ELSEVIER Journal of Corporate Finance 4 (1998) 71–85

Journal of CORPORATE FINANCE

# An options-based model of equilibrium credit rationing

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**Abstract**

This paper applies options theory to the model of equilibrium credit rationing developed by [Stiglitz, J.E., Weiss, A., 1981. Credit rationing in markets with imperfect information, American Economic Review, 71, 727–752.] by noticing that, given a standard debt contract and limited liability, the payoffs to the lender and the borrower when a loan is made involve a put and call option respectively. Information asymmetry is modelled using stochastic volatility option pricing methods. There are three advantages to the options approach. First, the well-known comparative statics of option pricing provide an alternative and immediate proof for many of Stiglitz and Weiss' results. Secondly, the framework accommodates several theoretical extensions to the basic results. Finally, the approach allows an assessment of the empirical significance of equilibrium credit rationing, since the model is easily parameterised. Simulations of the model suggest that rationing is unlikely to be significant at the collateral levels observed in the U.S and U.K. small commercial loan market. © 1998 Elsevier Science B.V.

*JEL classification:* D82; G13; G30
*Keywords:* Equilibrium credit rationing; Option pricing; Stochastic volatility

## 1. Introduction

Prices in well-functioning markets act to equate supply and demand. If demand were ever to exceed supply, both sellers and buyers would have incentives to raise

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*PII* S0929-1199(97)00010-2

the price, and restore equality between the two sides of the market. This 'law of supply and demand' is a fundamental tenet of economics. Yet many markets — credit and labour being notable examples — are characterised by excess demand; interest rates and wages do not conform to their Walrasian roles, and rationing is common.

A crucial question for policy-makers (as well as theorists) is: what is the source of this rationing — what prevents prices from adjusting to the market-clearing level? Usury laws and other exogenously imposed restrictions are one possible answer for the credit market; ad hoc costs of price adjustment are another. These explanations are not very satisfactory from a theoretical point of view, however, relying as they do on arbitrary forces imposed from outside of the model.

The first rigorous explanation of rationing was provided in the seminal papers of Jaffee and Russell (1976) and Stiglitz and Weiss (1981) (hereafter SW). These authors showed that credit rationing may occur in equilibrium as a result of ex ante information asymmetry between a lender and a borrower. When buyers cannot determine the characteristics of an individual good, prices will reflect average quality; there will then be a tendency for the highest quality goods to be withdrawn from the market — the adverse selection effect. When prices affect the actions of agents, this also will constrain their neoclassical role — the moral hazard, or incentive effect. In both cases, when the price affects the nature of the transaction, it may not clear the market. The two papers cited above apply this basic insight to show that, in equilibrium, the loan market may be characterised by credit rationing; interest rates are constrained from clearing the market for credit by the informational role that they play.

A natural question arising from these papers is: under what conditions will information asymmetry cause rationing? For example, might prices continue to function in their usual Walrasian capacity if the extent of asymmetric information is limited? In order to answer this question, the SW model is parameterised, using the option-like features of the standard debt contract assumed in their paper. The objective is to assess the empirical significance of equilibrium credit rationing (by determining the range of parameter values over which rationing occurs, and considering whether this range is realistic). At the same time, the approach has theoretical benefits — it provides a direct derivation of many of SW's results (using the comparative statics of options prices), and suggests several theoretical extensions which can be modelled easily using the options method.

The rest of this paper is structured as follows: the next section briefly discusses related literature [1]. The third section describes the model. The fourth section discusses the results of simulations of the model; the fifth section concludes.

[1] Only empirical studies of equilibrium credit rationing are considered. The theoretical objections to equilibrium credit rationing are reviewed in a companion paper (Mason, 1994).

## 2. Literature review

How important is equilibrium credit rationing in practice? This question has received relatively little attention. Most empirical studies have concentrated on the existence of disequilibrium (or dynamic) rationing (see, for example, Laffont and Garcia, 1987; Sealy, 1979; Itô and Ueda, 1981; Kugler, 1987; Martin, 1990). This literature has two weaknesses, however. The price adjustment processes used are necessarily ad hoc, requiring the assumption of quadratic adjustment costs, for example. In addition, price stickiness does not imply credit rationing; Berger and Udell (1992) note that possible alternative explanations are implicit contracts (analogous to those in labour market theory), and loan recontracting to avoid bankruptcy costs.

Berger and Udell (1992) is one of the few attempts to measure equilibrium rationing. Their analysis is based on two observations — first, any interest rate stickiness on commitment loans [2] cannot be due to rationing; and second, rationing should decrease the quantity of non-commitment loans, while leaving the quantity of commitment loan unchanged. They present four key findings: (i) price stickiness is almost as great on commitment loans as on non-commitment loans; (ii) loans with negative risk premia (not possible in rationing theories) exhibit price stickiness; (iii) loan rate premia do not move downwards during 'credit crunch' periods; and (iv) the proportion of loans issued under commitment does not increase substantially during credit crunch periods. All four findings put into question the empirical significance of equilibrium credit rationing.

