Università degli Studi di Ferrara

DIPARTIMENTO DI ECONOMIA, ISTITUZIONI, TERRITORIO

Corso Ercole I D'Este n.44, 44100 Ferrara

Quaderni del Dipartimento

n.17/2003

August 2003

Collateral as a signal. A simple model.

Jacopo Mattei

AUGUST 2003

Collateral as a signal.
A simple model

Jacopo Mattei*

Abstract

The research originates from a comment to the 1981 Stiglitz - Weiss paper. Specifically it is about the collateral role in the problem of credit rationing. The idea here analysed is that the posting of collateral by entrepreneurs could be interpreted as a signalling strategy about the "goodness" of the investment project; if this would be the case there could be a possibility for overcoming rationing. We present here a simple numerical example of a contracting game between entrepreneurs and banks, a case in which the strategy of posting high collateral is univocally associated with the entrepreneurs investing in "good" projects.

* University of Ferrara, Faculty of Economics, Via del Gregorio 13, 44100 Ferrara

Introduction

It is self evident that credit markets are characterised by a very high degree of information asymmetry. It is especially the case that the lender could not assess ex ante in a proper way the quality and the riskiness of the project to be financed. These information asymmetries cause the well known problems of adverse selection and moral hazard. A great part of the literature, starting from the pathbreaking 1981 paper by Stiglitz and Weiss, demonstrated how the above features of credit markets could cause the profit function of banks to be not monotonically increasing in the interest rate, and even in the collateral requirements. In particular Stiglitz and Weiss showed how increasing interest rate the bank could decrease its profit as at higher interest rates riskier investment project are likely to be undertaken; and even how "*increasing collateral requirements will, under plausible conditions, lower the bank's return*[1]". The results of these findings are that credit rationing occurs and nor interest rate nor collateral requirements are effective instruments to be used for equating the supply of loanable funds with the demand for them.

The present paper wants to further analyse the discussion around the collateral requirement instrument. In fact, while the explanation and the proof about how interest rates work seem to be plain and convincing, on the contrary the discussion offered insofar by the mainstream literature about how the collateral related problem is, for us, counterintuitive and troublesome. In fact the interest rate charged on a loan effectively acts directly on the expected return of the project for the entrepreneur, so that its raising can sort out the more safe projects and the more risk averse entrepreneur. Otherwise one could think at the collateral as an instrument which the entrepreneurs with more safe projects are more willing to post than those with "risky" projects, as the probability of default and of effectively "paying" the collateral is not so high as for the others. We will show that in a world with perfect ex ante information asymmetry and lenders competition the collateral offered (or the collateral requirement chosen) by borrowers could act as a signal strategy of the riskiness of the project to be financed. In that case the collateral would be negatively related to the riskiness of the project.

---

[1] Stiglitz-Weiss (1981, p.403.)

Hereafter in section I we present a brief description of how collateral could be intended and we overview some literature presented on the same argument of the present paper. In section II we go on presenting a simple model of how the choice of a given collateral requirement could be interpreted as a signal of the riskiness of the project. In section III we conclude and give some suggestions of possible implications of the model presented, to be further analysed.

1. Theoretical background.

Collateral could be of two types. The "inside" collateral, that are the assets used in the project to be financed. This collateral type is assumed in most standard debt models and its meaning is quite obvious: when the borrower defaults control of the project and ownership of depreciated assets goes to the lender. However the main literature on the topic, and this paper, especially refers to the second type: "outside" collateral, i.e. when the borrower pledges assets that are not used in the project, a fraction of its personal wealth.

Evidence and available data suggest that collateral is widely used. For example Black, de Meza and Jeffreys (1996) report that for 85% of small business loans in UK, the ratio of collateral to loan size exceeds unity.

