan contract,* or *contract* for short, could in general specify payments of output and collateral by the borrower for each possible return. In other words, a contract could consist of four numbers: payments of output and collateral when the return is high and payments of output and collateral when the return is low. We can restrict attention to simpler contracts without doing any harm, however. First, note that the low return is zero, so the payment of output when the return is low will always be zero. Second, consider the collateral payment when the return is high. It is easy to show that as long as R is large enough, it is never desirable to have a positive collateral payment in the good state since the collateral is more valuable to the borrower than to the lender. More precisely, any contract with a positive collateral payment in the good state is dominated by one with no collateral payment and commensurately larger payment of output in the good state.[5] Therefore, we can restrict attention to contracts that specify two numbers: r, a borrower's payment of output when the return is good, and C, a borrower's payment of collateral when the return is bad.

Because there are two types of borrowers and they might receive different contracts, we need a notation for each. Let (r_g, C_g) be the contract for a good borrower, and let (r_b, C_b) be the contract for a bad borrower. To be physically feasible, the output payment must not be greater than the return in the good state, R, and the collateral payment must be nonnegative and no greater than the borrower's collateral, K. I assume that R and K are large enough that these feasibility constraints never bind. Since they play no role in the analysis, from here on I will ignore them.

In the second period a borrower can hide the return R, making it appear that the return is zero. The hidden return can be consumed secretly by the borrower. This possibility constrains the contracts to which the borrower can credibly agree. For example, if a contract calls for no collateral payment when the return is low, but some positive payment r when the return is high, the borrower will always hide the return, pay nothing, and consume the entire return R in private; the alternative is to make the payment r and consume $R - r$. A collateral payment when the return is low can provide an incentive to make the required payment when the return is high. In this case the borrower compares paying r to hiding the return and transferring collateral with value C. If $C \geq r$, then the borrower has no incentive to hide the return. Therefore, contracts must satisfy the following.

[5] This is true under either of the definitions of equilibrium that appear below.

Incentive constraints:

$$r_h \leq C_h \qquad \text{for} \quad h = g, b. \tag{1}$$

Condition (1) ensures that the borrower has an incentive to repay the loan as agreed when the return is high, rather than hand over the collateral. The incentive constraints imply that loans must be "fully collateralized," meaning that the value of the collateral (to the borrower) is at least as large as the value of the promised repayment. If $C > r$, the loan is "overcollateralized." The only contracts that satisfy the incentive constraint (1) are collateralized debt contracts—noncontingent except when the return is insufficient to make the payment r.[6]

I can now describe the most crucial condition that contracts must satisfy in this environment. Suppose that the end result of the interactions between agents in this economy is that good borrowers receive contracts (r_g, C_g) and bad borrowers receive contracts (r_b, C_b). Since a borrower's type is private information, one type of borrower could conceivably participate pretending to be the other type of borrower, receiving the contract meant for the other type. All participants might be expected to be aware of this possibility. If the designation of contract (r_g, C_g) for good borrowers and contract (r_b, C_b) for bad borrowers is to correspond to reality, then it must not be in any borrower's interest to masquerade as the other type of borrower. This condition, which I call the *self-selection constraints*, must be satisfied by the outcome of any mechanism agents adopt. Stated formally, we have

Self-selection constraints:

$$\begin{aligned} &p_g u[(R - r_g) + K] + (1 - p_g)u(K - C_g) \\ &\qquad \geq p_g u[(R - r_b) + K] + (1 - p_g)u(K - C_b) \end{aligned} \tag{2}$$

$$\begin{aligned} &p_b u[(R - r_b) + K] + (1 - p_b)u(K - C_b) \\ &\qquad \geq p_b u[(R - r_g) + K] + (1 - p_b)u(K - C_g). \end{aligned} \tag{3}$$

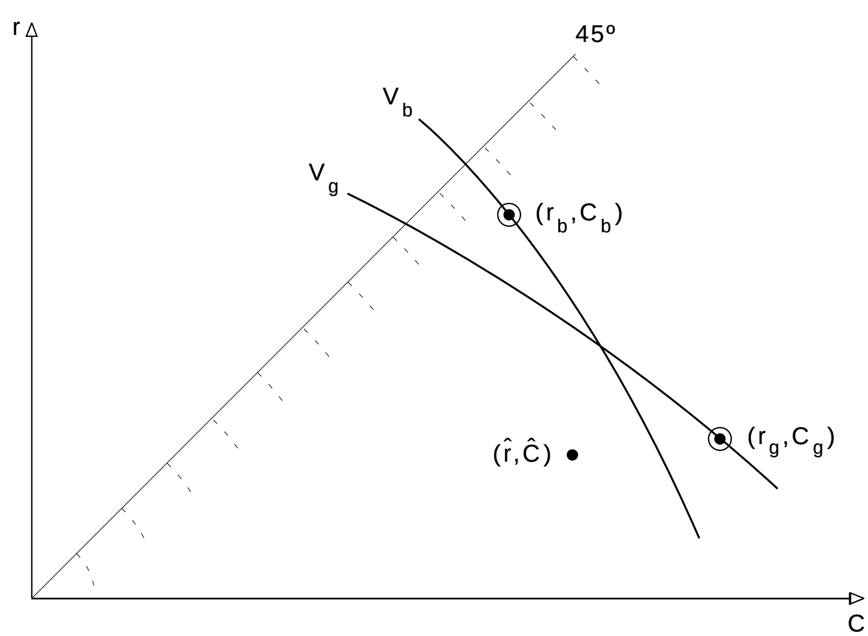
Constraint (2) states that the expected utility of a good borrower is at least as high under contract (r_g, C_g) as under contract (r_b, C_b). Similarly, constraint (3) states that the expected utility of a bad borrower is at least as high under contract (r_b, C_b) as under the contract (r_g, C_g). Neither type of borrower has an incentive to pose as the other.

[6] The distinction between a risky debt contract and a more general contingent claim is blurred when there are only two returns. For example, one might just as well call a contract satisfying (1) a collateralized profit-sharing plan; the borrower promises to pay a fraction r/R of the return or else hand over collateral when the return is zero. When there are many possible returns, however, the distinction is quite meaningful.

The self-selection constraints are illustrated in Figure 1. The good state output payment r is measured on the vertical axis, while the bad state collateral payment C is measured on the horizontal axis. Any arbitrary contract (r, C) can be represented by a point on the graph. Borrower preferences over contracts are shown by means of indifference curves. The curve labeled V_g is the set of contracts that leaves a good borrower indifferent to the contract (r_g, C_g). Similarly, the curve labeled V_b is the set of contracts that leaves a bad borrower indifferent to the contract (r_b, C_b).

Borrowers would like smaller payments in either state, so indifference curves slope down and borrower utility is increasing toward the lower left corner of the graph. A contract like $(\hat{r}, \hat{C})$ is preferred over (r_g, C_g) by good borrowers, since it lies below V_g, and is preferred over (r_b, C_b) by bad borrowers, since it lies below V_b. The indifference curves of a bad borrower are everywhere steeper than the indifference curves of a good borrower. Because the probability of having to surrender collateral is larger for bad borrowers,

Figure 1 Self-Selection and Incentive Constraints



Notes: r is the loan repayment amount, and C is the collateral that is transferred in the event of default. V_b is a bad-borrower indifference curve through the contract (r_b, C_b). V_g is a good-borrower indifference curve through the contract (r_g, C_g). Utility is increasing to the lower left. Incentive constraints for voluntary repayment of the loan require that contracts lie below the 45° line.

they are more averse to collateral requirements than are good borrowers. As a result, it is always possible to find a pair of contracts that "separate" the two types of borrowers, as shown in Figure 1. Bad borrowers prefer their contract (r_b, C_b) to the good borrowers' contract (r_g, C_g), because the latter would place them on an inferior indifference curve. Similarly, good borrowers prefer their contract to the bad borrowers' contract.

The incentive constraints imply that contracts must lie below the 45° line; the collateral payment must be at least as large as the good state payment. If (1) is not satisfied ($r > C$), then the borrower would hide the return in the good state and transfer collateral rather than pay more.

Figure 2 shows "break-even lines" for each type of borrower. The line labeled π_g is the set of loans to good borrowers that earn no excess profits for lenders. (Throughout this article "profits" refers to the expected profits of lenders.) In other words, π_g is the set of contracts that satisfy

$$p_g r + (1 - p_g)\beta C = \rho. \tag{4}$$

Contracts above π_g earn positive profits for lenders and contracts below π_g earn negative profits. The line labeled π_b is similarly defined as the set of loans to bad borrowers that earn no excess profits for lenders.

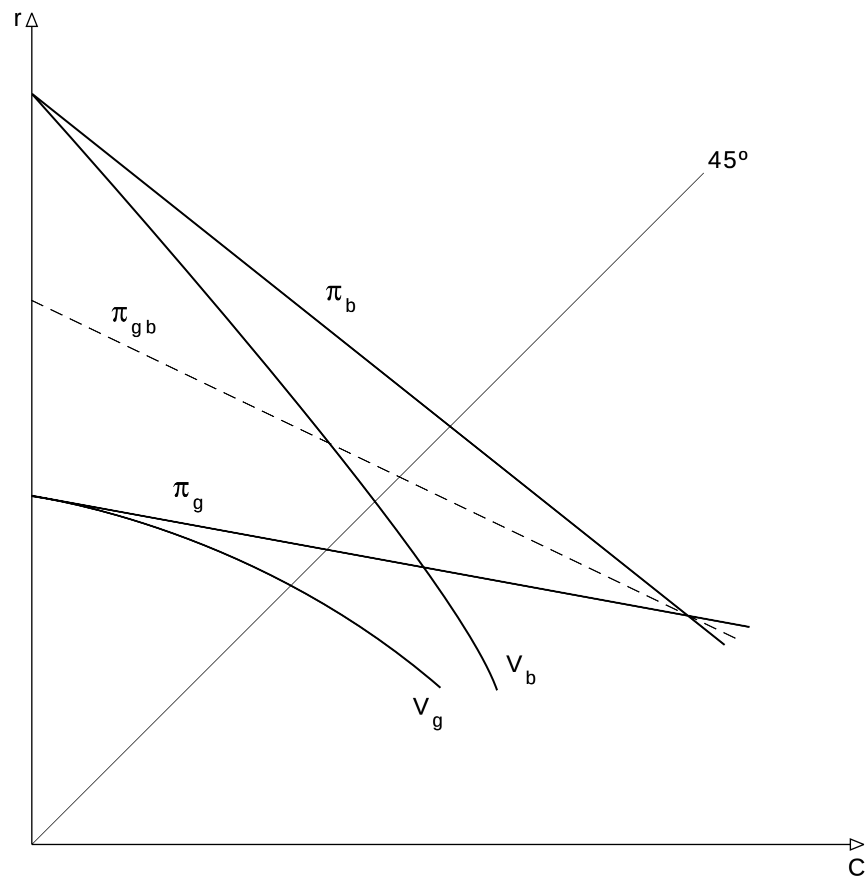
$$p_b r + (1 - p_b)\beta C = \rho. \tag{5}$$

