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Boundedly Rational Credit Cycles†

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Abstract

We propose an evolutionary model of a credit market. We show that the economy exhibits credit cycles. The model predicts dynamics which are consistent with some evidence about the Great Depression. Real shocks trigger episodes of credit–crunch which are observed in the process of adjustment towards the post shock equilibrium.

INTRODUCTION

This paper studies the evolutionary dynamics of a two-population asymmetric game in which no equilibrium is evolutionarily stable. The game can be interpreted as the model of a borrower-lender relation, and the dynamics are consistent with the empirical observation that economies tend to produce 'credit cycles'.

The emergence of periodical episodes of credit rationing and their effects on the aggregate economic activity have been the focus of substantial research in macroeconomics during the recent years. The existing explanations attribute the emergence of credit cycles to changes in the value of net worth and collaterals in the hand of the borrowers. In Bernanke and Gertler (1989) temporary shocks to net worth have persistent effects on the economy due to financial market imperfections. Kiyotaki and Moore (1993) obtain endogenous credit cycles in a dynamic model where borrowers' credit limits are affected by the price of their collaterizable assets (land). The interaction between asset prices and asset limits acts as a propagation mechanism through which the initial shock in one sector is amplified and transmitted to the rest of the economy. In this paper, cycles emerge from a simple game-theoretical *evolutionary* model which exhibits two types of equilibria, one with a fully developed credit market (no credit rationing) and one with no credit activity at all (financial collapse). Although financial collapse is not per se a stable outcome (in a sense which will be defined), it can 'attract' periodically the economy towards it. In particular, when some negative real shock hits the economy, potential lenders become increasingly 'scared' at the increasing number of defaults which they observe and start switching out of loans into safer investments; as a result, the economy is temporarily driven away from the *good* and towards the *bad* equilibrium. However, before the complete financial collapse is reached, granting credit to borrowers turns again profitable and the the economy starts reverting towards the *good* equilibrium in which all applications for a loan are satisfied. This explanation of the credit cycles relies on the assumption that agents are not fully rational. If agents played Nash equilibrium strategies at any moment in time, we could only observe either a fully active or a missing credit market. But as out-of-equilibrium behavior is part of the actual play, the cycles describe the dynamic behaviour of populations who learn their way to the equilibrium through iterative play.

The relations between borrowers and lenders are modelled as regulated by a very simple debt contract subject to the constraint of limited liability of investors. The two parts know nothing about each others' history. Investors can decide to invest the money in a productive activity or to 'take the money and run'; lenders can detect the fraudulent behaviour and enforce its punishment, but only if they engage in a costly monitoring process. Lenders, who can invest in a low return safe asset or lend to a borrower, charge the same interest rate to all possible borrowers because these are ex-ante indistinguishable to them. If banks decided to monitor all borrowers, potentially bad borrowers would find it optimal to invest in the productive activity, because they would certainly be penalized. If all borrowers were 'good' however, lenders would maximize profits by not monitoring any project. For these reasons there exists one equilibrium in which we observe a mixture of good and bad behaviour on the borrowers' side and the banks choosing to monitor randomly a positive proportion of the loans granted but not all of them. This is not the only Nash equilibrium, and, as we said, there are also equilibria with complete 'financial collapse'. When lenders expect to find many bad borrowers they invest in the safe asset and do not grant any loan. If the proportion of borrowers who would cheat should they receive a loan is large enough the banks behave optimally and so do the borrowers.

In this paper, individuals from large populations (borrowers and lenders) are randomly matched to play repeatedly a one-shot game representing the credit relation just described. The evolutionary approach stresses the importance of dynamics in the emergence of equilibrium; Nash equilibria are viewed as stationary points of dynamic processes representing some kind of evolutionary adaptation. We assume a very general type of regular dynamics whose only requirement is that strategies with higher payoffs grow relative to those with lower payoffs. These 'monotonous dynamics' arise from models of imitation and learning where individuals revise their strategies in the light of different strategies' relative payoffs. The dynamics represent the aggregate effect of the revising rules that individuals employ. Players behave conservatively by sticking to a strategy, and only periodically deciding whether or not to revise their behaviour by imitating more successful strategies.