Information asymmetry is the main theoretical explanation proposed in the literature to explain credit markets' imperfections and the use of collateral. As mentioned above, Stiglitz and Weiss in their 1981 paper showed that when there is information asymmetry the collateral requirement effectively acts as a screening mechanism, but increasing it causes that both the average and the marginal borrower is riskier (adverse selection). This argument was further extended by H. Wette (1983). She takes into consideration a Stiglitz-Weiss type model shifting from the assumption of risk averse investors to the more relaxed one of risk neutrality. In her model entrepreneur are endowed with investment projects with two possible outcomes: success or default. Different types of projects (j) have the same expected value and differ only for the value of the outcomes: rskier projects have higher return (R_j) in case of success and a lower return (F_j) in case of failure. Furthermore interest rate r^* is fixed and banks compete on the collateral requirements C. The entrepreneur expected profit could be written as:

$$\Pi_j = p(R_j - (1+r^*)L) - (1-p)C \quad \textbf{(1)}$$

where p is the probability and L is the loan size. Hence an increase in the collateral requirement, C, induces the exit from the market of the entrepreneurs with the lowest successful outcomes, i.e. the safest ones. Therefore collateral may cause a similar adverse selection effect as the interest rate. The adverse selection effects may be understood even by analysing the expected profit function of the bank: an increase in the collateral requirement has a positive direct effect, but a negative indirect effect due to an adverse change in the pool of entrepreneurs.

Other later studies, on the contrary, showed (Chan and Kanatas (1985)) that if the collateral's value is more stable or more "objective" than the distribution of returns from the project, the entrepreneur could profitably trade it for better interest rates. To understand this, suppose that an entrepreneur owns an investment project with a two points return distribution (0 and R). The asymmetry in information is intended as that the entrepreneur's assessment of the project success probability, p_e, exceeds the bank's assessment, p_b. Suppose that the project size is B and the entrepreneur finances the whole project through the loan. A "fair" loan would involve zero expected profit to the bank:

$$(1+i)B = (1-p_b)C + p_b(1+r)B \quad \textbf{(2)}$$

Where C is the amount of outside collateral, r is the interest rate on loans, and i is the interest rate at which the supply of funds to the bank is perfectly elastic. The entrepreneur's expected profit is:

$$\Pi_e = p_e(R_j - (1+r)B) - (1-p_e)C \quad \textbf{(3)}$$

As the entrepreneur's marginal valuation of collateral in terms of interest rates (the marginal rate of substitution) is always lower than the rate at which the bank is willing to exchange collateral for interest rate in its zero-profit contract, the optimal contract necessarily involves full collateralization. Partial collateralization may occur, as Chan and Kanatas argue, only if there are some increasing costs in using collateral. The extent at which collateral is used is proportional to the asymmetry of information $(p_e - p_b)$ and inversely proportional to its cost.

The two above approaches are subject to the obvious criticism that the bank, as could use two different instruments (collateral and interest rate), may want to use them jointly, rather than considering one of the two as fixed. Furthermore the cited studies seem to ignore that Spence (1973) showed that adverse selection problems could be solved by the use of contracts that give signals about the quality of different types. Signals allow screening and separation of types in equilibrium.

Bester (1987) investigated this problem and found that, under some "fairly" strict assumptions, the banks may design contracts which are effective in screening different type of borrowers, and therefore the market could achieve a separating equilibrium with no credit rationing. The main hypotheses applied by Bester that ensures the feasibility of perfect separation is that for entrepreneurs $U(0) = -\infty$, and that the availability of collateral is not scarce. The main point of his model is the observation that, for any pair of debt and collateral, the marginal rate of substitution between interest rate and collateral of the less risky entrepreneurs is lower than the one of riskier entrepreneurs because of their lower probability of default.

However Besanko and Thakor (1987) found that relaxing the two main Bester's hypotheses self-separation may prove to be impossible. Furthermore they found that a monopolistic bank would never use collateral to screen entrepreneurs: it will design contracts in order to extract the maximum possible surplus from all type of borrowers.