This conclusion is supported by Black and de Meza (1993), who use a simple numerical example to show that for equilibrium rationing to be significant, borrowers must behave in a way which is simply unrealistic. Their calculation is based on two empirical facts — that the risk premium on commercial loans is in the range of 3 to 6%, and that the average level of collateral is around 85% [3]. A risk premium of 3% and a recovery rate (roughly, the level of collateral) of 85% implies a default rate of 20%. In order for an increase in the risk premium to 4% to cause the bank's return to decrease, the default rate would have to rise to 26.7% — up by a third. Black and de Meza argue that such large responses to interest changes are implausible.

The next section formalises Black and de Meza's numerical example; it will do this by parameterizing the model developed by SW, taking as given the form of

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[2] Where the lender agrees to extend credit at a borrower's request up to some pre-specified amount over a given time period.

[3] In the U.S., average charges over base are 2.59% for approved loans and 2.89% for overdrafts; the ratio of collateral to loan size averages 1.2. See Binks et al. (1993). In the U.K., the loan mark-up averages 5.6% for small agreed loans (less than 1000£), falling to 3.0% for loans over 100,000£. The ratio of collateral to loan size in the U.K. exceeds unity for more than 85% of business loans. See Cressey (1993).

loan contract used in that paper (i.e., a standard debt contract). In this case, the payoffs to the investor and entrepreneur for a single period loan contract are a European, dividend-protected put (written by the investor) and call (bought by the entrepreneur) option respectively. Information asymmetry is modelled by allowing the project risk (the volatility of its returns) as perceived by the lender to vary stochastically. Recently-developed option pricing techniques are then used to determine the equilibrium loan rate charged by the lender.

## 3. The model

The model is, in virtually all respects, identical to SW's. A risk neutral entrepreneur needs to raise capital to invest in a single-period project. Each entrepreneur is endowed with the technology for an indivisible investment project with stochastic returns [4]. The investment requirement is too large for the entrepreneur to fund from his own wealth, and, as the project is not divisible, the entrepreneur must borrow the total difference between its equity and the cost of the project for the project to be undertaken. The risk neutral investor is assumed to have some price setting ability. The supply of loanable funds available to the lender is unaffected by the interest rate it charges borrowers.

The technology and information structure of the problem will follow that set out by SW. Project technologies are characterised by (i) the mean return $\hat{R}$ and (ii) the 'riskiness' $\theta$, which is defined as a mean-preserving spread (see Rothschild and Stiglitz, 1970). The distribution function of project returns can be written as $F(R;\ \theta)$ and the density function as $f(R;\ \theta)$, with support on $[\underline{R},\ \overline{R}]$ [5]. The entrepreneur is aware, however, ex ante of its true type $\theta$, and ex post of the actual, or realised project return. The investor observes the ex post realised project return, but does not know, either ex ante or ex post, the risk type of the borrower. The investor is able, however, to distinguish between entrepreneurs whose projects have different expected project returns. $F$, $f$ are common knowledge at $t=0$, and the investor knows the population distribution of types, which has density $g(\theta)$, and support on $[\underline{\theta},\ \overline{\theta}]$.

Following SW, the contract written between the investor and the entrepreneur is taken as a standard debt contract [6]. The form of this contract is as follows. If an entrepreneur borrows an amount $B$, he promises to repay an amount $B\ (1+r_l)$, where $r_l$ is the loan interest rate charged by the lender. The borrower is said to

[4] By treating the project technologies as endowments, moral hazard is ruled out — the project return distribution cannot be altered by the borrower.

[5] The definition of $\theta$ as a mean-preserving spread means that for $\theta_1 > \theta_2$, if: $\int_0^\infty Rf(R;\ \theta_1)\mathrm{d}R = \int_0^\infty Rf(R;\ \theta_2)\mathrm{d}R$, then for $y \geq 0$, $\int_0^y F(R;\ \theta_1)\mathrm{d}R \geq \int_0^y F(R;\ \theta_2)\mathrm{d}R$.

[6] de Meza and Webb (1987) and Mason (1994) show that a debt contract is not, in fact, optimal in this setting.

default on his loan if the return to the project $R$ plus the collateral $C$ is insufficient to pay back the promised amount i.e. default if:

$$C + R < B(1 + r_1).$$

In the event of default, the lender receives the entire project return, in addition to the collateral.