The break-even line for bad borrowers is steeper than the break-even line for good borrowers because the probability of default and collateral transfer is larger for bad borrowers. Contracts above π_g but below π_b (to the left of their intersection) earn excess profits on good borrowers but negative profits on bad borrowers. Figure 2 also shows the "pooling break-even line," π_{gb}. This is the set of contracts that earn no excess profits when all borrowers apply, satisfying

$$[\, p_g r + (1 - p_g)C\,]\, N_g + [\, p_b r + (1 - p_b)C\,]\, N_b \geq \rho(N_g + N_b). \tag{6}$$

Overcollateralization is inefficient in this environment, ceteris paribus. As Figure 2 shows, a borrower's indifference curve is always steeper than the break-even line for that borrower. In the absence of the incentive and self-selection constraints, a borrower choosing among all of the contracts on the appropriate break-even line would prefer the one on the vertical axis, where collateral transfer is zero. There are two reasons for this. First, such a contract minimizes the risk borne by the borrower. Second, collateral is more valuable in the hands of the borrower, so better loan terms are available if the collateral transfer is minimized. The inefficiency of collateral transfer implies that contracts will attempt to minimize the collateral component, subject to the incentive and self-selection constraints.

Figure 2 Collateral Transfers Are Undesirable, Ceteris Paribus



Notes: π_g (π_b) is the set of contracts earning zero expected profits on good (bad) borrowers. π_{gb} is the set of contracts earning zero expected profits on the average borrower.

2. AN ARGUMENT FOR GOVERNMENT INTERVENTION IN LOAN MARKETS

A Definition of Equilibrium: The Wilson Equilibrium

I have described an economic environment, in other words, the preferences, endowments and technologies (including information technologies) of an artificial economy. An economic model also requires a means of selecting a predicted outcome from among the many possible outcomes that are feasible for any given environment—in other words, a definition of "equilibrium." The usual candidate is the competitive equilibrium in which agents take prices as given and select utility- or profit-maximizing quantities.

The standard notion of a competitive equilibrium is problematic in adverse selection environments, however. In frictionless environments, the value of a commodity is known to the buyer and so the perceived desirability of a transaction depends only on the preferences of the buyer and the price. In an adverse selection environment, buyers' beliefs about the value of the item—a financial claim, in our case—hinge on the actions of sellers, which in turn may depend on the entire array of options available to sellers. Thus the desirability of a given transaction may depend on all of the other transactions taking place. In our environment, for example, a lender's beliefs about which borrowers have applied for a loan depend on what other loan contracts are available. Another lender could offer a contract that takes away the best borrowers, leaving behind high-risk borrowers.

A number of definitions of equilibrium have been proposed for adverse selection economies. Many have defined equilibrium as the outcome of some game agents are assumed to play. Formally, a *game* consists of a sequence of moves and countermoves available to agents, along with a specification of the payoffs they receive for any particular sequence of chosen moves. Players adopt *strategies,* functions determining their choice of move in various circumstances. The outcome of the game is presumed to be a *Nash equilibrium,* in which agents take other agents' strategies as given and choose a strategy that maximizes their expected payoff. In a Nash equilibrium, each player's strategy is a "best response" to other players' strategies.

The simplest version of this approach to adverse selection economies is a two-stage game. In the first stage lenders simultaneously offer loan contracts, and in the second stage borrowers choose which contracts to accept. Accepted contracts are then executed, determining payoffs. A lender decides on a loan offer, taking as given the loans offered by other lenders and the way in which borrowers select from the available loans. Unfortunately, as Rothschild and Stiglitz (1976) showed in a closely related environment, there often is no equilibrium for this game. The problem is that "pooling" contracts, in which all borrowers receive the same contract, are always vulnerable to contracts that "cream-skim" the best borrowers away, while separating contracts can be vulnerable to pooling contracts that make both types of borrowers better off. Thus in some cases this notion of equilibrium makes no prediction at all!

One alternative that has been proposed is a particular four-stage game. The first two stages are as before, with lenders making offers and borrowers accepting. In the third stage lenders can withdraw any loan offer made in the first stage, but no contracts can be added. Lenders cannot precommit to not withdraw a contract in the third stage. In the final stage borrowers choose contracts again, the game ends, and contracts that have been accepted are executed. This game always has an equilibrium, so it avoids the serious existence problem of the two-stage game. This definition of equilibrium, which I describe more explicitly below, was first proposed by Charles Wilson in 1977 and is widely known as the "Wilson equilibrium." As I will show, there is a rationale for government loan market intervention in models adopting the Wilson equilibrium.[7]

Many other definitions of equilibrium have been proposed for adverse selection environments, and models adopting some of them have been used to justify government intervention in loan markets. The rationale for government intervention under these other equilibria is similar to that of the Wilson equilibrium, and I will briefly comment on them at the end of this section. One advantage of the Wilson equilibrium is that it always exists.

To formally define a Wilson equilibrium, let S be a set of contracts. The set S could be a pair of separating contracts or a single pooling contract.

Definition (defeats): Given a set of contracts S and another set of contracts S', suppose borrowers self-select among both sets of contracts. If any contracts in S earn negative profits, delete the smallest number of contracts in S such that the remaining contracts are all profitable after borrowers again self-select. If all of the contracts in S' now earn nonnegative profits and at least one earns strictly positive profits, then the set of contracts S' *defeats* the set of contracts S.[8]

Definition: A *Wilson Equilibrium* is a set of contracts S satisfying the following conditions:

(i) the incentive constraints (1);
(ii) the self-selection constraints (2) and (3);
(iii) each contract earns nonnegative profits for lenders; and
(iv) no other set of contracts S' exists that defeats the set of contracts S.

The first two conditions require that contracts be consistent with the informational imperfections of the environment. Condition (iii) states that each individual contract must at least break even. The essential idea in condition (iv) is that a set of equilibrium contracts cannot be trumped by some other contracts earning excess profits. The critical component of the definition concerns the conjectures of lenders contemplating introducing the deviating contracts. A new contract might attract good borrowers from other lenders and might earn excess profits, but some of the original contracts may then earn negative profits. If the

[7] Innes (1991) describes the case for government intervention in loan markets based on the Wilson equilibrium. Crocker and Snow (1985a) prove the existence of Pareto-improving government tax schemes in the Rothschild-Stiglitz insurance model.

[8] This definition, following Wilson, does not rely on an explicit formal definition of a game. Wilson viewed these conditions as defining a competitive equilibrium. As is typical, the game has multiple equilibria. One could view the definition as selecting a particularly plausible equilibrium. Hellwig (1987) conjectures that recently proposed equilibrium "refinements" select the Wilson equilibrium.

original contracts now earning negative profits are withdrawn, borrowers will reallocate themselves among the remaining contracts and some new contracts may now earn negative profits. Such contracts do not defeat the equilibrium. If the new contracts remain profitable, then they have defeated the original set of contracts, which could not have been an equilibrium.

Condition (iii) is crucial. It is sometimes called the "type-wise break-even" condition, since it requires that each contract earn nonnegative profits on its own. This condition is derived from the ability of lenders to withdraw any unprofitable contracts at the third stage of the game. Furthermore, lenders cannot precommit to *not* withdraw unprofitable contracts. As we will see below, condition (iii) implies a welfare-enhancing role for government intervention.

What Does the Wilson Equilibrium Look Like?

There is a unique set of contracts that constitutes a Wilson equilibrium. Depending on parameter values, the Wilson equilibrium is one of two types.[9] One type, the *separating equilibrium*, is shown in Figure 3. The bad borrower receives the contract (r_b^*, C_b^*), where the bad-type break-even line, π_b, intersects the 45° line. Of all the contracts that break even on bad borrowers and satisfy the incentive constraint (1), the contract (r_b^*, C_b^*) is the one most preferred by bad borrowers. The good borrower's contract has to lie on or above V_b^*, the bad borrower's indifference curve through (r_b^*, C_b^*), in order to satisfy the self-selection constraint (3). Since it must at least break even, it must also lie on or above π_g. Of all the contracts satisfying (3) and the good-type break-even condition, the contract (r_g^*, C_g^*) is the one most preferred by good borrowers.