The main focus of the paper is the characterization of the dynamics. Cyclical patterns to both the credit and the real activity are shown to be an intrinsic feature of this economy. Negative productivity shocks trigger periods of recession with credit rationing which are observed during the process of adjustment towards the post shock equilibrium. Banks switching out of loans into the safe asset act as the propagation mechanism of the recessions.

The model predicts a positive correlation between credit supply and economic activity which is consistent with Bernanke's (1983) description of the Great Depression. The persistence and depth of this episode is attributed by Bernanke (1983) to the crisis experienced by the banking sector which was triggered by the fall of output and the adverse development in the US economy. Similar evidence is observed for other countries and periods (Bernanke and James (1991) and Schreft (1990)). The mechanism of our model closely resembles this chain of events.

Although borrower-lender relations have typically a long-term nature which is not captured by the random matching, one-shot set-up which we propose, the model can be regarded as a description of the inherently risky market for loans to new investors and small firms whose access to the credit market is sporadic and the information about their past behaviour is little reliable. Bernanke (1983) observes that this segment of the market was significant and important during the Great Depression. Also customer relations were weakened in that period by the fact that many borrowers were separated from their banks when these were forced to close. This caused a considerable amount of borrowers to seek for credits in new banks. There is evidence that credit rationing was particularly significant to these segments of the market.

The paper is organized as follows: In the first part we introduce the model and characterize the equilibria. In the second section we introduce the dynamics and study the behaviour of the economy. Section 3 relates the findings to the evidence from the Great Depression. Section 4 concludes.

1. CREDIT ACTIVITY IN AN ECONOMY WITHOUT COLLATERAL

We consider a stylized economy in which potential investors hold no collateral. As it is known the lack of collateralizable wealth makes lenders liable to large losses in the event of bankruptcy of the debtor and raises an important incentive problem if some of the borrower's actions are unobservable. Assume that the probability of success of an enterprise depends on some unobservable costly effort on the part of the entrepreneur. If he borrows funds with little or no collateral, he will typically put in less effort than in a world of perfect information. This happens because he is liable, in the event of bankruptcy, only for the value of his collateral, whereas the reward to its success is limited by the payment due to the lender (debt–overhang problem with wealth constraints).

We assume that all agents are risk-neutral. There exists a safe asset in the economy that provides an exogenously given interest rate. All potential investors need to borrow a fixed amount of money W and have no collateral. Entrepreneurs may either exert effort, or do nothing. Effort increases the probability that an investment is successful. There are two states of the world, which are observable by everybody at the end of each period. In the *good state* of the world the borrower gets revenue $H > W$, pays back the debt with the agreed payment (R) and earns a net profit, whereas in the *bad state* the borrower gets nothing and cannot repay the debt.[1]

Let π and $(\pi+\alpha)$ be the probabilities of good crop without and with effort, respectively. Let e be the disutility of the effort. We also define r as the gross payment obtained by the lender investing W in the safe activity. Imagine that agents cannot play mixed strategies. It is then possible to choose parameters such that a credit market would exist under perfect information if effort were contractible but is missing in a world with imperfect information. This is the case if

$$[\pi + \alpha][H - R] > e \text{ and } (\pi + \alpha)R > r, \tag{1}$$

for some R, but

$$\pi R < r, \tag{2}$$

for all R and

$$\pi[H - R] > (\pi + \alpha)[H - R] - e \tag{3}$$

[1] We implicitly assume that there is no equilibrium value of R that makes the borrower's choice incentive compatible, i.e. that induces the lender to exert effort, while giving the lender a higher expected payoff than that warranted by investing in the safe asset.

for all R's that satisfy (1).