The model is therefore a single period principal-agent game with asymmetric information — at the beginning of the game ($t = 0$), the principal (lender) announces the loan interest rate and collateral level to the agent (borrower), and the agent chooses whether to undertake the project; if he does, then at $t = 1$, the project returns are realised, and the borrower decides whether to repay or default. The net return to the borrower $\pi_B$ is:

$$\begin{aligned}\pi_B(R, r_1) &= \max\{R - (1 + r_1)B;\ -C\} \\ &= \max\{R - [(1 + r_1)B - C];0\} - C. \end{aligned} \tag{1}$$

The return to the lender $\pi_L$ is:

$$\begin{aligned}\pi_L(R, r_1) &= \min\{R + C;\ (1 + r_1)B\} \\ &= \min\{R - [(1 + r_1)B - C];0\} + (1 + r_1)B. \end{aligned} \tag{2}$$

Drawing the payoff diagrams for the lender and the borrower shows that the underlying problem is closely related to option pricing (see Fig. 1). The borrower can be seen as purchasing a call option while borrowing an amount $C$; the exercise price of this call option is $[(1 + r_1)B - C]$. If the return to the project is below this level, the borrower will choose not to exercise the option to purchase the project from the lender (i.e., it will default). Conversely, the lender can be seen as writing a put option, while lending an amount equal to $(1 + r_1)\ B$; the exercise price of this put option is also $[(1 + r_1)B - C]$. Both options, given the simplest form of debt contract, are European (exercise only at the maturity date) and dividend-protected (no interim interest payments). The standard techniques of option pricing can therefore be applied to this problem.

### 3.1. Pricing the bank's and firm's options

Suppose that, over the period of the project, the project's gross returns follow a geometric Brownian motion [7]:

$$\mathrm{d}R_t = \mu R_t \mathrm{d}t + \theta_t R_t \mathrm{d}B_{R_t}, \tag{3}$$

where $\mu$ is the mean growth rate of project returns, $\theta_t$ is the volatility of returns (or riskiness of the project), and $dB_{R_t}$ is a Wiener process.

[7] Equivalently, assume that the project produces a single good, which will be sold in a competitive market at a price which follows a geometric Brownian motion.

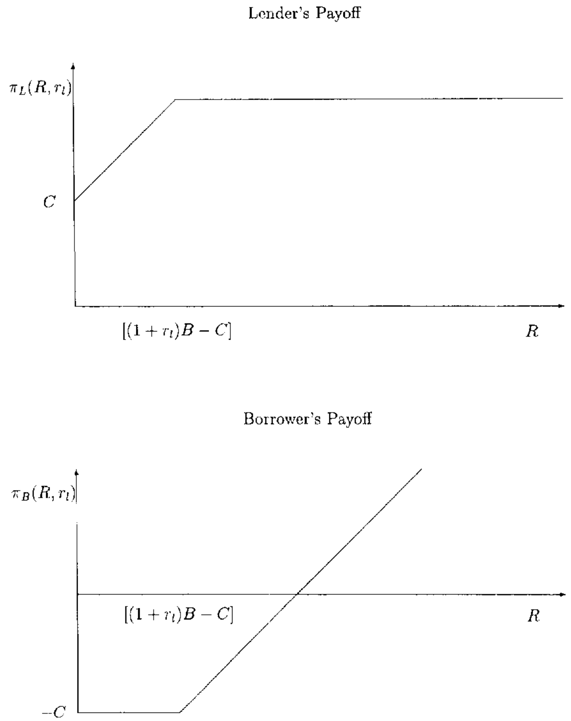


Fig. 1. Lender and borrowers payoffs.

There are two important points to note when projects' returns are generated by the process in Eq. (3). First, projects can be distinguished in the same way as in SW's model. $R_1$, the realised project return at $t = 1$, is log-normally distributed, with mean $R_0\,\mu e^{\mu}$ and variance $R_0^2\,\mu e^{2\mu}\,(e^{\theta^2} - 1)$. Projects with equal drifts but different variances are therefore mean-preserving spreads of each other. Secondly, the Black–Scholes (Black and Scholes, 1973) formula for European options prices can be applied directly to give expressions for the put and call values, since: (i) underlying asset returns follow a geometric Brownian motion; (ii) universal risk neutrality holds; (iii) there is a single period, with no 'early exercise' opportunity; and (iv) there are no interim cash payments. The Black–Scholes formula for the price of a call and a put option is:

$$\text{call} = R_0 N[x_1] - X e^{-r} N[x_1 - \theta],$$
$$\text{put} = -R_0 N[-x_1] + X e^{-r} N[-x_1 + \theta],$$

where

$$x_1 = \frac{\ln(R_0/X) + r + (\theta^2/2)}{\theta}$$

$R_0$ is the $t=0$ level of the underlying asset, $N[.]$ is the cumulative normal distribution function, $X$ is the exercise price of the option, and $r$ is the riskless rate of interest. Applying these expressions to the lender's and borrower's payoffs: the exercise price is given by $[(1+r_1)B - C]$; the borrower buys a call option; the lender writes a put option; so the value of the project to the borrower and the lender at time $t=0$ is:

$$\pi_B(R_0, r_1) = \text{call} - C,$$

$$\pi_L(R_0, r_1) = -\text{put} + (1+r_1)B.$$

Theorems 1–4 of SW follow immediately from the comparative statics of the option prices.