It is easy to see why this is an equilibrium. First, imagine trying to attract good borrowers without attracting the bad borrowers. To do so the new contract would have to lie below the good-type indifference curve V_g^* but above V_b^*, to the southeast of (r_g^*, C_g^*) in Figure 3. But such contracts earn negative profits since they lie below π_g. Similarly, there is no contract that attracts only the bad borrowers, satisfies the incentive constraint, and earns nonnegative profits. Finally, imagine introducing a pooling contract that attracts both good and bad borrowers. Such a contract would have to lie on or above the pooling break-even line, π_{gb}. No such contract would succeed in attracting the good borrowers, since π_{gb} lies everywhere above V_g^*.[10]

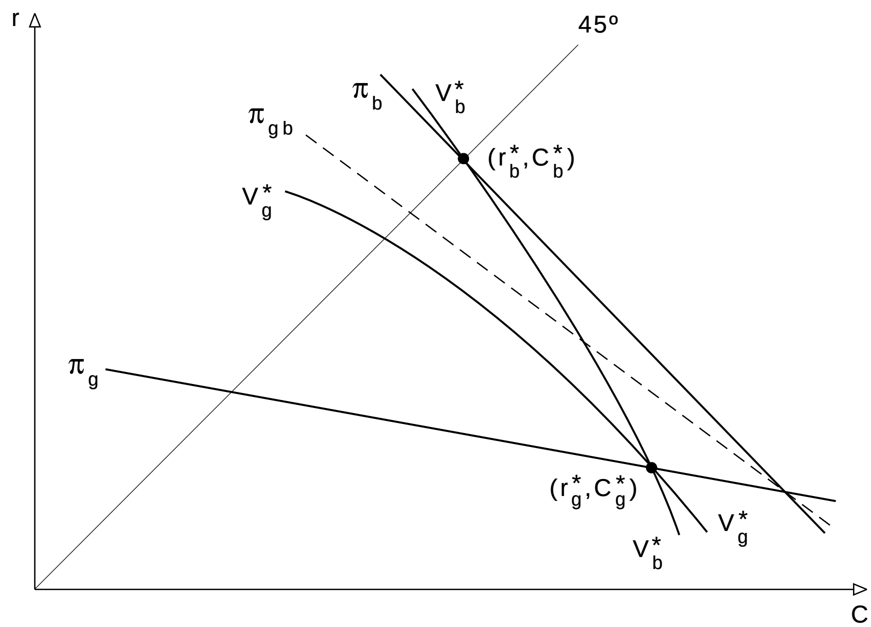
The other type of Wilson equilibrium is a *pooling equilibrium*. Both types of borrowers receive the same loan contract, (r^{**}, C^{**}) in Figure 4. This contract lies at the tangency of the pooling break-even line, π_{gb}, and a good borrower's

---

[9] There is a knife-edge case of a single set of parameter values for which both types of equilibria coexist, which I will ignore.

[10] In this case the Wilson equilibrium is the same as the equilibrium of the two-stage game analyzed by Rothschild and Stiglitz (1976).

Figure 3 The Wilson Equilibrium When N_b/N_g Is Large: Type-Wise Break-Even Separating Contracts



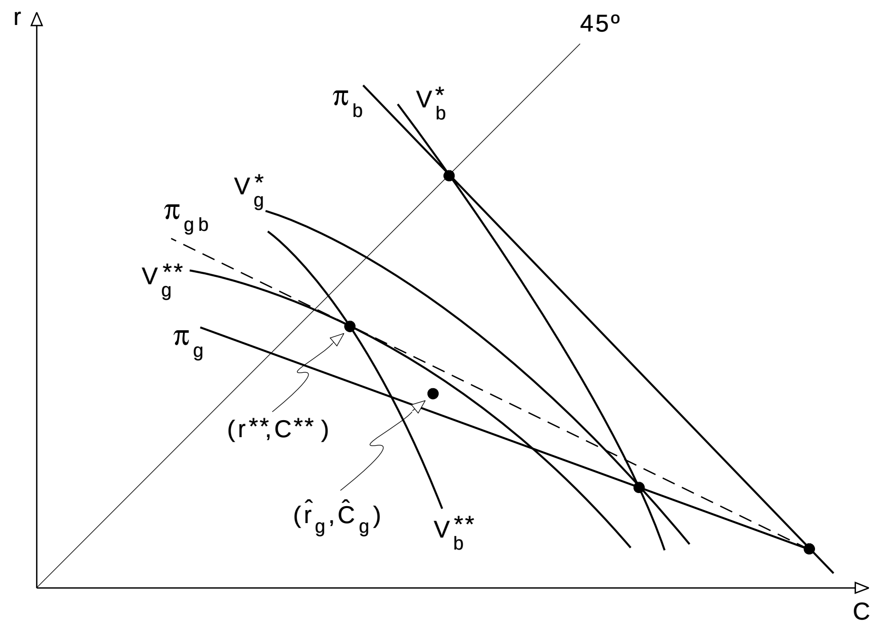
Notes: Bad borrowers receive the contract (r_b^*, C_b^*), where the bad-borrower break-even line, π_b, intersects the 45° line. Good borrowers receive the contract (r_g^*, C_g^*), where the good-borrower break-even line intersects the bad borrower's indifference curve through (r_b^*, C_b^*); the bad borrower is indifferent between (r_b^*, C_b^*) and (r_g^*, C_g^*). Good borrowers prefer (r_g^*, C_g^*) to any contract on the pooling break-even line, π_{gb}. This type of equilibrium occurs for *high* and *very high* levels of N_b/N_g in Table 1.

indifference curve, V_g^*. This contract provides higher expected utility for a good borrower than the separating equilibrium, since it lies below the indifference curve through the separating allocation, V_g^*. Of all of the pooling contracts, (r^{**}, C^{**}) is most preferred by the good borrowers.[11]

To see why this is an equilibrium, consider how a lender might try to attract good borrowers by offering a contract like $(\hat{r}_g, \hat{C}_g)$ in Figure 4. This would indeed attract good borrowers and it would make positive profits as well, since it lies above the good-type break-even line, π_g. But now the contract (r^{**}, C^{**}) would lose money, since it would only be selected by bad borrowers. It would

[11] Note that the pooling equilibrium might lie on the 45° line. This occurs if there is no point below the 45° line on π_{gb} tangent to a good borrower's indifference curve.

Figure 4 The Wilson Equilibrium When N_b/N_g Is Small: A Pooling Contract



Notes: The Wilson equilibrium contract (r^{**}, C^{**}) is the pooling contract that maximizes the expected utility of the good borrower. The rival contract $(\hat{r}_g, \hat{C}_g)$ would attract all of the good borrowers, but fails to defeat (r^{**}, C^{**}) because the latter would then lose money on just bad borrowers and be withdrawn, forcing all borrowers to take $(\hat{r}_g, \hat{C}_g)$, which would then lose money. This type of equilibrium occurs for *intermediate, low,* and *very low* levels of N_b/N_g in Table 1.

be withdrawn in the third stage of the game, leaving only the new contract $(\hat{r}_g, \hat{C}_g)$. The new contract would now attract both types of borrowers, and since it lies below π_{gb} it would earn negative profits. Such a contract thus fails to defeat (r^{**}, C^{**}). It should be clear that no other pooling contract is able to defeat (r^{**}, C^{**}) either, since none would break even *and* attract just the good borrowers after (r^{**}, C^{**}) is withdrawn.[12]

Which equilibrium occurs depends on whether π_{gb}, the pooling break-even line, intersects V_g^*, the good borrower's indifference curve that passes through the good-type separating contract. If it does, the equilibrium is a pooling

[12] In this case the Rothschild and Stiglitz equilibrium does not exist because the contract $(\hat{r}_g, \hat{C}_g)$ *would* defeat the candidate equilibrium (r^{**}, C^{**}); their equilibrium does not allow subsequent withdrawal of contracts earning negative profits.

contract like (r^{**}, C^{**}) in Figure 4. If it does not, the equilibrium is the set of break-even separating contracts shown in Figure 3. This depends on whether π_{gb} lies closer to π_g or π_b, which in turn depends on the ratio N_b/N_g. If there are many bad borrowers relative to good borrowers, pooling allocations are unattractive to the good borrower, so the type-wise break-even separating allocation is the equilibrium. If there are few bad borrowers relative to good borrowers, then the good borrower does well in a pooling allocation. As N_b/N_g approaches zero and the bad borrowers become a negligible portion of the market, the equilibrium allocation approaches the intersection of π_g and the 45° line, the loan that the good borrower would receive if there were no bad borrowers.

Is the Wilson Equilibrium Pareto-Optimal?

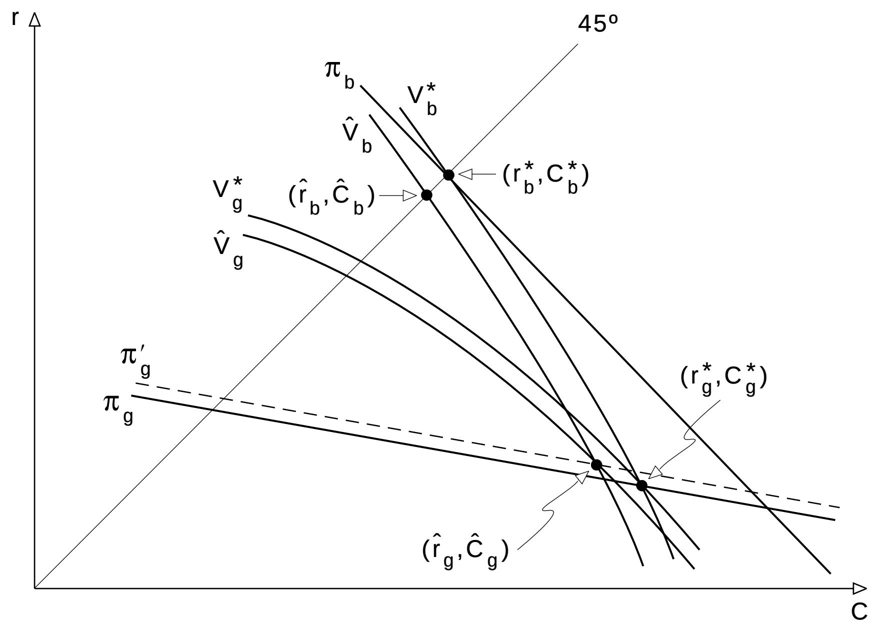
Are there any alternative allocations that make no agents worse off and make at least one agent strictly better off? If the answer is no, the given allocation is Pareto-optimal. The only relevant alternative allocations to check, of course, are those that are attainable—allocations that respect the resource, incentive, and self-selection constraints of the environment.