Inequality (1) guarantees that under perfect information (observable effort) there would be credit for some range of values of R, with the borrower exerting the effort. Inequality (2) says, however, that if no effort is exerted by the borrower, there is no R at which the lender is willing to grant credit. Inequality (3) implies that for all R's satisfying (1) there is an incentive problem: the expected payoff of the borrower is higher when he shirks. The source of this standard missing market problem is the absence of collateral. In order to close the model we assume that the lender is entitled to monitor borrower's activity. If cheating is detected, the lender asks for his money back (without earning interest) and the borrower is liable to legal prosecution, with a high loss in terms of utility. However, monitoring entails a cost c. We can imagine that the lender delegates and pays some specialized institution for this purpose. Monitoring reduces the risk involved in lending. In order to focus on the interesting case, we will assume that, when effort is exerted, the payoff to the lender, net of the cost c, is still higher than if W were invested in the safe asset.

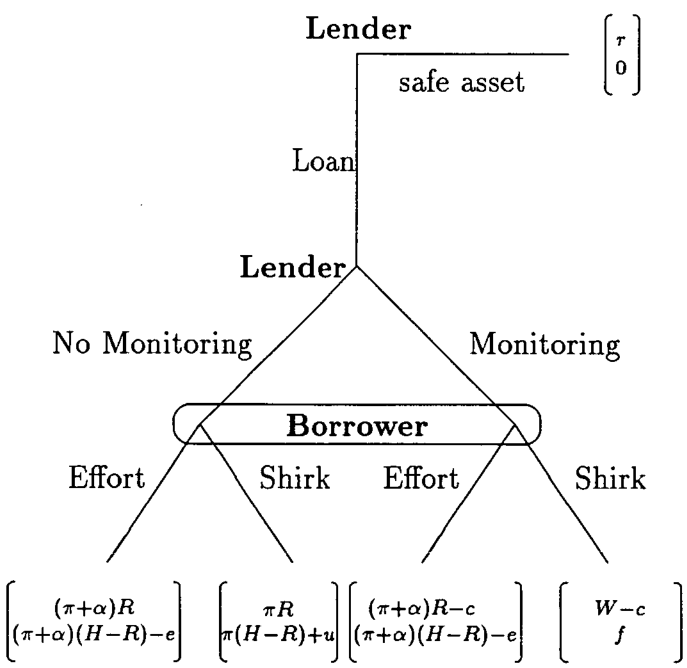

Figure 1: Borrower-Lender Game

Figure 1 is the extensive form representation of the situation described above. The lender decides whether to invest in a *safe asset* (SA) or to grant a *loan* (L). If the loan is granted the lender chooses between *no monitoring* (NM) and *monitoring* (M). Observe that the lender has four pure strategies: (SA, NM), (SA, M), (L, NM) and (L, M). The borrower, when he is given a loan, decides either to exert *effort* (E) or to *shirk* (S). The interpretation of each payoff pair is straightforward. For example, strategy (L, NM) matched with strategy E gives an expected payoff of $(\pi + \alpha)R$ to lenders (the probability of success for a honest entrepreneur times the payment agreed in the case of success) and $(\pi + \alpha)(H - R) - e$ to investors (the probability of success when effort is exerted times the net profit minus the effort cost). The quantity u represents the utility to borrowers of consuming the borrowed funds rather than investing them. The quantity f represents the disutility from the prosecution in the case of being caught when shirking.

	E	S
(SA,NM)	0 r	0 r
(SA,M)	0 r	0 r
(L,NM)	$(\pi + \alpha)(H - R) - e$ $(\pi + \alpha)R$	$\pi(H - R) + u$ πR
(L,M)	$(\pi + \alpha)(H - R) - e$ $(\pi + \alpha)R - c$	f $W - c$

Figure 2: Game G

Figure 2 is the normal form of the borrower-lender game. Since the strategies (SA, NM) and (SA, M) are behaviourally indistinguisable, we will refer to both of them with the same label SA. For notational simplicity we will relabel (L, NM) and (L, M) as N and M, respectively.

