# Restrictions on Interest and the Evolution of Trust

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This paper provides an explanation for prohibitions on the taking of interest that are found in many traditional societies. When legal enforcement of contractual performance is nearly absent, as it is in traditional societies, transactions must be based on trust. Trust, in turn, requires a "nucleus" of agents (called "reciprocators") who honor trust even when their material incentives favor reneging, in order for the remaining, opportunistic agents to develop reputations for being the desired, reciprocator type. This paper endogenizes the proportion of reciprocators in a traditional community in the framework of an infinitely repeated game, using an evolutionary approach. The game played by members of the community is composed of two, interlinked games: a market transaction game and a loans game. In each stage of their careers, players decide (a) whether to honor trust in their market transactions, (b) whether to loan funds without interest to other agents undergoing "bad" time periods, and (c) whether to repay loans that they have taken. It is shown that the evolutionary stability of the reciprocator type is enhanced if individuals are required, by a *self-enforcing* social norm, to give interest-free loans to others in times of need, since the granting of loans can signal that the lender is not an opportunist. The loans game relies on the market transaction game to ensure that loans are repaid, while trust in the market transaction game is enhanced when the loans game is played in conjunction with it.

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Prohibitions on interest are a common feature of traditional societies.[1] Such restrictions are puzzling to an economist. Just as in the case of a price ceiling in a market for a good or service, bans on the taking of interest would seem to be inefficient: they would create an excess demand for loanable funds. The present paper proposes an explanation for prohibitions on interest that explicates why, in traditional societies, the inefficiency of such restrictions is likely to be outweighed by benefits to the stock of "social capital" crucial to the operation of the economic system.

In a fascinating contribution, Posner (1980) addressed the fact that interest is often banned in what he called "primitive" societies. Posner proposed that prohibitions on the taking of interest are part of a primitive form of insurance. Posner emphasized that traditional societies lack a sophisticated legal system that would permit the operation of large, impersonal insurance companies. Additionally, the means of storing produce from "good" to "bad" years, he argued, are often absent in such societies, and there is a lack of durable goods for which "surplus" agricultural produce can be traded. In the absence of insurance firms and adequate means of storage, a farmer having an unusually good year would have more produce than he and his family would want to consume, or, more precisely, the marginal utility of such consumption is likely to be very low, relative to that of consumption in a bad year. Thus such a farmer would be interested in lending produce to another farmer having a bad year, in return for an obligation to return the favor when the fortunes of the two farmers are reversed. Given the low marginal utility of consuming produce in a good year relative to the farmer's anticipated marginal utility of consuming such produce in a bad year, a zero interest rate may have only a negligible effect on the availability of produce to be lent to farmers having bad years.

Posner's explanation leaves a number of important questions unanswered. First, according to his theory, a zero interest rate is close to the market-clearing rate. Why, then, is interest *prohibited* by the norms or legal systems of major religions and in traditional societies? A prohibition would seem to be understandable only if there are individual incentives to take interest, while Posner's explanation suggests that farmers having good years might even be willing to lend produce at a *negative* rate of interest.[2]

[1] See, e.g., the discussion in Glaeser and Scheinkman (1998).

[2] To add credence to his (implicit) claim that the equilibrium rate of interest in traditional societies may be zero or even negative, Posner points to institutions of gift-giving, such as the American Indian potlatch. As he writes (p. 14),

Second, there is the enforcement problem connected with such an informal insurance scheme. As Posner acknowledges (p. 17),

> The system of reciprocal exchange, as we may describe the network of institutions described above for allocating a food surplus in a primitive society, would appear to be a fragile one because there are no legal sanctions for failure to reciprocate promptly and adequately for benefits received.

To solve this problem, Posner points to the fact that traditional societies are geographically immobile, so that the "game" played by village members is a repeated game with a long time horizon. Posner does not explain how, precisely, this immobility solves the enforcement problem. As is well known, in repeated games with a sufficiently uncertain endpoint, mutual cooperation is only one of a multitude of equilibria. If, on the other hand, the endpoint of a given player's "career" is known with sufficient certainty, backwards induction leads to the prediction that opportunistic players will always cheat (fail to reciprocate).