Is the Wilson equilibrium Pareto-optimal? Often the answer is no. Figure 5 shows why. Suppose the set of contracts $\{(r_g^*, C_g^*), (r_b^*, C_b^*)\}$ is a separating Wilson equilibrium, as before. (This occurs when the ratio of bad to good borrowers is above a certain threshold.) Now replace the bad borrowers' contract with the contract $(\hat{r}_b, \hat{C}_b)$, down and to the left along the 45° line. This new contract makes bad borrowers better off, but earns negative profits since it lies below π_b. In order to maintain resource feasibility, the new contract for good borrowers must earn excess profits. As a result, the good borrowers' new contract must lie on or above a line parallel to (but above) π_g, shown as a dashed line in Figure 5. The new contract for bad borrowers relaxes the self-selection constraint, which now requires that $(\hat{r}_g, \hat{C}_g)$ lie on or above $\hat{V}_b$. Among the contracts that satisfy the two constraints, the contract $(\hat{r}_g, \hat{C}_g)$, at the intersection of the dashed line and $\hat{V}_b$, is the one most preferred by good borrowers.

As shown in Figure 5, the good borrowers' new contract lies on an indifference curve that is superior to V_g^*, the indifference curve through the Wilson equilibrium contract.[13] The new set of contracts makes both types of borrowers better off, and by construction, lenders receive just as much expected consumption (and therefore expected utility) as before. In addition, the new contracts have been constructed to satisfy incentive and self-selection constraints. Therefore, the set of contracts $\{(\hat{r}_g, \hat{C}_g), (\hat{r}_b, \hat{C}_b)\}$ Pareto-dominates the separating Wilson equilibrium contracts.

[13] The new contract gives the good borrower a consumption pattern that is less risky than under the original contract. In addition, the good borrower benefits from reduced collateralization.

Figure 5 The Wilson Equilibrium Is Pareto-Dominated: The Separating Case



Notes: Bad borrowers prefer the contract $(\hat{r}_b, \hat{C}_b)$ to the equilibrium contract (r_b^*, C_b^*). Because $(\hat{r}_b, \hat{C}_b)$ lies below π_b, the resource feasible contracts for good borrowers now lie along π_g'. The good borrower can now obtain the contract $(\hat{r}_g, \hat{C}_g)$, where the bad borrower's indifference curve, $\hat{V}_b$, intersects π_g'. As shown, $(\hat{r}_g, \hat{C}_g)$ yields greater expected utility than (r_g^*, C_g^*).

The Wilson equilibrium *is* Pareto-optimal when N_b/N_g is very large. Whenever N_b/N_g is above some critical threshold, the dashed good-borrower resource feasibility line lies so far above π_g that no improvement for good borrowers is possible. This might even be true for any possible choice of alternative bad-borrower contract along the 45° line. If N_b/N_g is below the critical threshold the separating equilibrium is Pareto-dominated.

When the Wilson equilibrium is a pooling contract and does *not* lie on the 45° line, it is easy to show that it is not Pareto-optimal. The equilibrium allocation is dominated by a pair of separating contracts lying along V_b^{**}; the alternative contract for bad borrowers is above π_{gb} and the contract for good borrowers is below. Thus bad borrowers are indifferent and good borrowers are made strictly better off. If the Wilson equilibrium is the 45° line pooling contract, then it *is* Pareto-optimal. This occurs for values of N_b/N_g below some threshold. To summarize then, for a range of intermediate values of N_b/N_g the

Wilson equilibrium is *not* Pareto-optimal. For values of N_b/N_g above or below this range, the Wilson equilibrium *is* Pareto-optimal.[14]

Government Intervention Can Be Pareto-Improving

A crucial feature of the alternative allocations that Pareto-dominate the Wilson equilibrium is that they involve *cross-subsidy*. A pair of feasible contracts involve cross-subsidy if they do *not* lie on the individual break-even lines π_g and π_b; in other words, one earns positive expected profits while the other earns negative expected profits. In the allocations that Pareto-dominate the Wilson equilibrium, the good borrowers subsidize the bad borrowers, loosening the self-selection constraint and allowing good borrowers a less risky consumption pattern and reduced collateral transfer. Such allocations cannot be Wilson equilibria because they violate the type-wise break-even condition. When the Wilson equilibrium is not Pareto-optimal, government intervention can help by performing the cross-subsidization that is ruled out in equilibrium. Tax and subsidy schemes can provide bad borrowers with better loan terms, relaxing the bad borrower's self-selection constraint and allowing more desirable loan terms for good borrowers. Good borrowers are better off, even though they bear the tax burden.

Government intervention in this credit market can take many forms. One method is a subsidy for high-interest (bad-type) loans. The government could fund the subsidy through taxes levied on lenders' returns. This would relax the bad-borrower break-even line faced by lenders, making them willing to offer subsidized loan terms. The net tax on loans to good borrowers would shift upward the good-type break-even line. Tax and subsidy rates can be selected so that the resulting Wilson equilibrium Pareto-dominates the no-intervention equilibrium.[15]

One difficulty with a subsidy scheme of this sort is that it must be applied only to the loan contracts selected in equilibrium by the bad borrowers. A simpler alternative is a government loan guarantee applicable to all loans, funded by a tax on lenders' interest income. The government would guarantee a fraction δ of the stipulated loan repayment r, where $\beta < \delta < 1$. If the collateral transfer yielded $\beta C < \delta r$, the government would pay the lender $\delta r - \beta C$. This could be funded by a tax, τ, on lenders' net interest earnings, $(r - \rho)$. The parameter β can be set so that only bad borrowers are subsidized in equilibrium. The break-even lines for loans to type h borrowers $(h = g, b)$ is now

$$p_h[r - \tau(r - \rho)] \; + \; (1 - p_h)\text{MAX}[\beta C, \delta r] \; = \; \rho. \tag{7}$$

[14] For a complete welfare analysis of the closely related Rothschild-Stiglitz insurance environment, see Crocker and Snow (1985b).

[15] Crocker and Snow (1985a) consider such tax/subsidy schemes.

The government budget constraint is

$$\tau p_g(r_g - \rho)N_g \ + \ \tau p_b(r_b - \rho)N_b \ \geq \ (1 - p_g)N_g \mathrm{MAX}[0, \delta r_g - \beta C_g] + (1 - p_b)N_b \mathrm{MAX}[0, \delta r_b - \beta C_b]. \tag{8}$$

The effect of the tax is to rotate both break-even lines in a clockwise direction around the point at which they intersect. The effect of the guarantee is to make the lines flat to the left of where $\delta r = \beta C$. The combined effect is illustrated in Figure 6.

The allocation $\{(\hat{r}_g, \hat{C}_g), (\hat{r}_b, \hat{C}_b)\}$ can be attained by setting τ so that $(\hat{r}_g, \hat{C}_g)$ satisfies (7), and then setting δ so that $(\hat{r}_b, \hat{C}_b)$ satisfies (7). The feasibility of the new set of contracts implies that the government budget constraint is satisfied.[16] In the case of the pooling Wilson equilibrium, parameters could similarly be set to achieve a Pareto-dominating separating allocation.

Other welfare-enhancing schemes are easy to imagine, but all share the same principle. The government is able to cross-subsidize loan contracts in a way that is ruled out in the Wilson equilibrium. Cross-subsidies are inconsistent with rational strategies in the multi-stage game that agents are assumed to play. A natural question that arises is: Why would agents play this particular game?

Other Definitions of Equilibrium

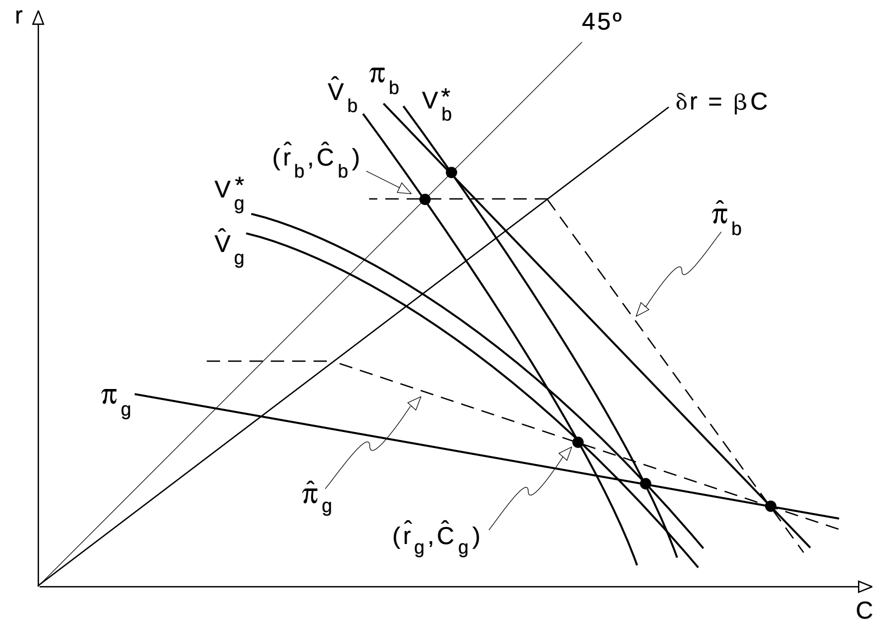
As I mentioned earlier, other definitions of equilibrium in adverse selection models have been used to justify government intervention in loan markets. Some authors select the Rothschild-Stiglitz equilibrium (type-wise break-even separating contracts) and restrict attention to cases in which it exists (Smith and Stutzer 1989; Gale 1990). Some authors adopt pooling allocations and note that such allocations are sometimes Pareto-dominated (Greenwald and Stiglitz 1986; de Meza and Webb 1987; Mankiw 1986). John Riley (1979) proposed an equilibrium very similar to Wilson's, in which lenders cannot withdraw contracts in the third stage (as they can under the Wilson setup) but *can* propose new contracts if they wish.[17]

---

[16] This scheme would be affected by the possibility that the new pooling break-even line may now intersect the good borrower's indifference curve through $(\hat{r}_g, \hat{C}_g)$. If it did, the Wilson equilibrium in the presence of this government guarantee is a pooling contract on the 45° line. If the tax and subsidy parameters are set to balance the budget at the separating contracts, they may violate the budget constraint at the pooling equilibrium. This problem might limit the magnitude of the Pareto-improvement. Adding a fixed lump-sum component to the tax schedule can get around the problem. See Crocker and Snow (1985a).