Let us assume that players can randomize over pure strategies. Let S_i be player's i strategy space and let $|S_i|$ be its cardinality. In the borrower-lender game the strategy spaces are $S_1 = \{SA, N, M\}$ and $S_2 = \{E, S\}$. Player i's mixed strategy x_i is a vector which belongs to the $|S_i| - 1$ dimensional probability simplex Δ_i

$$\Delta_i = \{x_i \in R_+^{|S_i|} : \sum_{h=1}^{|S_i|} x_{ih} = 1\}$$

where x_{ih} is the probability assigned by x_i to the player's hth strategy.

Let x_{11}, x_{12} and x_{13} be the probabilities assigned by a lender to strategies SA, N and M, respectively. The vector $x_1 = (x_{11}, x_{12}, x_{13})$ is a lender's mixed strategy. Notice that $x_{13} = 1 - x_{11} - x_{12}$. Let x_{21} and x_{22} be the probabilities assigned to the strategies E and S by a borrower. His mixed strategy is described by a vector $x_2 = (x_{21}, x_{22})$ with $x_{22} = 1 - x_{21}$. A mixed strategy profile is a vector $x = (x_1, x_2)$ in the mixed strategy space $\Delta = \Delta_1 \times \Delta_2$. The set Δ is a 3-dimensional polyhedron in R^5. We shall describe a mixed strategy profile by the vector $x = (x_{11}, x_{12}, x_{21})$.

We assume that payoffs satisfy the following conditions:

(c.1) $(\pi + \alpha)R - c > r > W - c > \pi R.$

(c.2) $(W - c - \pi R)((\pi + \alpha)R - W) > (r - (W - c))(W - \pi R).$

(c.3) $(\pi + \alpha)(H - R) - e > f.$

(c.4) $\alpha(H - R) - e < u.$

Condition $(c.1)$ guarantees that when the borrower exerts effort the most profitable strategy is N followed by M and SA, whereas when the borrower shirks the ordering is strictly reversed. Conditions $(c.1)$ and $(c.2)$ together guarantee that every strategy in S_1 is a strict best-reply for some values of x_{21}. Condition $(c.3)$ guarantees that, when the lenders monitors, exerting effort is the best-reply for the borrower. Condition $(c.4)$ guarantees that, when the lender doesn't monitor, to shirk is the best-reply for the borrower.

If payoffs satisfy conditions $(c.1)$-$(c.4)$, the Borrower-Lender Game has a set of Nash equilibria with two components,

(i) a mixed equilibrium

$$x^* = \left(0, \frac{(\pi + \alpha)(H - R) - e - f}{\pi(H - R) + u - f}, \frac{(W - c) - \pi R}{W - \pi R}\right)$$

$x^*_{12} \in (0, 1)$ by condition $(c.4)$, $x^*_{21} \in (0, 1)$, $\delta x^*_{12}/\delta\pi > 0$, $\delta x^*_{12}/\delta\alpha > 0$ and $\delta x^*_{21}/\delta\pi < 0$.

(ii) A set $C = \{(x_1, x_2) \in \Delta_1 \times \Delta_2 : x_{11} = 1 \text{ and } x_{21} \leq \hat{x}_{12}\}$ with

$$\hat{x}_{21} = \frac{r - (W - c)}{(\pi + \alpha)R - W}$$

$\hat{x}_{21} \in (0, 1)$ by condition $(c.1)$, $\delta\hat{x}_{21}/\delta\alpha < 0$ and $\delta\hat{x}_{21}/\delta\pi < 0$.

The mixed equilibrium, which is subgame perfect, corresponds to the existence of credit. All equilibria in C imply no credit. Under our restrictions on the payoffs, any equilibrium belonging to C which corresponds to the absence of credit, is Pareto dominated by the singleton equilibrium.

The problem of the existence of credit therefore reduces to studying an equilibrium selection problem in game theory. In the following section we follow an evolutionary approach.

2. CREDIT CYCLES

Rather than assuming that we have two players randomizing over pure strategies we assume that there are two large populations of boundedly rational players, playing pure strategies, which are randomly matched. In this view a mixed strategy in population i is a population profile $x_i \in \Delta_i$ with $x_{ih} \geq 0$ denoting the relative frequency of the hth pure strategy in population i.