*Theorem 1. For a given interest rate $r_l$, there is a critical value $\theta^*$ such that a firm borrows from the bank if and only if $\theta > \theta^*$.*

*Proof.* This is a direct result of the call option value being a monotonically increasing function of $\theta$: $(\partial\pi_B)/(\partial\theta) = (\partial\,\text{call})/(\partial\theta) > 0\ \forall\theta$. Therefore $\exists\theta^*$ s.t. $\pi_B(\theta^*) = 0$ and $\pi_B(\theta) > 0$ for $\theta > \theta^*$. □

*Theorem 2. As the interest rate increases, the critical value of $\theta$, below which individuals do not apply for loans, increases (i.e. $(\partial\theta^*)/(\partial r_l) > 0$).*

*Proof.* This adverse selection effect follows because the call price is a monotonically decreasing function of the exercise price. □

*Theorem 3. The expected return on a loan to a bank is a decreasing function of the riskiness of the loan (i.e. $(\partial E[\pi_L])/(\partial\theta) < 0$).*

*Proof.* This holds since the put option value is monotonically increasing with $\theta$ (and so minus the put option value, which is what the lender considers, decreases with $\theta$). □

*Theorem 4. The expected profit of the lender may be maximised at an interior lending rate $r_l$.*

*Proof.* This follows because raising the loan interest rate has three effects on the lender's return: (i) the bankruptcy and sorting effects:

$$\frac{\mathrm{d}(-\text{put})}{\mathrm{d}r_1} = \frac{\partial(-\text{put})}{\partial r_1} + \frac{\partial(-\text{put})}{\partial\theta}\frac{\partial\theta^*}{\partial r_1} < 0;$$

(ii) the revenue effect:

$$\frac{\partial(1+r_1)B}{\partial r_1} > 0. \quad \square$$

### 3.2. Theoretical extensions

One of the advantages of the options-based approach is that it provides a rich framework for theoretical extensions. Two examples are given in this section. The first is an analysis of the effect of increased collateral requirements. SW argued that an increase in collateral will harm lenders' profits if entrepreneurs are risk averse, with decreasing absolute risk aversion and heterogeneous wealth (since raising collateral causes low wealth, and therefore low risk, borrowers to drop out). Wette (1983) argued that the same might hold even when entrepreneurs are risk neutral. The comparative statics of option prices show that raising the collateral requirement unambiguously decreases the lender's returns. The intuition for this is as follows: raising collateral (all other things equal) decreases the entrepreneur's return ($\pi_B = \text{call} - C$ and $|(\partial\text{call})/(\partial C)| < 1$). As a result, low risk borrowers drop out, and hence $\theta^*$ increases. The increase in collateral therefore has two effects on I's payoff: a direct revenue effect (returns are increased in default states); and a sorting effect ($\theta^*$ increases); it turns out that the latter effect always dominates.

This result can be shown analytically. $\theta^*$ is defined by $\text{call}(\theta^*, C) = C$. Therefore:

$$\frac{\partial\theta^*}{\partial C} = -\left[\frac{(\partial\text{call}/\partial C) - 1}{(\partial\text{call}/\partial\theta)}\right] = \frac{1 - e^{-r}N[x_1 - \theta]}{R_0 N'[x_1]}$$

$$\frac{\text{dput}}{\text{d}C} = \frac{\partial\text{put}}{\partial C} + \frac{\partial\text{put}}{\partial\theta}\frac{\partial\theta^*}{\partial C} = -e^{-r}(1 - N[x_1 - \theta]) + (1 - e^{-r}N[x_1 - \theta])$$

$$= 1 - e^{-r} > 0 \; (r > 0)$$

$$\Rightarrow -\frac{\text{dput}}{\text{d}C} < 0.$$

This makes clear why a stronger result than SW's is possible. The additional structure imposed on the problem by assuming that project returns follow a geometric Brownian motion (and hence are log-normally distributed) ensures that the sorting effect always outweighs the revenue effect.

The second example (not developed in this paper) extends the model to multiple periods, to analyze the effect of the lender learning about the borrower's project over time. This extension can be carried out quite naturally within the options framework — the options implicit in the parties' payoffs become American, rather than European. If interest payment occurs at the termination of the loan, then only the lender faces an incentive to foreclose the loan before the maturity date of the project (this is a direct consequence of the well-known result that it is never optimal to exercise early dividend-protected American calls). The resulting loan contract has a term structure — the loan interest rate is a function of the termination date of the loan (being either the date at which the loan is foreclosed by the lender, or the maturity date of the project). Moreover, this contract structure may overcome the adverse selection problem (and hence involve no rationing) by separating risk types. See Webb (1991) for a related model.