[17] A vast literature studies adverse selection environments as "signaling games," in which the informed agents (our borrowers) move first by taking some irrevocable action or making a contract offer; see Cho and Kreps (1987). This approach has not yet been applied to policy analysis.

Figure 6 A Pareto-Improving Government Credit Guarantee



Notes: $\hat{\pi}_g$ ($\hat{\pi}_b$) is the set of contracts that break even after taxes when accepted by good (bad) borrowers. The tax on net interest income rotates the break-even lines, while the guarantee flattens them out to the left of the line $\delta r = \beta C$, where the guarantee just pays off.

All of these other definitions of equilibrium impose a particular structure on the way agents interact, some through explicit games, some in an ad hoc fashion. All share the feature that "equilibrium" allocations can fail to be Pareto-optimal, providing a role for government intervention. Under all definitions, equilibrium is Pareto-dominated in all the cases in which the Wilson equilibrium is Pareto-dominated. Under some definitions, equilibrium is Pareto-dominated in other cases as well. In a sense, the Wilson equilibrium provides the strongest case for government intervention because, of the equilibria that have been proposed, the laissez-faire Wilson equilibrium is least likely to be Pareto-dominated; if government intervention is warranted for the Wilson equilibrium, it is warranted under other definitions as well. In any event, the Wilson equilibrium is representative of definitions that give rise to market failure in adverse selection environments, and my remarks apply with equal force to all.

What About Credit Rationing?

Adverse selection models of credit markets are often associated with the notion of "credit rationing" (Stiglitz and Weiss 1981). The parameter values I have assumed for my economy imply that credit rationing never occurs.[18] It should be clear that the adverse selection justification of government intervention in loan markets does not depend on the existence of credit rationing (Smith and Stutzer 1989; Gale 1990). The justification relies on the effects of self-selection constraints, and these perturb equilibrium whether or not credit rationing occurs.

3. ADVERSE SELECTION MODELS OF FINANCIAL INTERMEDIARIES[19]

Financial intermediaries such as banks, pension funds, and insurance companies surely play an important role in loan markets. And yet standard frictionless models have little to say about financial intermediaries. Either organizations such as banks or firms are taken as primitive elements, or they are economically inessential because equilibrium allocations can be achieved without them. Financial intermediaries can be viewed as large multilateral arrangements that arise to overcome the problems of asymmetric information that are absent in the standard frictionless models. Much recent effort has gone into the search for environments in which "realistic" multilateral arrangements, or at least aspects of them, are in some sense endogenous outcomes rather than imposed constraints. Much of this effort has focused on environments in which information is limited in some way, either being asymmetrically distributed or costly to obtain.

Adverse selection environments have been the basis for a number of prominent recent models of financial intermediation.[20] In this section I will describe a simple model of financial intermediaries using the economic environment laid out in Section 1. In Section 2 I took the same environment, adopted a particular definition of equilibrium—the Wilson equilibrium—and showed that government loan market intervention could be Pareto-improving. In this section I adopt a different definition of equilibrium; this is the only difference between the two models. Under the definition adopted here, financial intermediaries can emerge endogenously in equilibrium. Furthermore, there is no welfare-enhancing role for government intervention, since equilibrium allocations turn out to be Pareto-optimal.

---

[18] Insufficient collateral—a low value of K—often gives rise to borrowing constraints.

[19] The results presented in this section are due to joint ongoing work with John Weinberg.

[20] See Boyd and Prescott (1986), Boyd, Prescott, and Smith (1988), and Lacker and Weinberg (1993). One should add Hajime Miyazaki (1977), who interprets cross-subsidizing wage-employment contracts as an "internal labor market," in other words, a firm. Adverse selection is not the only possible approach; Diamond (1984) and Williamson (1986) present models of endogenous financial intermediaries based on costly verification and delegated monitoring.

Financial Intermediaries Are Inhibited Under the Wilson Equilibrium

One hallmark of financial intermediaries is that almost all of their assets and liabilities are financial claims, as opposed to physical assets. Because financial intermediaries hold large portfolios, they do not necessarily need to break even on each individual claim. In contrast, when individual claims are sold directly by borrowers to ultimate lenders, equilibrium requires that each claim at least break even. Cross-subsidization thus appears to be inconsistent with nonintermediated lending. Therefore, financial intermediaries should be expected to arise whenever allocations require cross-subsidization. Adverse selection models of financial intermediaries are based on just such reasoning.[21]

If we want to allow for the possibility of financial intermediaries, the equilibrium notion adopted in the previous section is clearly inadequate. The Wilson equilibrium assumes that lenders and borrowers can only enter into *bilateral* financial contracts. Multilateral financial arrangements are precluded by assumption. For simplicity, lenders in our environment have only one unit each to lend, exactly the amount each borrower wants to borrow. Thus no lender offers more than one contract. It would make no difference for the models, however, if each lender was large relative to borrowers and made many loans.

More to the point, the Wilson equilibrium imposes a particular *game* on the agents in the economy. Agents are assumed to interact through a specific sequence of moves and countermoves governed by a specific set of rules. In particular, the game underlying the Wilson equilibrium specifies that in the third stage lenders are able to withdraw *individual* loan contracts. This prevents a lender from offering a menu of contracts as a whole in the first stage and precommitting not to drop any single contract. This feature gives rise to the break-even constraint, which implies a welfare-enhancing role for government intervention. The same feature rules out the cross-subsidizing allocations associated with financial intermediaries.

In many instances, participants in real world economies interact within highly structured institutions, governed by rules, laws, customs, and so forth. A wide variety of market institutions come to mind, from decentralized search markets, to trading fairs, to auctions, to highly centralized (and organized) open-outcry markets. Many of these institutional arrangements can easily be cast as games since they impose binding restrictions on the interaction of participants. Game theory is obviously quite useful for analyzing the implications of alternative institutional and market structures.

However, when we are interested in predicting institutional arrangements, when we want a model of *which* game agents will play, we need a different

[21] The situation is analogous to a multiproduct firm with economies of scope across products. In a sustainable equilibrium one product might be subsidized in the sense that the price is less than the stand-alone marginal cost.

approach. Indeed, outcomes in adverse selection environments are known to be particularly sensitive to the assumed "market convention," as Wilson's subsequent (1979) research demonstrated. He showed that equilibrium can be very different depending on whether the informed agents (the borrowers in our environment) or the uninformed agents (the lenders) propose contracts. Wilson's 1979 results stand as a strong warning about the reliability of predictions from adverse selection models in which equilibrium is identified as the outcome of one particular game.

A Different Definition of Equilibrium: The Sustainable Equilibrium[22]

A different definition of equilibrium is needed then, a different way of selecting a predicted outcome for this environment, one that allows for the possibility of financial intermediaries. Three ideas guide the definition described below. First, I want to be agnostic about the game agents might play to implement the resulting allocation, since imposing a particular game could arbitrarily restrict the allocations agents can achieve. Second, there should be some notion of competition between rival financial intermediaries. If a financial intermediary is part of an equilibrium, there must be no other rival financial intermediary that "beats" it by doing better for the agents involved. Third, for a rival financial intermediary to beat a candidate intermediary, the rival must be "credible" in the sense that it cannot be beaten by any other (credible) rival intermediary. If a rival intermediary is itself vulnerable to another rival, it cannot be taken seriously as a threat to overturn the candidate allocation. It is important to note that the credibility requirement is imposed on *any* subsequent proposed rival intermediary.

While the definition of the Wilson equilibrium was stated in terms of contracts, the definition of the sustainable equilibrium can be stated more clearly in terms of *coalitions* and *allocations*. A *coalition* is simply a collection of some or all of the agents in the economy. Let n designate a typical coalition; n is a list of the names of each agent in the coalition. Let N designate the coalition consisting of every agent in the economy, that is, the *coalition of the whole*. An *allocation* for a given coalition is a list of the consumption plans of all agents in a coalition, together with their investment decisions. An allocation is equivalent to specifying all of the contracts among agents in a coalition. Let a designate a typical allocation.

The central ingredient in the definition of a sustainable equilibrium is the idea of *blocking*, which captures the notion of competition between rival

[22] The equilibrium described here was introduced in Lacker and Weinberg (1993) and is related to the idea of "coalition-proof Nash equilibrium" formulated by Bernheim, Peleg, and Whinston (1987) and Greenberg (1989). Kahn and Mookherjee (1991) independently developed a closely related equilibrium notion for games in adverse selection environments also based on the coalition-proof idea, but their approach differs enough in certain details that their results have a very different flavor.

coalitions. Intuitively, an allocation for a given coalition can be blocked by a subcoalition if the subcoalition can feasibly make all its members at least as well off and some strictly better off. In an adverse selection environment this idea must be specified with some care. A key consideration is that allocations for a subcoalition are limited by the incentive and self-selection constraints, as are all allocations. An additional consideration arises, however. If a subcoalition is proposed, will any of the agents left behind in the original coalition wish to misrepresent themselves in order to gain entry into the deviating subcoalition? If so, the self-selection constraints for the subcoalition will be undermined, making the proposed deviation infeasible. The following definition of blocking takes these considerations into account.

Definition: An allocation a for coalition n is *blocked* by a subcoalition n', together with an allocation a', if:

(i) the blocking allocation a' satisfies the incentive and self-selection constraints and is resource feasible for n';
(ii) all agents in n' are at least as well off under a' as they would be under a, and at least one agent is made strictly better off; and
(iii) no agents that the subcoalition leave behind in the original coalition could make themselves better off by joining the subcoalition, including by claiming to be a different type.

Conditions (i) and (ii) are standard. Condition (iii) implies that if one type of agent is made strictly better off, the coalition attracts all of that type of agent. Condition (iii) also implies that if a deviating subcoalition wants to attract some, but not all, of a given type of agent, they must make that type of agent indifferent between joining the subcoalition (truthfully) and receiving the original allocation. Also, that type of agent must have no incentive to join the subcoalition by claiming to be another type of agent in the subcoalition. Condition (iii) merely extends the self-selection constraints to cover potential blocking subcoalitions; it recognizes a subcoalition's vulnerability to strategic behavior.