We assume a very general type of continuous dynamics which ensure that more profitable strategies increase relative to less profitable strategies. This type of dynamics can be obtained from models of imitation and learning (Friedman (1992) and Weibull (1995)). We could assume, for instance, that players can observe a sample of contemporaneous interactions and imitate more profitable strategies. Lenders could meet and talk about businesses and borrowers tell each other their credit experiences.

ASSUMPTION 1. The evolution of the economy is described by a system of differential equations (time indices suppressed)

$$\dot{x}_{ih} = x_{hi} g_{ih}(x) \qquad \forall i \in \{1,2\}, h \in S_i, x \in \times\Delta_i$$

with $g_i : \Delta \to R^{|S_i|}, \forall i \in \{1,2\}$,and $g = \times_i g_i$ is such that

(i) g is Lipschitz continuous on Δ,

(ii) $\sum_{h\in S_i} \dot{x}_{ih} = \sum_{h \in S_i} x_{hi} g_{ih}(x) = 0, \ \forall i \in \{1,2\}, x \in \times\Delta_i$.

The growth rate function g assigns to each state x, population i and pure strategy h the growth rate g_{ih} of the associated population share x_{ih}. The system of differential equations which meet (i) and (ii) are called *regular selection dynamics* (Weibull (1995)). Existence and uniqueness of a solution is guaranteed by the Picard-Lindelöf theorem. In every regular selection dynamics both Δ and its interior int(Δ) are invariant and extinct strategies stay extinct forever.

Let $\pi_{ih}(x)$ be the expected payoff to a player from population i who employs strategy h in state x.

ASSUMPTION 2. (*Monotonicity*). $g_{ih}(x) > g_{ik}(x) \iff \pi_{ih}(x) > \pi_{ik}(x)$ for all $h, k \in supp\{x_i\}$ and $g_{ih}(x) = 0$ for $h \notin supp\{x_i\}$.

Observe that $\frac{d}{dt}(x_{ih}/x_{ik}) > 0$ when $\pi_{ih}(x) > \pi_{ik}(x)$ The ordinal relationship applies only to nonextinct strategies. Let $\mathcal{M}$ be the set of all monotonous dynamics.

Since several strategies will coexist at any time, including strategies which are not current best-replies and agents are randomly matched, the expected payoff to each strategy will depend on the probability of matching with each of the strategies played by the opponent population. In a world with many honest borrowers, to lend without monitoring is likely to be a successful strategy. In a world with almost all dishonest borrowers the best one can do is to invest in the safe asset. The state space, with the Nash equilibrium components, is represented in figure 3. The states where the credit market is fully developed ($x_{11} = 0$) correspond to the floor of the polyhedron, which contains the mixed equilibrium. The component of Nash equilibria is the thick segment on the edge where $x_{11} = 1$. The arrows along the edges of the polyhedron show the associated directions of the vector field for any monotonic dynamics. We have also drawn the directions of the vector field on the face where $x_{11} = 0$.

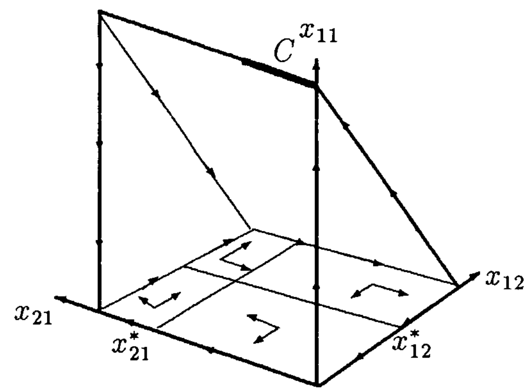

Figure 3: State space

In the following lemmata we describe the stability properties of the absorbing sets of the system. We asume that some players tremble and play an arbitrary strategy. Alternatively we could assume that new players (mutants), who know nothing about the economy, come along and play arbitrary strategies. The mutants' role is to resurrect extinct strategies and to perturb the rest points of the dynamics. We characterize the dynamic properties of set C and the face of the polyhedron $D = \{x \in \Delta : x_{11} = 0\}$, which contains the mixed equilibrium.