### 3.3. Modelling information asymmetry

The central innovation of this section is to use stochastic volatility option pricing to model information asymmetry. In the SW set-up, the riskiness of the project is known (and hence non-stochastic) to the borrower. The lender, however, knows only the probability distribution of borrower types (denoted $F(R;\ \theta)$ above), but not an individual borrower's project variance. This information asymmetry can be parameterised by noticing that a (subjective) distribution over variances is analogous to assuming a stochastic process for the project riskiness. Specifically, suppose that the lender-perceived variance of the project returns follows a geometric Brownian motion:

$$\mathrm{d}\theta_t^2 = \phi\theta_t^2\,\mathrm{d}t + \xi\theta_t^2\,\mathrm{d}B_{\theta t}$$

where $\mathrm{d}B_{\theta t}$ is a Wiener process (for simplicity, uncorrelated with $\mathrm{d}B_{Rt}$). Then the probability distribution of the project variance, as perceived by the lender, is a log-normal distribution with support $[0, \infty]$, mean $\theta_0^2 e^{\phi}$, and variance $\theta_0^4 e^{2\phi}(e^{\xi^2} - 1)$.

Advantage can be taken of the growing literature which deals with option pricing and stochastic volatility (see, inter alia, Hull and White, 1987; Chesney

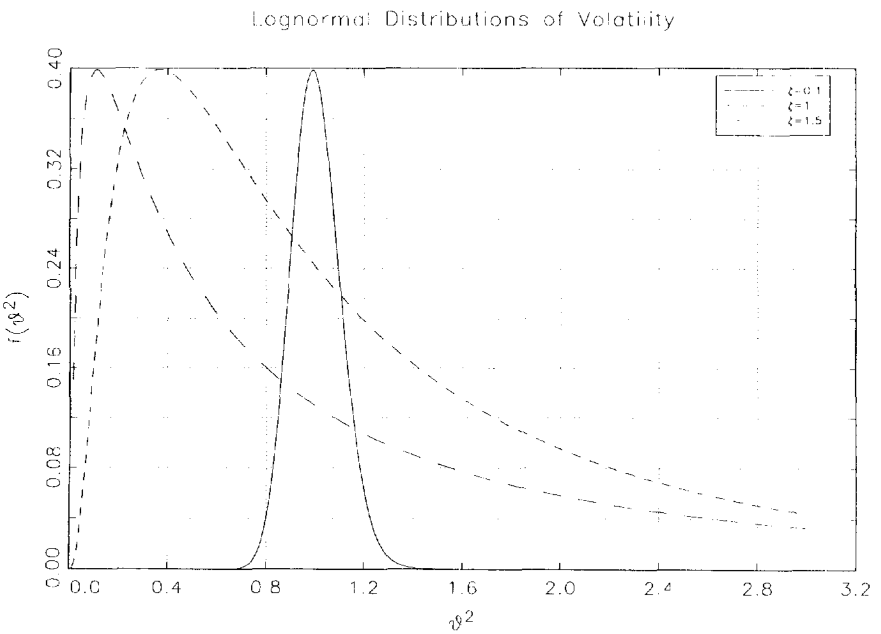


Fig. 2. Log-normal distribution of volatility.

Table 1
Model parameters

| Parameter | Meaning |
|---|---|
| $R_0$ | Initial project return |
| $B$ | Amount borrowed (normalised to 1) |
| $C$ | Collateral |
| $r$ | Risk-free interest rate (3%) |
| $\xi$ | Degree of information asymmetry |
| $\theta^*$ | Lower bound project risk |
| $\theta_0$ | Mean project risk (normalized to 1) |
| $r_l^*$ | Bank's optimal loan rate |

and Scott, 1989; Scott, 1991; Stein and Stein, 1991; Heston, 1993). Hull and White give a Taylor series approximation and numerical solution techniques for a geometric Brownian motion variance process. To implement the latter, the following simplifications are made: $\phi$ is set equal to zero (without loss of generality, in this case); and $\mu$ and $\xi$ are constant.

$\xi$ measures the degree of information asymmetry. This is illustrated in Fig. 2, which shows the ($t = 1$) distribution of $\theta$ for different $\xi$. When $\xi$ is small, the distribution has a small variance, and the lender knows quite precisely the project riskiness of an entrepreneur (for $\xi = 0.1$, the bank knows that the variance of project returns lies between 0.8 and 1.2 with probability near one). When $\xi$ is large, so is the variance of the distribution of $\theta$, and the lender is highly uncertain about the riskiness of the entrepreneur's project.