I am now ready to define a sustainable equilibrium. In order to do so I must define the sustainable allocations *for each possible subcoalition,* as well as for the coalition of the whole. The sustainable equilibrium is then just the sustainable allocation for the coalition of the whole. Let $s(n)$ denote the set of sustainable allocations for coalition n. The definition is then simple: an allocation is sustainable if it is not blocked by any subcoalition together with a sustainable allocation for that subcoalition. The mapping $s(n)$ is defined formally as follows.

Definition: The mapping $s(n)$ is the set of *sustainable allocations* for each coalition n if it satisfies the following properties:

(i) allocations a in $s(n)$ satisfy the incentive and self-selection constraints and are resource feasible for the coalition n and

(ii) an allocation a is in $s(n)$ if and only if there does not exist a subcoalition n' together with an allocation a' in $s(n')$ such that (a', n') blocks a.

Condition (i) merely states that sustainable allocations must satisfy resource and informational constraints. Condition (ii) captures the notion of credibility. An allocation is sustainable if it is not blocked by any subcoalition together with an allocation that is sustainable for that subcoalition. If an allocation *is* blocked by such a subcoalition and allocation, then it is *not* sustainable.

A *sustainable equilibrium*, then, is any allocation that is sustainable for the population as a whole.[23]

What Does the Sustainable Equilibrium Look Like?

It turns out that there is a simple way to find the sustainable equilibrium for our economy. Solutions to a particular maximization problem, shown below, are sustainable allocations.

The Miyazaki Problem:

$$\text{MAX} \quad p_g u(R - r_g + K) \; + \; (1 - p_g) u(K - C_g)$$

$$\begin{aligned} \text{s. t.} \quad & p_b u(R - r_b + K) \; + \; (1 - p_b) u(K - C_b) \\ & \geq \; p_b u(R - r_g + K) \; + \; (1 - p_b) u(K - C_g) \end{aligned} \tag{10}$$

$$[p_g r_g + (1 - p_g)\beta C_g] N_g \; + \; [p_b r_b + (1 - p_b)\beta C_b] N_b \; \geq \; \rho(N_g + N_b) \tag{11}$$

$$r_h \; \leq \; C_h \qquad h = g, b \tag{12}$$

$$p_b u(R - r_b + K) \; + \; (1 - p_b) u(K - C_b) \; \geq \; V_b^0, \tag{13}$$

[23] The sustainable equilibrium is closely related to the *core*—the set of allocations that are simply unblocked. The core is empty in the cases in which the Rothschild-Stiglitz equilibrium does not exist—that is, the cases in which the Wilson equilibrium is a pooling allocation. It should be clear that the set of sustainable equilibria always contains the set of core allocations, when they exist, because the latter allows "easier" blocking. Townsend (1978) studies the core in a perfect information economy with fixed costs of bilateral exchange. There, intermediaries are required to overcome the nonconvexity. Interestingly, he describes a noncooperative game that allows contract proposals to include multilateral financial arrangements. The equilibrium of the noncooperative game attains the core allocation, thus bridging the gap between the game-theoretic and cooperative approaches. Boyd and Prescott (1986), Boyd, Prescott, and Smith (1988), and Marimon (1988) also study core-like equilibria in adverse selection environments. Given the definition of blocking, the core is the set of unblocked allocations. Unfortunately, the core is often empty in our economy, as it is in many adverse selection economies.

where

$$V_b^0 \equiv \text{MAX} \quad p_b u(R - r_b + K) + (1 - p_b)u(K - C_b)$$

$$\text{s. t.} \quad p_b r_b + (1 - p_b)\beta C_b \geq \rho$$

$$r_b \leq C_b.$$

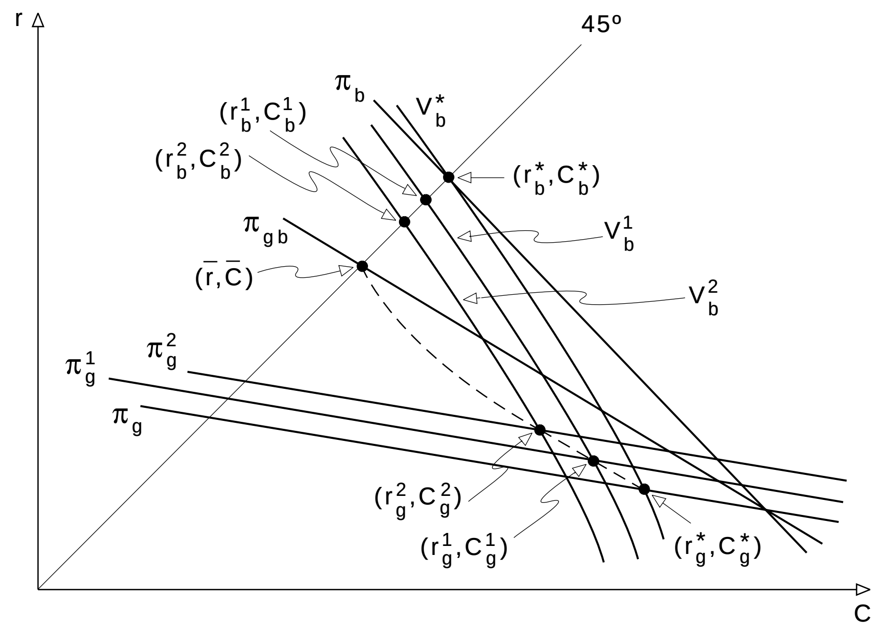
The Miyazaki Problem maximizes the expected utility of the good borrowers. The first constraint (10) states that bad borrowers have no incentive to pretend to be good borrowers. The second constraint (11) is just resource feasibility. The third constraint (12) ensures repayment incentives. The fourth constraint (13) states that the bad borrowers receive no less expected utility than V_b^0, the expected utility they would receive if they were on their own. V_b^0 is the maximum expected utility for bad borrowers under a contract that breaks even and respects the incentive constraint. It should be apparent that V_b^0 is equal to V_b^*, the expected utility under the Wilson equilibrium separating contract, (r_b^*, C_b^*) in Figure 3.

Hajime Miyazaki, in a 1977 paper in the *Bell Journal of Economics,* proposed that equilibrium be defined as solutions to an analogous problem in an adverse selection labor market economy. He argued that employers (analogous to lenders in our economy) are able to offer cross-subsidized wage-employment schedules, a situation he identified as an "internal labor market"—in other words, a multilateral financial arrangement. The "Miyazaki equilibrium," as it has come to be called, has been neglected in the adverse selection literature because cross-subsidization seemed hard to reconcile with a narrow conception of competitive behavior.

Using a few key properties of the sustainable equilibrium, there is a simple procedure that finds it. One important property is that bad borrowers receive contracts on the 45° line, minimizing the risk they bear and the collateral they transfer. Any other contract providing the same expected utility for the bad borrowers would use more resources and would thus make good borrowers worse off.

The first step in the procedure to find a sustainable equilibrium is to trace out the set of contracts that are feasible for the good borrower, shown as a dashed line in Figure 7. This set is constructed by varying the bad borrower's contract along the 45° degree line between (r_b^*, C_b^*), the separating Wilson equilibrium contract, and $(\overline{r}, \overline{C})$, the pooling contract on the 45° line. Start by taking the contract (r_b^*, C_b^*) for the bad borrower as given. Then the best possible contract for the good borrower is (r_g^*, C_g^*), where both the self-selection and the resource constraints bind. Now consider the contract (r_b^1, C_b^1) for the bad borrower, a short distance down along the 45° line from (r_b^*, C_b^*). Since (r_b^1, C_b^1) lies below π_b, the overall resource constraint is tightened; now contracts along π_g^1 are feasible for the good borrower. Because the bad borrower's self-selection

Figure 7 The Feasible Allocations

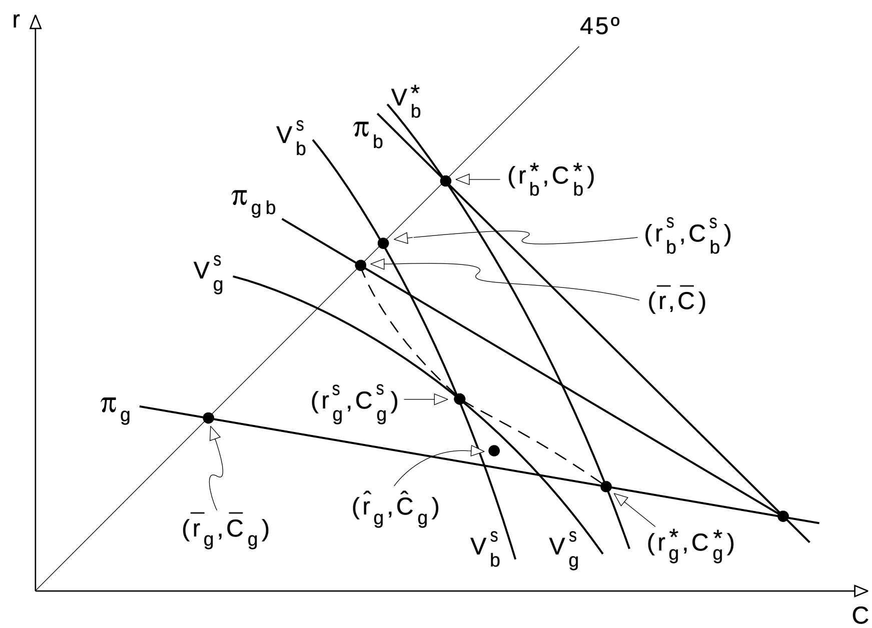


Notes: This figure shows the construction of the dashed line—the set of the best feasible contracts for the good borrower. Each point on the dashed line corresponds to a particular bad-borrower contract along the 45° line. For the bad-borrower contract (r_b^1, C_b^1), the best contract for the good borrower is (r_g^1, C_g^1), where the bad-borrower indifference curve V_b^1 intersects the break-even line π_g^1. Similarly, for bad-borrower contract (r_b^2, C_b^2), the best feasible contract for the good borrower is (r_g^2, C_g^2).

constraint is relaxed, the best possible contract for the good borrower is now (r_g^1, C_g^1), up and to the left of (r_g^*, C_g^*). Continuing this procedure for every bad-borrower contract between (r_b^*, C_b^*) and $(\bar{r}, \bar{C})$ traces out the dashed line, the set of the best possible good-borrower contracts for various levels of bad-borrower utility.