LEMMA 1. *C is not Lyapunov stable.*

Proof. Consider the state $(1, 0, \hat{x}_{21} - \delta)$ $(\delta \geq 0)$ in C and an ϵ-proportion of mutants who play N and M in proportions γ and $(1 - \gamma)$, respectively. At $(1 - \epsilon, \gamma\epsilon, \hat{x}_{21-\delta})$ $\dot{x}_{21} > 0$ for all $\gamma/(1-\epsilon) < x^*_{12}$, $d/dt(x_{11}/x_{13}) > 0$ and $\dot{x}_{12} < 0$. At $(1-\epsilon, \gamma\epsilon, \hat{x}_{21}+\delta)$, $d/dt(x_{11}/x_{13}) < 0$ for all $\gamma \in [0, 1]$. □

LEMMA 2. *For any monotonous dynamics $\dot{x}_{11} > 0$ at all $x = (\epsilon, x_{12}, x_{21})$ with $x_{21} \leq \hat{x}_{21}$ and $\epsilon \in (0, 1)$.*

Proof. By (c.1) and (c.2) SA is the most profitable strategy for all $x_{21} < \hat{x}_{21}$. □

LEMMA 3. *The face D is not asymptotically stable.*

Proof. It follows directly from lemma 2. □

The following proposition describes the behaviour of the economy under general monotonous dynamics. We would like to stress that model relates the economic activity and the development of the credit market. The higher the proportion of good borrowers, the higher the investment and the production and the higher the number of loans which are granted. The higher the proportion of credits which are granted the higher the level of economic activity.

Let $\mathcal{M}_1$ be the set of monotonous dynamics for which x^* is the α-limit of any state in the interior of D, i.e the dynamics bend outward. Let $\mathcal{M}_2$ be $\mathcal{M}/\mathcal{M}_1$.

PROPOSITION 1. *Assume that the behaviour of the economy is described by a system of differential equations that satisfy assumptions 1 and 2.*

i) If dynamics belong to $\mathcal{M}_1$ the economy exhibits credit cycles and fluctuations of the economic activity for any initial condition.

ii) For any dynamics belonging to $\mathcal{M}_2$ there exist a set of initial conditions such that the economy exhibits credit cycles and fluctuations of the economic activity.

Proof. (i) Let us assume that the dynamics belong to $\mathcal{M}_1$ and that the economy is at the mixed equilibrium. Consider a perturbation in t such that $x(t) \in D$ and $x(t) \neq x^*$. Under any dynamics in $\mathcal{M}_1$ the system will swirl outwards and reach a state with $x_{21} \leq \hat{x}_{21}$. By lemma 2, $\dot{x}_{11} > 0$ if SA happens to be played by a mutant. In the process of credit contraction the proportion on monitored over unmonitored loans is increasing, $d/dt(x_{13}/x_{12}) > 0$, by conditions $(c.1)$ and $(c.2)$ and monotonicity. A state is reached at which $\dot{x}_{21} > 0$, by monotonicity and conditions $(c.3)$ and $(c.4)$. The process of credit rationing slows down and is reverted when $x_{21} > \hat{x}_{21}$, by lemma 1. A state in D is reached and a new credit cycle arises after a period of fully developed credit market. (ii) Consider all the states $x(0) \in \Delta$ such that $x(t) \in D' = \{x \in D : x_{21} \leq \hat{x}_21\}$ for some $t \geq 0$. Apply the argument in (i). □

Figure 4 shows a simulation with replicator dynamics.[2] Under replicator dynamics the rate of growth of population share x_{ih} is given by

$$g_{ih}(x) = (\pi_{ih}(x) - \bar{\pi}_i(x))\forall i \in \{1,2\}, h \in S_i, x \in \times\Delta_i$$

where $\bar{\pi}_i(x)$ is the average payoff in population i. All strategies which get a higher than average payoff have positive rates of growth and those with higher payoff grow faster. The mixed equilibrium is a center point which is neutral, neither asymptotically stable nor unstable (see Hofbauer and Sigmund (1988)).