2. The numerical example.

Relying on the above literature, and even despite a part of it, we are convinced, observing the functioning of credit markets and the behaviours of entrepreneurs, that collateral always acts as a signal device. In particular that entrepreneurs going to invest in better and safer projects are more willing to post outside collateral than their "colleagues" with worst and riskier projects.

To prove this we are going to consider a very simple model trying to describe the reality of a given firm and the behaviour of entrepreneurs searching debt financing for their investment projects.

We are going to analyse a setting where entrepreneurs are expected profit maximisers and where there is perfect ex-ante information asymmetry between them and banks; that is as to say that entrepreneurs know exactly all the elements of the project they are

going to undertake, while the banks could not distinguish ex-ante any of those characteristics. Furthermore, as the banks are not aware ex ante of the projects quality and are competing between them, for financing its investment the entrepreneur could choose, at any given interest rate, contracts with high or low collateral requirements. Finally we want that our theoretical setting try to approximate the reality of a firm, where investment decisions have effect on more than one period and liquidation of assets is costly.

Hereon we specify further assumptions of our model:

- there are only two expected profit maximisers entrepreneurs;
- one of them is endowed with a "good" investment project, while the other with a "bad" one;
- projects have only two possible outcomes: success (S) or default (F);
- a project is to be implemented in a firm in a two period time, and gives (S) or (F) for each period;
- the result over the two periods are statistically independent;
- at the end of the first period both the entrepreneur and the bank observe the result, and the firm has to decide whether to continue the investment or to exit it;
- exit from the project liquidating assets is costly: for example in terms of loosing the cost of workers training or of loosing the firm reputation;
- the "good" project is strictly stochastically dominating the second, in the sense that has higher expected value, lower variance and assigns a greater probability, p_S, to the event of a successful outcome.

Hereafter we will use a numerical example to show our model:

- both investments projects involve an initial (t_0) investment of 100, to be financed for 90 with debt, and for 10 with equity;
- for simplicity there is no interest rate charged on the debt;
- at time 1 (t_1) the project gives a return (S) or (F) and the borrower has to pay back a part of the debt (40);
- in (t_1) the project could be liquidated only suffering a cost of, say, 50; for continuing the project the entrepreneur has to invest (for example for maintenance) a certain amount, 20, let say all financed with equity;

- at time 2 (t_2) the project again gives a return (S) or (F) and the borrower has to pay back the remainder of the debt; the liquidation value of the assets is L.

The two projects are made as follows:

- "Good" project: $S_g = 50$ and $F_g = 0$ with $p_S = 0.75$, $L_g = 50$;
- "Bad" project: $S_b = 110$ and $F_b = 0$ with $p_S = 0.50$, $L_b = 10$.

Hence the two projects present the following cashflows:

"Good":

t0	t1	t2	joint prob.
-100	30	100	0,5625
-100	30	50	0,1875
-100	-20	100	0,1875
-100	-20	50	0,0625

Its expected net present value is: $E(g) = 5$ with variance $Var(g) = 113{,}5254$.

"Bad":

t0	t1	t2	joint prob.
-100	90	120	0,25
-100	-20	120	0,25
-100	90	10	0,25
-100	-20	10	0,25