The second step is to select the contract along the dashed locus that maximizes the good borrower's expected utility; the associated allocation is the sustainable equilibrium. The best contract for the good borrower is shown as (r_g^s, C_g^s) in Figure 8, where the dashed locus is tangent to a good-borrower indifference curve. The bad borrower receives (r_b^s, C_b^s). Depending on the ratio of bad borrowers to good borrowers, the sustainable equilibrium could instead be at either of the endpoints of the dashed line. If the ratio of bad borrowers to good borrowers is relatively large (the range labeled "very high" in Table 1), the dashed line is very steep and the sustainable equilibrium is the set of

Figure 8 The Sustainable Equilibrium

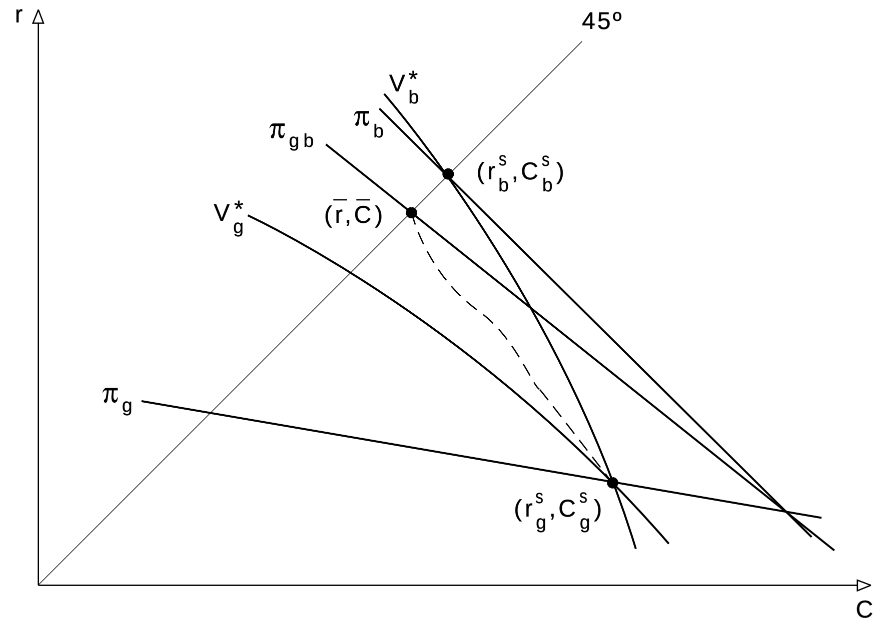


Notes: The contract along the dashed line that maximizes the expected utility of the good borrower is the sustainable equilibrium: (r_g^s, C_g^s). The associated contract for the bad borrower is (r_b^s, C_b^s). The contract $(\hat{r}_g, \hat{C}_g)$ for the good borrowers fails to credibly block the sustainable equilibrium because it in turn is credibly blocked by $(\bar{r}_g, \bar{C}_g)$, the sustainable allocation for the coalition of just good borrowers.

break-even separating contracts, the same as the Wilson separating equilibrium. This case is shown in Figure 9. If there are few bad borrowers (the range labeled "very low" in Table 1), the dashed line is relatively flat and the pooling contract on the 45° line is the sustainable equilibrium, the contract $(\bar{r}, \bar{C})$ in Figure 10. Table 1 summarizes the different types of sustainable equilibria for various values of the ratio of bad borrowers to good.

What prevents lenders from skimming off the good borrowers, offering a contract they prefer and which earns excess profits (a contract like $[\hat{r}_g, \hat{C}_g]$ in Figure 8)? Such a deviation lacks credibility because it does not meet the sustainability requirement defined above. If such a coalition were to form, it would consist entirely of good borrowers, but it would be vulnerable to the sustainable allocation for that coalition—the contract $(\bar{r}_g, \bar{C}_g)$ at the intersection of the good-type break-even line, π_g, and the 45° line. In other words, agents would anticipate that if the proposed deviation $(\hat{r}_g, \hat{C}_g)$ were to occur, it would itself be blocked by a subcoalition proposing $(\bar{r}_g, \bar{C}_g)$. Since the latter is

Figure 9 The Sustainable Equilibrium for N_b/N_g "Very High"



Notes: When N_b/N_g is very high, the dashed line is steep and the best contract for the good borrower lies at the lower endpoint. In this case, sustainable equilibrium is identical to the separating Wilson equilibrium and is Pareto-optimal, and financial intermediaries are unnecessary.

sustainable, that threat is credible and succeeds in blocking the cream-skimming deviation. There is no sustainable allocation that attracts the good borrowers away from the equilibrium contract (r_g^s, C_g^s). Attracting just the bad borrowers is unsuccessful, since any contract that they alone prefer earns negative profits. Finally, there is no pooling contract that would succeed in attracting the good borrowers, since every feasible pooling allocation gives them utility lower than V_g^s.

Government Intervention Is Never Pareto-Improving

The sustainable equilibrium is always Pareto-optimal. The Miyazaki Problem maximizes the expected utility of the good borrowers subject to resource, incentive, and self-selection constraints, and a participation constraint for the bad borrowers. No other feasible allocation yields higher expected utility for good borrowers without violating the bad borrower's participation constraint. The sustainable equilibrium is not necessarily the best possible allocation for the bad borrowers, but any other feasible allocation that provides higher expected

Table 1 Properties of Equilibria as N_b/N_g Varies

	Ratio of Bad to Good Borrowers, N_b/N_g				
	Very Low	**Low**	**Intermediate**	**High**	**Very High**
Wilson equilibrium	pooling, 45° line	pooling, 45° line	pooling, below 45° line, Fig. 4	separating, break-even, Fig. 3	separating, break-even, Fig. 3
Is the Wilson equilibrium Pareto-optimal?	yes	yes	no	no	yes
Can government intervention be Pareto-improving?	no	no	yes	yes	no
Sustainable equilibrium	pooling, 45° line, Fig. 10		separating, cross-subsidizing, Fig. 8		separating, break-even, Fig. 9
Is the sustainable equilibrium Pareto-optimal?	yes		yes		yes
Are financial intermediaries necessary?	no		yes		no

utility for the bad borrower must provide lower expected utility for the good borrower.[24]

Government intervention in whatever form it takes must respect the resource, incentive, and self-selection constraints of the environment. Since the sustainable equilibrium is Pareto-optimal with respect to those constraints, there are no allocations that the government can feasibly achieve that Pareto-dominate the sustainable equilibrium. In contrast, sometimes Wilson equilibrium allocations are not Pareto-optimal with respect to resource, incentive, and self-selection constraints; in exactly these cases government intervention can make all agents better off (see Table 1).

When Do Financial Intermediaries Arise?

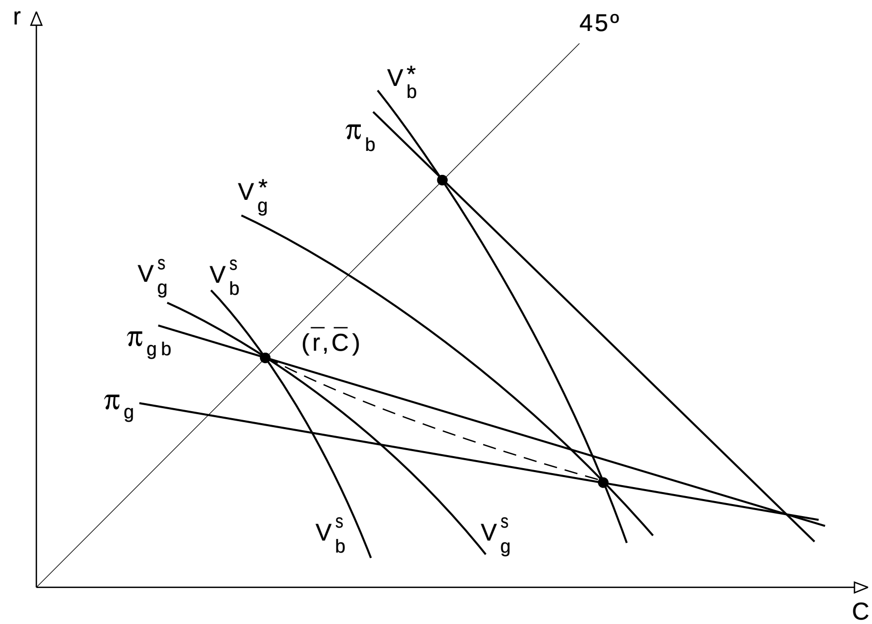
In some cases the sustainable equilibrium involves cross-subsidization across contracts. This occurs whenever the sustainable equilibrium is a pair of distinct contracts that do *not* lie on the individual break-even lines, π_g and π_b. In these cases the sustainable equilibrium is somewhere along the dashed line, as in Figure 8. When the ratio of bad to good borrowers is very high, the sustainable equilibrium is a pair of contracts that each break even, as in Figure 9; no cross-subsidization occurs in this case. When the ratio of bad to good borrowers is very low, as in Figure 10, the sustainable equilibrium is a single pooling contract and so cross-subsidization occurs.

Financial intermediaries are required whenever the sustainable equilibrium involves cross-subsidy across contracts. In this case a financial intermediary can break even on a portfolio of loans to both good and bad borrowers even though individual contracts do not break even; the bad contract earns positive expected profits while the good contract earns negative expected profits. Direct lending, with each investor making a single loan, is inconsistent with cross-subsidized contracts, since no lender would make a single loan earning negative profits. The allocation that *can* be achieved by direct bilateral lending, the Wilson equilibrium, cannot be a sustainable equilibrium in this case because it can be blocked by a financial intermediary offering contracts preferred by both borrowers.