This paper develops an approach to understanding prohibitions on interest in traditional societies, which builds on Posner's theory but answers the questions posed above. In the model developed here, members of a traditional community play an infinitely repeated game with incomplete information. Agents may be either "opportunistic types" or "reciprocator types." The repeated game has either a unique Perfect Bayesian Equilibrium or a small number of equilibria, in which loans are granted as signals of an agent's trustworthiness. Without the repeated-game structure of the model, loans would not be granted, i.e., the market-clearing interest rate is positive. The role of *prohibitions* of interest is to "load" the act of giving a loan with signaling value. Unlike standard models of asymmetric information, the proportions of reciprocators and opportunists in the community are endogenized in an indirect evolutionary model, and it is shown that the interest-free loan system of a traditional community enhances the evolutionary stability of the reciprocator type, thus facilitating trust in regular market transactions.

Section 1 sets out the assumptions of the model. Section 2 solves the model for a given population mixture of reciprocators and opportunists. Sec-

[I]n a society where consumption goods are limited in variety and durability, giving away one's surplus may be the most useful thing to do with it...

tion 3 endogenizes the proportion of reciprocators in an evolutionary model, and Section 4 offers concluding comments.

# 1 Assumptions

## 1.1 Market Transactions

Consider a community of agents. Time is discrete, indexed by $t = 0, 1, 2, ..., \infty$.[3] In each of these periods, agents are randomly matched to play an extensive-form "trust game," which models a market transaction between a buyer and a seller, in which the costs of employing the legal system (if one exists) to enforce contractual performance are prohibitively high. Each agent plays this game once in each time period in the role of a buyer, and once in the role of a seller. The first mover in this game is the buyer, who decides whether to trust the seller and pay for a unit of some good or service that the seller undertakes to sell, or not to trust the seller. If the buyer does not trust the seller, the game ends at that point, and both agents receive a zero payoff. If, on the other hand, the buyer trusts the seller, the seller decides whether to exert a "high" level of effort, which ensures that the good or service will be of the agreed-upon quality, or to exert a "low" level of effort, in which case there is a probability $\theta \in (0, 1)$ that the good or service will be of low quality. Thus $\theta$ measures the "detectability" of the agent's cheating. If the seller exerts the high effort level and the good is high-quality, the seller receives a payoff $1 - e$ and the buyer receives a payoff of 1. If the seller cheats (exerts the low effort level), he or she saves effort whose cost is $e$, and thus his or her payoff is 1. If, in this case, the good is defective, the buyer receives a payoff of $-a$. The fact that the good delivered was defective then becomes known to all members of the community, from the next time period onward. The length of a time period is defined as the time required for information on an agent's past moves to become common knowledge to the entire community.[4]

[3] Strictly speaking, we cannot assume that agents have infinitely long lifetimes or "careers," since we will consider (in Section 3) the average payoffs of *generations* of agents, implying that they have finite lifetimes. We therefore are only assuming that agents behave *as if* they have infinite horizons, in order to simplify the analysis. This would be consistent with agents' having a random but finite lifespan, where their probability of survival into the next period is sufficiently high to make their optimal strategies similar to those of an infinitely repeated game.

[4] Throughout, we assume that members of the community have a great deal of information about each other's past behavior and current life circumstances. Posner (1980)