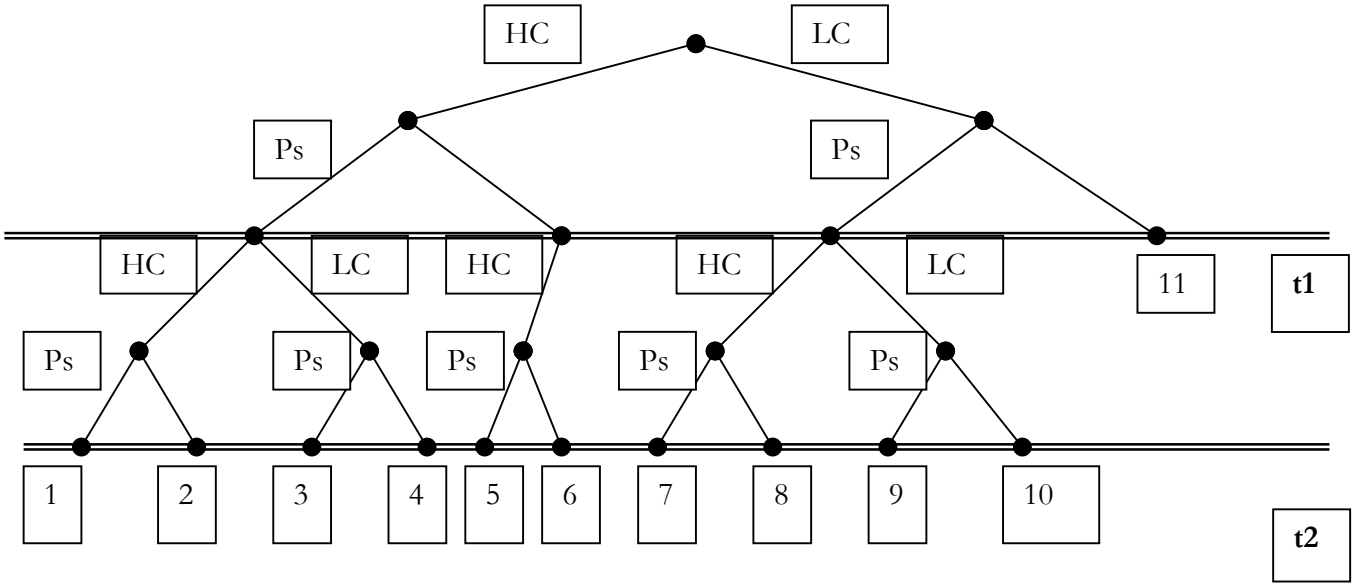
Its expected net present value is: $E(b) = 0$ with variance $Var(b) = 378{,}125$.

In t_0 the entrepreneur could choose between two different types of loan contracts: one with high collateral posting (collateral = debt), and one with low collateral (let say 50). In (t_1) the bank observes the first outcome of the project and on its basis estimates the quality of the project. We assume in (t_1) there is a possibility to renegotiate the collateral posting for the contract; if the bank observes a success is willing to offer again all the

two alternatives (high or low collateral). If the projects incurs in a failure in the first period, then we could distinguish two different cases: if the bank had received high collateral it could permit the continuing of the project to time 2, while if the bank had received low collateral it could estimate the risk of continuation too high and thus force the entrepreneur to bankruptcy and to abandon the project. Furthermore, on the side of the entrepreneur, we assume that if the project incurs in a failure in the first period he finds better to continue the investment in period two, rather than incurring the liquidation costs.

The possible outcome (from num.1 to num.11) could be represented in the following graph as the results of the interaction between the choices of the entrepreneur, the bank and the Nature, which determines the possible outcomes (Success with probability Ps).

GRAPH1



The possible returns to the entrepreneur associated to the projects' outcomes (1 to 11) are[2]:

outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
"good" proj	30	-20	30	-5	-20	-70	30	-20	30	-5	-50
"bad" proj	110	0	110	0	0	-110	110	0	110	0	-50

[2] The returns to the entrepreneur are calculated as: $\Pi = R_1 + R_2 + L - D - E$, or $\Pi = R_1 + R_2 + L - C - E$ when the results are failures and the collateral posted is less than the debt; R_i, E are respectively the results of the project in the two periods and the equity invested (30).

Given the above possible outcomes we can compute the expected profit to the entrepreneur of choosing high or low collateral contracts in (t_0); For doing this we can compute the probabilities associated to each of the 11 possible outcomes, while we don't make any hypotheses about the renegotiation of the collateral posting in (t_1) and thus we assign $p = 0{,}5$ to the one or the other of the possibilities in (t_1), when both the alternatives are offered.
Hence for the entrepreneur endowed with the "good" project the expected profit of the strategy "choose high collateral" (associated to outcomes 1 to 6) is 6,406, while that of the strategy "choose low collateral" (associated to outcomes 7 to 11) is 2,031.
On the contrary for the entrepreneur endowed with the "bad" project the expected profit of the strategy "choose high collateral" (associated to outcomes 1 to 6) is 0, while that of the strategy "choose low collateral" (associated to outcomes 7 to 11) is 16,25.