For extreme values of the ratio of bad to good borrowers, financial intermediaries are not necessary to achieve the sustainable equilibrium. When the ratio is very high, each contract breaks even in the sustainable allocation. Individual lenders know they will break even on the borrowers that request the loans they offer. When the ratio of bad to good borrowers is very low, lenders offering the

[24] All of the allocations corresponding to contracts along the dashed line between the sustainable equilibrium and the pooling contract on the 45° line are Pareto-optimal. For a very high ratio of bad borrowers to good borrowers, as in Figure 9, all of the dashed line corresponds to Pareto-optimal allocations. For a very low ratio of bad borrowers to good borrowers, as in Figure 10, only the pooling contract on the 45° line is Pareto-optimal.

Figure 10 The Sustainable Equilibrium for N_b/N_g "Very Low"



Notes: When N_b/N_g is very low, the dashed line is relatively flat and the best contract for the good borrower is at the upper endpoint; both borrowers receive the contract $(\bar{r}, \bar{C})$. In this case, the sustainable equilibrium is identical to the Wilson equilibrium and is Pareto-optimal, and financial intermediaries are unnecessary.

pooling contract make excess profits on good borrowers and negative profits on bad borrowers. Lenders do not know which type of borrower accepts their loan, but if they believe that the probability that a given borrower is of a given type is the same as that type's representation in the population, then ex ante expected profits are zero.[25]

Financial intermediaries arise in all cases in which the Wilson equilibrium is *not* Pareto-optimal. This occurs for ranges of the ratio of bad to good borrowers labeled "intermediate" and "high" in Table 1. In these situations the Wilson equilibrium can be improved upon by government intervention. For the same reason government intervention is Pareto-improving, the Wilson equilibrium allocation is unsustainable because it is vulnerable to a financial intermediary offering a Pareto-improving set of contracts. Thus whenever the Wilson equilibrium suggests a role for government intervention, the sustainable equilibrium

[25] Note that financial intermediaries *could* be operative in this equilibrium, but they are not *required*.

suggests a role for financial intermediaries and no role for government intervention. The welfare-enhancing role of government intervention in the Wilson equilibrium is the direct result of restrictions that prevent the emergence of financial intermediaries.

4. CONCLUDING REMARKS

In this article I examined a single economy under two different definitions of equilibrium. The Wilson equilibrium assumes that agents interact by playing a specific four-stage game. Equilibrium allocations are often not Pareto-optimal under this definition of equilibrium, and a government tax/subsidy scheme can be Pareto-improving. Under the other equilibrium, agents are free to communicate and propose alternative arrangements, and outcomes are required to be sustainable in a certain sense. The sustainable equilibrium is Pareto-optimal and implies no welfare-enhancing role for government intervention. The sustainable equilibrium also gives rise to financial intermediaries, a widely observed phenomenon in loan markets. By contrast, conditions implicit in the Wilson equilibrium prevent intermediaries from playing any role. This observation suggests that the Wilson equilibrium, and others like it, are too restrictive and that models based on them are unreliable guides to policy. Thus, on the basis of these considerations, I conclude that adverse selection does *not* justify government intervention in loan markets. Intervention could, of course, be desirable on redistributive grounds.

One might wonder if the approach advocated here is somehow rigged to minimize the potential efficiency role of the government. The notion of sustainability places only minimal restrictions on agents' interactions. Does this approach give private agents an unrealistic capacity to coordinate their activities to achieve the best of all possible allocations? Are these assumptions Panglossian?

This is a legitimate question to raise. To put the question another way, Under what conditions would such an approach ever predict that government intervention is welfare-improving? One response is to give the models a normative rather than positive interpretation. In other words, treat the model as if it were telling us the best allocation. If we are confident the primitive assumptions on preferences, endowments, and technologies match well with the actual economy and we observe that the recommended allocation is not being attained, then government intervention to achieve the optimal allocation is warranted. The difficulty with this approach, however, is that without a positive model of why the observed allocation falls short of the one recommended by the economist, we can have little confidence that we have accurately identified all of the relevant impediments to trade. Without such confidence, we are forced to rely on ignorance or irrationality to explain out-of-equilibrium observations.

An alternative response is to view government intervention as a potential outcome, an endogenous component of the equilibrium multilateral arrangement. Indeed, in many models it is hard to distinguish between endogenous financial intermediaries and government-mandated reallocations. A rationale for government intervention would require a model in which government actions and private contracts are clearly distinguishable, perhaps in the methods of enforcing contracts. A case for government intervention could then be made if a plausible model predicted allocations that could not be achieved through private arrangements alone, but instead required identifiably governmental arrangements. I know of no such model at the present time that justifies government intervention in loan markets.

REFERENCES

Bernheim, B. Douglas, Belalel Peleg, and Michael D. Whinston. "Coalition-Proof Nash Equilibrium: I. Concepts," *Journal of Economic Theory,* vol. 42 (June 1987), pp. 1–12.

Boyd, John H., and Edward C. Prescott. "Financial Intermediary-Coalitions," *Journal of Economic Theory,* vol. 38 (April 1986), pp. 211–32.

__________, and Bruce D. Smith. "Organizations in Economic Analysis," *Canadian Journal of Economics,* vol. 21 (August 1988), pp. 477–91.

Boyd, John H., and Bruce D. Smith. "The Equilibrium Allocation of Investment Capital in the Presence of Adverse Selection and Costly State Verification," *Economic Theory,* vol. 3 (1993), pp. 427–51.

Cho, In-Koo, and David M. Kreps. "Signaling Games and Stable Equilibria," *Quarterly Journal of Economics,* vol. 102 (May 1987), pp. 179–221.

Crocker, Keith J., and Arthur Snow. "A Simple Tax Structure for Competitive Equilibrium and Redistribution in Insurance Markets with Asymmetric Information," *Southern Economic Journal*, vol. 51 (April 1985a), pp. 1142–50.

__________. "The Efficiency of Competitive Equilibria in Insurance Markets with Asymmetric Information," *Journal of Public Economics,* vol. 26 (March 1985b), pp. 207–19.

de Meza, David, and David C. Webb. "Too Much Investment: A Problem of Asymmetric Information," *Quarterly Journal of Economics,* vol. 102 (May 1987), pp. 281–92.

Diamond, Douglas W. "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies,* vol. 51 (July 1984), pp. 393–414.

Gale, William G. "Economic Effects of Federal Credit Programs," *American Economic Review,* vol. 81 (March 1991), pp. 133–52.

__________. "Collateral, Rationing, and Government Intervention in Credit Markets," in R. Glenn Hubbard, ed., *Asymmetric Information, Corporate Finance, and Investment*. Chicago: University of Chicago Press, 1990.

Greenberg, Joseph. "Deriving Strong and Coalition-Proof Nash Equilibria from an Abstract System," *Journal of Economic Theory,* vol. 49 (October 1989), pp. 195–202.

Greenwald, Bruce C., and Joseph E. Stiglitz. "Externalities in Economies with Imperfect Information and Incomplete Markets," *Quarterly Journal of Economics,* vol. 101 (May 1986), pp. 229–64.

Hellwig, Martin. "Some Recent Development in the Theory of Competition in Markets with Adverse Selection," *European Economic Review,* vol. 31 (February–March 1987), pp. 319–25.

Innes, Robert. "Investment and Governmental Intervention in Credit Markets When There Is Asymmetric Information," *Journal of Public Economics,* vol. 46 (December 1991), pp. 347–81.

Kahn, Charles, and Dilip Mookherjee. "Coalition Proof Equilibrium in an Adverse Selection Insurance Economy." Manuscript. University of Illinois, Urbana-Champaign, July 1991.

Lacker, Jeffrey M. "Why Is There Debt?" Federal Reserve Bank of Richmond *Economic Review,* vol. 77 (July/August 1991), pp. 4–19.

__________, and John A. Weinberg. "A Coalition Proof Equilibrium for a Private Information Credit Economy," *Economic Theory,* vol. 3 (1993), pp. 279–96.

Lang, William W., and Leonard I. Nakamura. "A Model of Redlining," *Journal of Urban Economics,* vol. 33 (March 1993), pp. 223–34.

Mankiw, N. Gregory. "The Allocation of Credit and Financial Collapse," *Quarterly Journal of Economics,* vol. 101 (August 1986), pp. 455–70.

Marimon, Ramon. "The Core of Private Information Economies." Manuscript. University of Minnesota, 1988.

Miyazaki, Hajime. "The Rat Race and Internal Labor Markets," *Bell Journal of Economics,* vol. 8 (Autumn 1977), pp. 394–418.

Prescott, Edward C., and Robert M. Townsend. "Pareto Optima and Competitive Equilibria with Adverse Selection and Moral Hazard," *Econometrica,* vol. 52 (January 1984), pp. 21–45.

Riley, John G. "Informational Equilibrium," *Econometrica,* vol. 47 (March 1979), pp. 331–59.

Rothschild, Michael, and Joseph Stiglitz. “Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information,” *Quarterly Journal of Economics,* vol. 90 (November 1976), pp. 629–50.

Smith, Bruce D., and Michael J. Stutzer. “Credit Rationing and Government Loan Programs: A Welfare Analysis,” *AREUEA Journal,* vol. 17 (Summer 1989), pp. 177–93.

Stiglitz, Joseph E., and Andrew Weiss. “Credit Rationing in Markets with Imperfect Information,” *American Economic Review,* vol. 71 (June 1981), pp. 393–410.

Townsend, Robert M. “Intermediation with Costly Bilateral Exchange,” *Review of Economic Studies,* vol. 45 (October 1978), pp. 417–25, reprinted in Robert M. Townsend, *Financial Structure and Economic Organization*. Cambridge, Mass.: Basil Blackwell, 1990.

Williamson, Stephen D. “Do Informational Frictions Justify Federal Credit Programs?” Manuscript. University of Iowa, August 1993.

__________. “Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing,” *Journal of Monetary Economics*, vol. 18 (September 1986), pp. 159–79.

Wilson, Charles. “The Nature of Equilibrium in Markets with Adverse Selection,” *Bell Journal of Economics,* vol. 10 (Spring 1979), pp. 108–30.

__________. “A Model of Insurance Markets with Incomplete Information,” *Journal of Economic Theory,* vol. 16 (December 1977), pp. 167–207.