Consider a state such as a in figure 4 with a high proportion of good borrowers and nonmonitored loans. Under monotonous dynamics both S and N will grow: in a population with many good borrowers from the lenders' point of view it is better to grant loans

[2]Justifications to the use of the replicator dynamics to the modelling of learning are found in Cabrales (1992), Binmore and Samuelson (1993b), Börgers and Sarin (1994) and Schlag (1994) . See Samuelson and Zhang (1992) for the properties of replicator dynamics which are shared by monotonous dynamics.

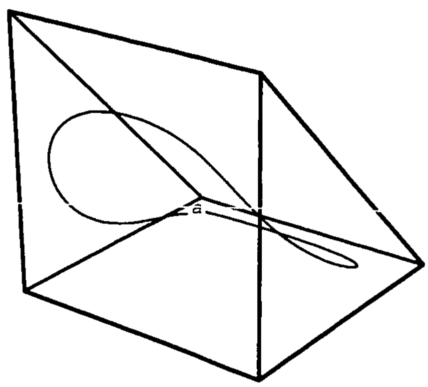

Figure 4: A credit cycle.

without paying the monitoring costs while when there is little risk of being caught cheating is better. The system will move East and reach states characterized by a high rate of cheating and bankruptcy. In those states the outside option turns out to be relatively profitable and the system falls into a progressive credit crunch. Notice, however, that this process does not lead to the complete disappearance of credit activity. It is destined to revert to a new stage of credit expansion accompanied by a reduction of the rate of bankruptcy.

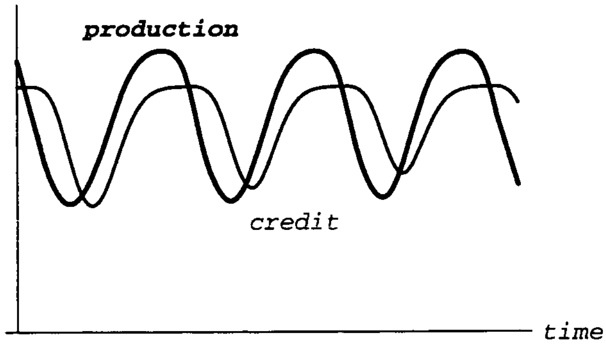

Figure 5: Credit and economic activity.

Figure 5 shows the behaviour of the credit and the economic activity. Observe that the financial system responds to the aggregate output. The economic activity starts recovering before the credit market because of a change in the composition of the credit. The increase of the relative proportion of monitored loans incentives the good behaviour which enhances the probability of a succesful investment. The expansion of the credit market, however, is always accompanied by economic recovery.

3. REAL SHOCKS AND THEIR PROPAGATION

The Great Depression of 1929 originated in a real shock of the economy which was dramatically amplified by the subsequent reaction of the financial sector. The initial fall in output was magnified by a subsequent period of credit contraction, in which banks switched out of loans and into more liquid investments. Bernanke observes that "credit outstanding declined very little before October 1930, this despite a 25 percent reduction in industrial production that had occurred by that time. With the first banking crisis of November 1930, however, a long period of credit contraction was initiated. ... In October 1931 ... the net credit reduction was a record 31 percent of personal income" (p. 303). The response of the banks to the crisis and the increasing number of defaults was not to make loans to some people that they might have lent to in better times. "...the extraordinary rate of default on residential mortgages forced banks and life insurance to practically stop making mortgage loans... This situation precluded many borrowers, even with good projects from getting funds ... Money (was) available in great plenty for things that are obviously safe, but not available at all for things that are in fact safe, and which under normal conditions would be entirely safe, but which are now viewed with suspicion by lenders..."