## 4. Model simulations

This section determines the values of the model parameters (which are summarised in Table 1) required to support equilibrium credit rationing (to generate an interior mode to the lender's payoff), and examines whether these values are reasonable. The simulation has two stages — first, the critical value of project variance $\theta^*$ is determined. (The lender's subjective distribution of $\theta_l^2$ is truncated at $\theta_l^2 = \theta^{*2}$, since he knows that no borrower with $\theta < \theta^*$ will apply for a loan.) $\theta^*$ is given by the non-linear equation:

$$\mathrm{call}(R_0, r_l, \theta^*) = C.$$

The second stage of the simulation calculates the lender's payoff (shown in Fig. 4 for different parameter values) [8]. The loan interest rate corresponding to a

[8] The 'jaggedness' of the plots in Fig. 4 is due to the use of Monte Carlo simulations to obtain numerical valuations of the lender's payoff. The plots could be smoothed by using a finer grid for the simulation; the computational cost would be large, however — with the resolution used in these plots, each run took twelve hours to complete.

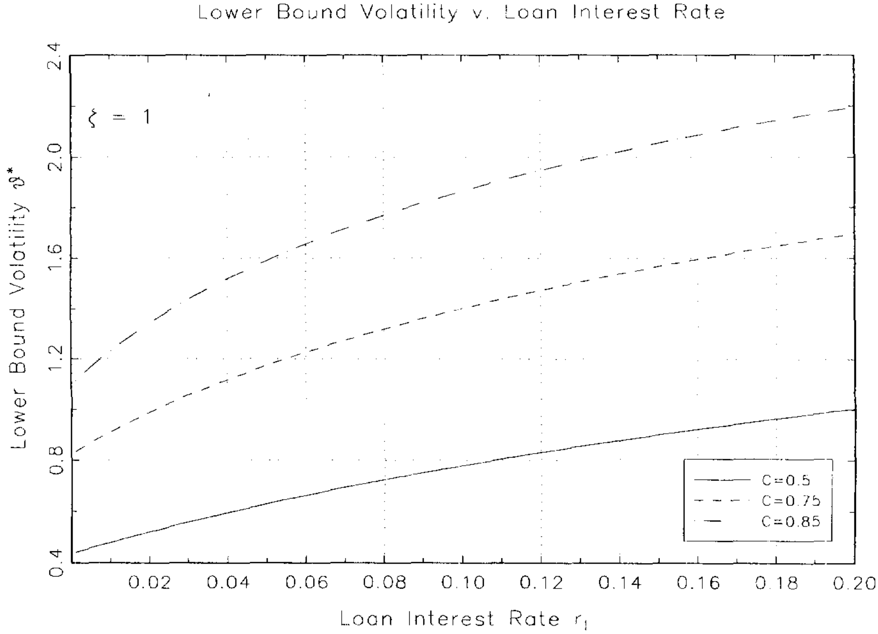


Fig. 3.

maximum in this function (if it exists) is $r_1^*$. The following parameter values were used: the amount borrowed by the entrepreneur was normalised to 1; the risk-free interest rate was set at 3% p.a.; the mean project riskiness $\theta_0$ was set to 1. Three levels of collateral were considered — 50%, 75%, and 85% (as suggested by Black and de Meza). Four different values of the initial project return values were used: $R_0 = 0.950$, 1.000, 1.025 and 1.075. Finally, three values of $\xi$ were used: 0.01, 0.5 and 1.0. The values used in the four panels of Fig. 4 are shown in each panel.

Figs. 3–5 show the six simulation results. First, $\theta^*$ increases with $r_1$ (see Fig. 3); this is just the adverse selection effect. Secondly, $r_1^*$ is monotonically decreasing in $\xi$, for a given level of collateral; this can be seen most clearly in the top left-hand panel of Fig. 4. Thirdly, the lender's maximum return increases with $R_0$ (as one might expect); refer to the bottom right-hand panel of Fig. 4. Fourthly, no interior optimum can be generated for a collateral level of 85% (bottom left-hand panel of Fig. 4) [9]; for a collateral level of 75%, rationing occurs only at higher levels of information asymmetry (there is no maximum in the lender's

[9] Although it appears that the curve may have a turning point for $\xi = 0.5$, once the standard errors of the simulation are considered, the claim that there is no turning point cannot be rejected at any reasonable level of statistical significance.