Summarising, for the sake of clarity:

		EXP.PROFIT
"Good" proj.	strat. High c.	6,40625
	strat. Low c.	2,03125
"Bad" proj.	strat. High c.	0
	strat. Low c.	16,25

Therefore it results evident that in our setting, with expected profit maximising entrepreneurs, who has a "good" project does prefer to post high collateral in loan contracts, while entrepreneurs with not enough good projects do prefer to sign contracts with low collateral requirements.

3. Conclusions

Above we presented, using a numerical example, a model of how entrepreneurs could choose to post different amounts of collateral to loan contracts, in function of the "goodness" of their investment projects. Their choice could, in this way, be interpreted

as a signal of the projects quality. Hence bank could take borrowers' choices for approximately assessing the riskiness of a given financing possibility.

Of course the problem has to be fully analysed by the banks' side. But the intuition lead us to think that, as the willingness to post collateral could be interpreted as a signal, the credit market could achieve a discriminating equilibrium where creditworthy borrowers are offered loan contracts with low interest rates and high collateral postings, while more risky borrowers sign contracts with which they pay high interest rates (and thus high risk premiums) for posting not enough collateral.

This doesn't exclude the possibility that credit rationing still occurs, as banks could find convenient not to accept certain contracts[3] even with enough high interest rates, but at least could assure that "good" borrowers are not rationed.

Our argument is an example of how credit markets could work. Theoretically the argument could be further developed, in the direction that the price mechanism could be really seen as effective even in credit markets, and its operation assures the possibility of equilibrium, or at least, of a rationing less dramatic of what predicted by Stiglitz and Weiss in their 1981 paper.

[3] Anyway, we could think that, if separation of borrower is possible relying on our argumentation, with a continuum of profitable projects types and of possible collateral requirements a bank could design a contract (i,C) such that never incurs in an expected loss.

REFERENCES

Akerlof G.A. (1970)	"The market for lemons": Quality uncertainty and the market mechanism"; in The Quarterly Journal of Economics vol.84 (3) pagg.488-500.
Besanko D. – Thakor A.V. (1987)	"Collateral and rationing: sorting equilibria in monopolistic and competitive credit markets"; in International Economic Review vol.28 (3), 1987, pagg. 671-689.
Bester H. (1987)	"The role of collateral in credit markets with imperfect information"; in European Economic Review vol.31, 1987, pagg. 887-899.
Bester H. (1994)	"The role of collateral in a model of debt renegotiation"; in Journal of Money, Credit and Banking vol.26 (1), pagg.72-86.
Black J. - de Meza D. – Jeffreys D. (1996)	"House prices, the supply of collateral and the enterprise economy"; in The Economic Journal vol.106, 1996, pagg. 60-75.
Chan Y.S. – Kanatas G. (1985)	"Asymmetric valuations and the role of collateral in loan agreements"; in Journal of Money Credit and Banking vol.17 (1), 1985, pagg. 84-95.
Spence A.M. (1973)	"Job market signalling"; in Quarterly Jounal of Economics vol.87 (3), 1973, pagg.355-374.
Stiglitz J.E. – Weiss A. (1981)	"Credit rationing in markets with imperfect information"; in American Economic Review vol.71 (3), 1981, pagg. 393-410.
Stiglitz J.E. – Weiss A. (1987)	"Credit rationing: reply"; in American Economic Review vol.77 (1), 1981, pagg. 228-231.
Wette H.C. (1983)	"Collateral in credit rationing in markets with imperfect information: Note"; in American Economic Review vol.73 (3), 1983, pagg.442-445.