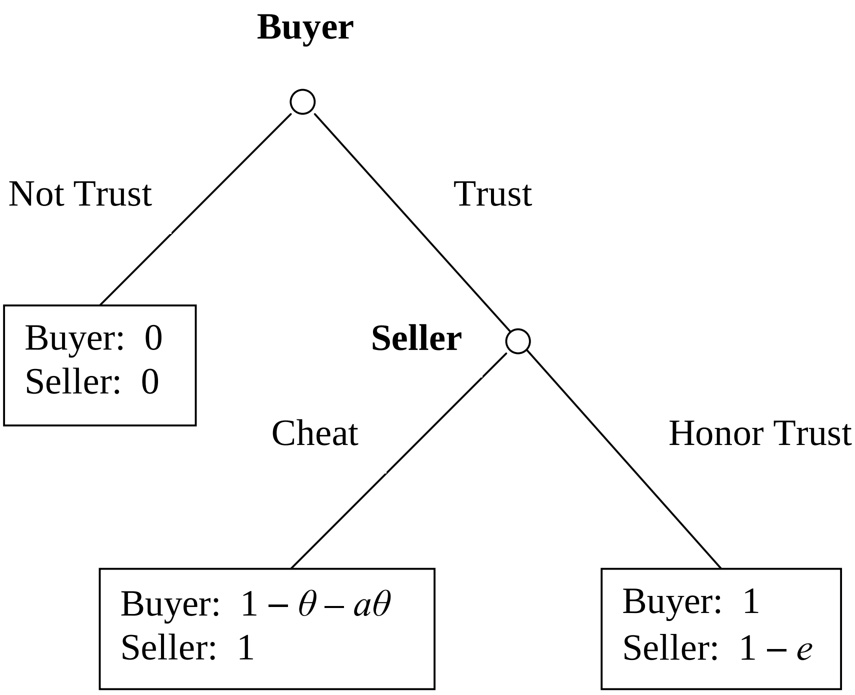


Figure 1: Market transaction trust game

If the good is nevertheless of high quality (which has a probability of $1-\theta$), the buyer receives a payoff of 1. Thus the buyer's expected payoff, if the seller cheats, is $1-\theta-a\theta$.

This market trust game is depicted in Figure 1. We assume that $1-\theta(1+a)<0$, so that the buyer, if he or she knew that the seller would cheat, would not trust the seller. Since the seller's optimal move is to cheat, the subgame perfect equilibrium of the (one-shot) game is that the buyer does not trust the seller, and both agents receive a zero payoff.

emphasizes that such information is indeed very complete. As he writes (p. 6),

> No matter what the ratio of territory to inhabitants is (and often it is very high), primitive people tend to live in crowded conditions where they are denied the preconditions of privacy—separate rooms, doors, opportunities for solitude or anonymity... The denial of privacy in a primitive society serves to enlist the entire population as informers and policemen.

The outcome just described is the subgame perfect equilibrium in a one-shot game, if the seller is known by the buyer to be an *opportunist type.* Such a type maximizes his or her expected (material) payoff. But we assume that there is a second type in the community as well, whom we call a *reciprocator type.* The reciprocator type "has a conscience," and therefore always honors trust (does not cheat). The buyer does not know the seller's type, but knows that a proportion $\alpha \in (0,1)$ of the community's agents are reciprocators, and a proportion $1-\alpha$ are opportunists.

The seller's cost of effort in producing the high-quality good, denoted above generically as $e$, is assumed to take two levels, $e_1$ and $e_2$, where $0 < e_1 < e_2 < 1$. Sellers for whom $e = e_1$ will be called "efficient" sellers, and sellers for whom $e = e_2$ will be called "inefficient" sellers.[5] As will be further detailed below, $e_2$ is assumed to be sufficiently high that an inefficient seller always optimally cheats, even in the infinitely repeated game that we model, while $e_1$ is sufficiently low that an efficient seller will optimally honor trust. The proportion of *all* agents who have $e = e_2$ is denoted $\beta \in (0,1)$. The distinction between these two types will be relevant only for opportunists, since reciprocators always honor trust. Buyers do not know whether sellers are efficient or inefficient, but they know the parameter $\beta$ for the community. Thus each agent's prior probability that a seller is an efficient opportunist is $(1-\beta)(1-\alpha)$, while his or her prior probability that a seller is an inefficient opportunist is $\beta(1-\alpha)$.

To keep the analysis in Section 2 tractable, we assume that agents have no information on how many periods a given seller has been in the community. (Such information, if possessed by buyers, could be used to update their prior beliefs that the seller is an opportunist.)

## 1.2 Loans

In each normal time period, agents have an endowment of $y$, all or part of which they can either consume or (if asked) lend to another agent. (This endowment is apart from the agent's payoffs in the market transaction trust game.) Each time period, however, has a probability $p$ of being a "bad"

[5] The partition of agents between efficient and inefficient types is introduced in order to have, in effect, three player types: (1) reciprocators, who never cheat, (2) efficient opportunists, who sometimes honor trust and sometimes cheat, depending on their incentives, and (3) inefficient opportunists, who always cheat. This three-way partition of player types follows Tirole (1996).

time period, in which the agent's endowment is reduced by $\lambda \in (0, y)$, by some unpredictable shock (e.g., a disease of the agent's crops or livestock). When an agent undergoes a bad time period, this is common knowledge to all agents.