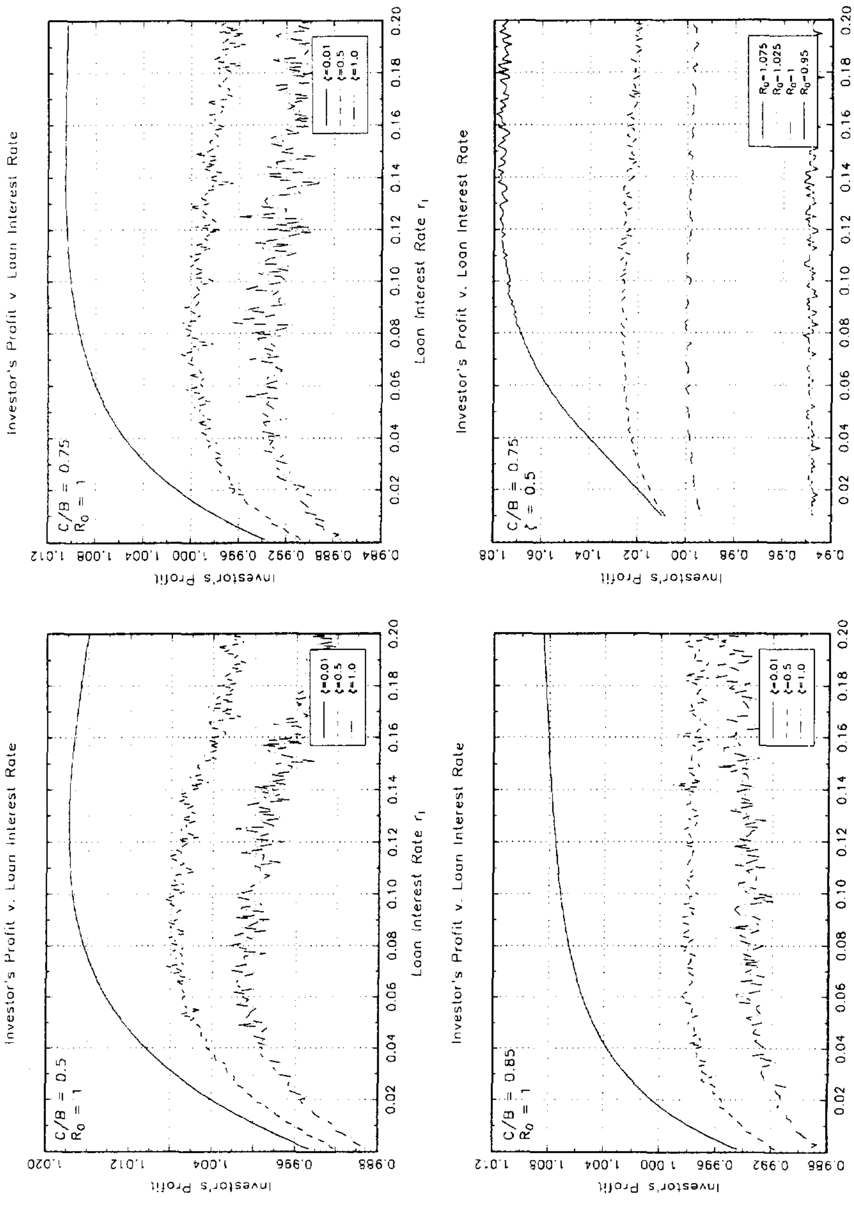
Investor's Profit v. Loan Interest Rate
C/B = 0.75
R0 = 1
ζ=0.01
ζ=0.5
ζ=1.0
Loan Interest Rate r_l
Investor's Profit
Investor's Profit v. Loan Interest Rate
C/B = 0.75
ζ = 0.5
R0=1.075
R0=1.025
R0=1
R0=0.95
Loan Interest Rate r_l
Investor's Profit
Investor's Profit v. Loan Interest Rate
C/B = 0.5
R0 = 1
ζ=0.01
ζ=0.5
ζ=1.0
Loan Interest Rate r_l
Investor's Profit
Investor's Profit v. Loan Interest Rate
C/B = 0.85
R0 = 1
ζ=0.01
ζ=0.5
ζ=1.0
Loan Interest Rate r_l
Investor's Profit

Fig. 4.