Corollary 1 relates real shocks with the dynamic behaviour of the economy. We assume that shocks change the payoffs matrix without altering the topological properties of the equilibria, i.e conditions (c.1)-(c.4) hold for the new payoffs. Let $x^*(A)$ and $\hat{x}(A)$ be x^* and $\hat{x}$ when the payoff matrix is A. Corollary 2 considers productivity shocks, namely a fall in the probability of success of each project regardless of the effort exerted π (alternatively we could consider α). It formalizes in an evolutionary fashion Bernanke's ideas about the relation between real and financial crises as well as his interpretation of the persistence of the crisis. The results are true for both, permanent and transitory shocks.

COROLLARY 1. *Let us assume a shock that changes the payoff matrix from M to M' then, if $x^*(M) \leq \hat{x}(M')$ the shock generates credit cycles and fluctuations of the economic activity for all monotonous dynamics.*

Proof. This is a straightforward implication of proposition 1: assume that $x(0) = x^*(M)$ and that at some $t > 0$ the payoff matrix is M'. □

Let us consider now a productivity shock which only affects the probability π of success of a project.Let π_0 be the initial probability of success of a project and let $\tau\pi_0$ be the post shock probability.

COROLLARY 2. *For any payoff matrix A satisfying $(c.1) - (c.4)$, there exists a $\bar{\tau}_A \in (0,1)$ such that all productivity shocks such that $\tau < \bar{\tau}_A$ generate credit cycles for all monotonous dynamics .*

Proof. It follows from corollary 1 and the fact that $\delta \hat{x}_{21}/\delta\pi < 0$. □

Figure 6 shows a simulation in which the initial equilibrium a becomes unstable after the shock. Credit cycles are observed before the economy reaches a new long run equilibrium with higher proportion of monitored loans and of 'good' borrowers. Observe that the new mixed equilibrium is asymptotically stable in the face D.

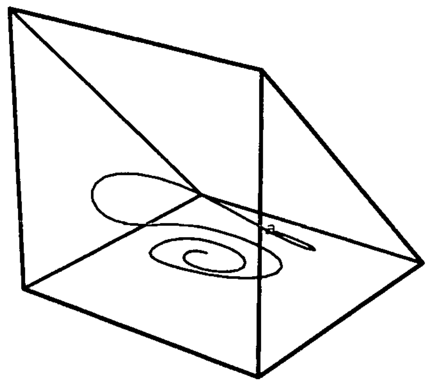

Figure 6: Post-shock dynamics.

Figure 7 shows the dynamics of the credit and the economic activity. Observe that the period of recession is observed during the process of adjustement towards the post-shock Nash equilibrium.

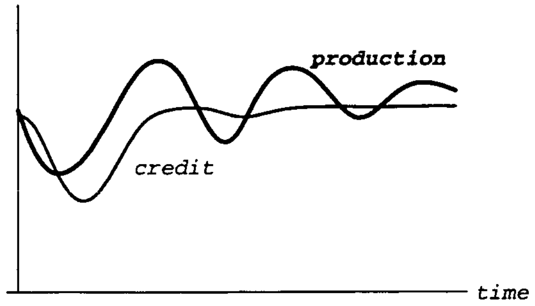

Figure 7: Credit and real activity

4. CONCLUSIONS

In this paper we have developed an evolutionary model of a credit market which predicts periods of credit rationing followed by periods of full credit activity. Credit rationing is explained as a non-equilibrium phenomenon within an evolutionary framework with exogenous real shocks. In particular, credit crunches are observed during the process of adjustment towards the post shock equilibrium.

Although the evolutionary elements of the model are not very realistic whenever long-term relations are important, we have argued, in line with Bernanke (1983) that such long-term relations are of little importance in significant segments of the credit market where information about agents' past behaviour is either inexistent (newcomers) or unreliable. An example of such a market is the market for loans to new investors and small firms.

A limitation of our model is the lack of a explicit role for financial intermediation. In our simplified set-up each lender finances, under direct lending, a whole project. In Williamson (1986) financial intermediators arise because with direct lending there is a duplication of monitoring costs. Each borrower borrows from several lenders, and each of them monitors in case of default. Although our model could be extended to consider more explicitly this aspect of 'delegated monitoring' we believe that the extension would not change the main results of the paper.

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