If an agent undergoes a bad time period, he or she can ask other agents for interest-free loans. When an agent receives a loan from another member of the community, this fact becomes common knowledge to all community members, as does the size of the loan. The sum of the value of the loans which an agent who is undergoing a bad period can obtain, as determined by a social norm agreed upon by the members of the community, is $c \in (0, \lambda]$, and increases the borrower's income from the inefficient-period level of $y - \lambda$ to some minimally acceptable level $y - \lambda + c$. For simplicity, we assume that each loan must be repaid in the following time period under all circumstances. If the following time period is also a bad time period, the borrower can seek two sets of loans: one to repay the previous loans and a second set of loans to bring his or her current income up to $y - \lambda + c$. In the agent's first normal period after the string of bad periods, he or she must therefore repay two sets of loans. This will be feasible if the standard loan $c$ is no larger than one-third of $\lambda$.[6]

Agents who are asked to lend, and who (a) are not currently undergoing bad time periods and (b) did not undergo a bad period in the previous time period (in which case they are currently repaying debts), are considered to be obligated to grant such loans only if the lender is "deserving"—i.e., he or she is undergoing a bad time period, *and* has never defaulted on a loan. Agents refusing to lend are not punished by any direct sanctions. Nevertheless, the refusal to lend to a "deserving" agent signals that the agent is an opportunistic type, since reciprocators (driven by a desire to abide by

[6]Let $y_{\min} \equiv y - \lambda + c$, the minimum acceptable consumption level. If an agent can repay two loans in one normal time period, we have $y - 2c \geq y_{\min}$, implying $c \leq (y - y_{\min})/2$. From the definition of $y_{\min}$, we have

$$\frac{y - y_{\min}}{2} = \frac{\lambda - c}{2}.$$

It follows that

$$c \leq \frac{\lambda - c}{2},$$

and therefore $c \leq \lambda/3$, as claimed.

social norms of reciprocity) always grant loans when requested by deserving agents, when they themselves are not undergoing bad time periods.[7] This institution, in which agents not undergoing bad time periods lend to those who are undergoing such time periods, will be feasible if and only if $p \leq 1/2$; otherwise, there will not be enough funds to finance the loans to the agents undergoing bad time periods.

Since the costs of using the legal system to enforce the repayment of loans are prohibitively high, the loan transaction is also a "trust game." A lender, by granting a loan, is trusting the borrower that the loan will be repayed. The borrower can default on the loan, if he or she wishes. But if a borrower does not abide by the rules of repaying debts, this fact is immediately known to the entire community from the next period onward. In order to make this assumption realistic, we assume that there is a norm that limits the *number* of loans that a borrower can obtain, even when the sum of the loans is valued at $c$. This maximum number of loans plays no role in the model, but simply ensures that each loan is sufficiently "visible" that it is observed (and default on the loan is observed) by all members of the community. Consistent with the previous characterization of the two types (reciprocator and opportunist), reciprocators always uphold the above-specified rules of repaying loans, while opportunists repay loans when it "pays" in terms of maintaining their reputations.

Figure 2 depicts the loan trust game, where the size of the loan, for simplicity, is denoted by $c$.[8] If the potential lender chooses not to trust

[7] Posner (1980) also notes the fact that individuals in traditional societies are considered to be morally obligated to grant loans. Consider the following, acute observation (p. 15, italics in original):

> A "loan" in primitive society is often just the counterpart to the payment of an insurance claim in modern society—it is the insurer's fulfillment of his contractural undertaking and to allow interest would change the nature of the transaction. Also, custom may *require* a man to make a loan when requested. The involuntary loan is another dimension of the duty of generosity noted earlier.

[8] Since defaulting on any loan, even when its value is less than $c$, becomes known to all members of the community from the next time period onward, each loan "trust game" is identical, strategically, to one in which the agent obtains a single loan whose value is $c$. If an agent ever decides to default, he or she will optimally default on all loans in that time period (whose total value is $c$), since in any case his or her reputation will be ruined by defaulting on one loan.