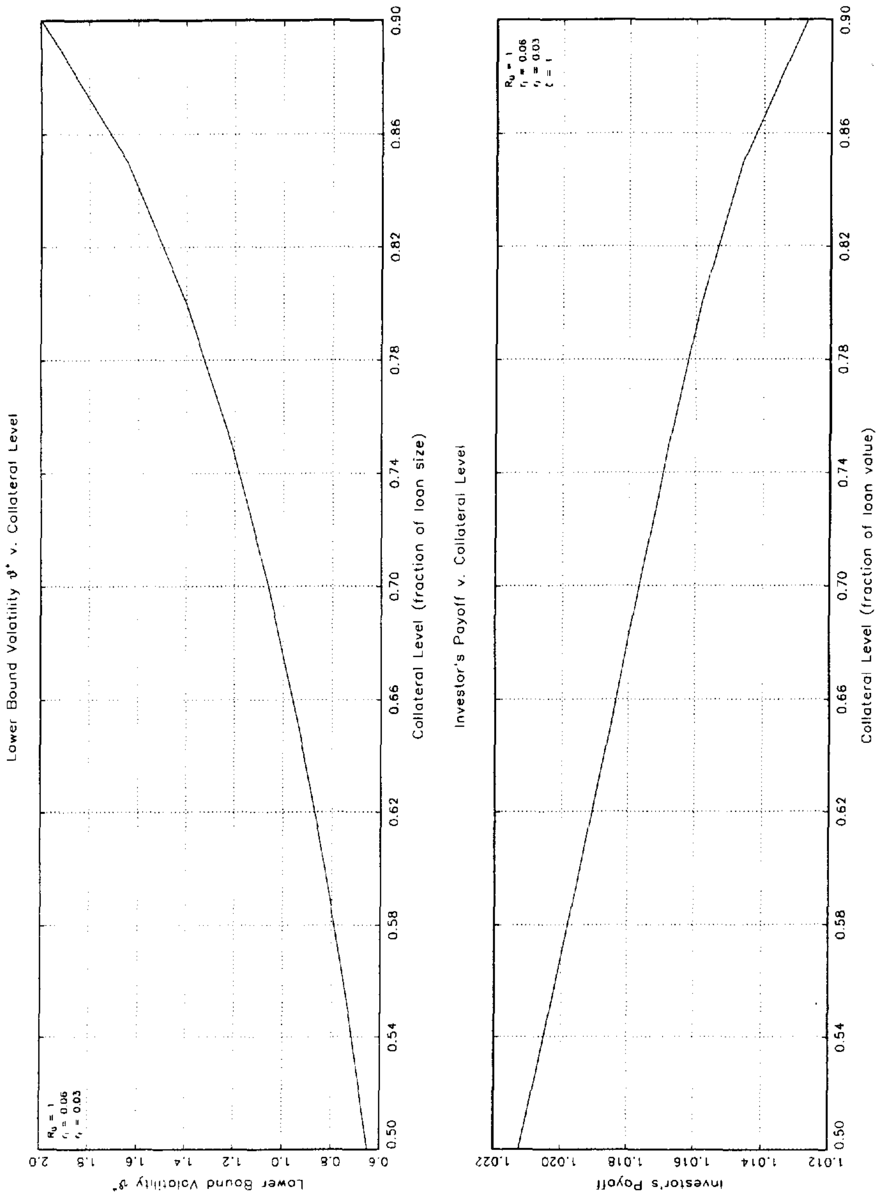
Lower Bound Volatility $\vartheta^*$ v. Collateral Level
Lower Bound Volatility $\vartheta^*$
Collateral Level (fraction of loan size)
$R_0 = 1$
$r_l = 0.06$
$r_f = 0.03$
0.50 0.54 0.58 0.62 0.66 0.70 0.74 0.78 0.82 0.86 0.90
0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
Investor's Payoff v. Collateral Level
Investor's Payoff
Collateral Level (fraction of loan value)
$R_0 = 1$
$r_l = 0.06$
$r_f = 0.03$
$c = 1$
0.50 0.54 0.58 0.62 0.66 0.70 0.74 0.78 0.82 0.86 0.90
1.012 1.014 1.016 1.018 1.020 1.022

Fig. 5.

payoff for $\xi = 0.01$ in the top right-hand panel); for $C = 0.5$, rationing occurs even when the lender knows that the entrepreneur's project has the lowest possible risk (the top left-hand panel). Fifthly, the adverse selection effect is not large, even when it gives rise to rationing (contrast this with Black and de Meza's argument): when $r_1$ increases from 3 to 4%, the change in the critical project riskiness is less than 4% (see Fig. 3). Finally, $\theta^*$ increases, and hence $r_1^*$ and $\pi_L$ decrease, as collateralisation $C/B$ increases (see Figs. 3–5), as predicted in Section 3.2.

## 5. Conclusions

Interpreting the Stiglitz and Weiss (1981) model using an options framework allows many of their results to be derived directly from the comparative statics of options pricing. Moreover, the framework is sufficiently rich to accommodate several theoretical extensions. Finally, parameterisation of the model is straightforward, allowing empirical testing. Simulation indicates that equilibrium credit rationing is unlikely to be empirically significant in the U.S. and U.K. small commercial loans markets, where collateral levels exceed 85% on average. (At lower levels of collateral, rationing is possible; the extent of information asymmetry will be an important determinant.)

## Acknowledgements

Helpful comments from Paul Klemperer, William Perraudin, Stephen Satchell, Michael Selby, Chris Wallace and the editor, and financial support from Pembroke College, Cambridge (the Janeway bursary) and the E.S.R.C. (grant number R00429324220), are gratefully acknowledged. The usual disclaimer applies.

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