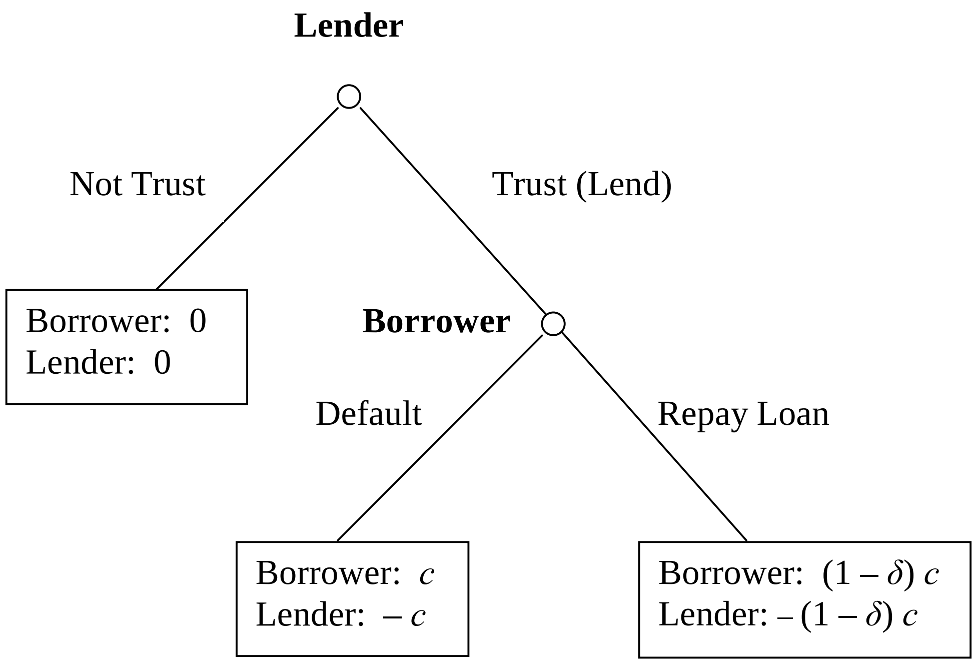


Figure 2: Loans trust game

the borrower, both agents receive a zero payoff. If the lender trusts the borrower and grants the loan at period $t$, the borrower can repay the loan at period $t + 1$ (assuming that period is a normal period), giving him or her a discounted net payoff, evaluated at $t$, of $c - \delta c$, where $\delta \in (0, 1)$ is the borrower's subjective discount rate (which is the same for all agents). In this case, the lender suffers a loss, in present-value terms, of $(1 - \delta)c$. Alternatively, the borrower can default, in which case the borrower's payoff is simply $c$ and the lender's loss is $c$. If the loan trust game were played as a one-shot game, an opportunistic lender's optimal strategy would be not to grant the loan and receive a zero payoff.

The game, however, is not one-shot. If an agent refusing to grant a loan signals he or she is an opportunist, then opportunistic lenders may optimally grant loans in order not to reveal their type. By revealing that they are opportunists, (a) they will not be trusted in their market transactions, and (b) they will not receive loans if they suffer bad periods themselves, in the future. As the analysis of the next section makes clear, under certain conditions these incentives will suffice to ensure that loans are granted by all agents, to deserving borrowers.

## 2 Analysis of the Game

In this section, we analyze the repeated game played by the members of the community. We begin with the market transaction game, in the absence of loans. We then introduce the loan component of the game. Our solution concept will be the Perfect Bayesian Equilibrium (PBE), and we consider only stationary and symmetric equilibria.

### 2.1 The Market Transaction Game

As we noted in the previous section, in a one-shot market transaction game, a buyer will not trust a seller known to be an opportunist. Given that a proportion $\alpha$ of the agents in the community are reciprocators, however, it may be rational to trust the seller even in a one-shot game.[9] If opportunists are expected to cheat, the buyer's expected payoff of trusting is

$$\begin{aligned} E\pi(trust) &= \alpha + (1-\alpha)(1-\theta-a\theta) \\ &= 1-\theta(1+a)+\alpha\theta(1+a). \end{aligned} \tag{1}$$

$E\pi(trust)$ will be non-negative if and only if

$$\alpha \geq 1 - \frac{1}{\theta(1+a)}.$$

We denote the r.h.s. of this weak inequality as $\alpha_{\min}$. Since we have assumed that $\theta(1+a) > 1$ (in order for it to be irrational to trust a seller who is known to be opportunistic), we have $\alpha_{\min} > 0$.

We first prove the following result.

**Proposition 1.** *If a seller ever sells a defective product, he or she will not be trusted, in equilibrium, in all further stages of his or her career.*

**Proof.** There are two types of equilibrium to consider, under the stationarity restriction imposed above: (a) efficient opportunistic types honor trust given them in all stages of their careers in the community; and (b) efficient

[9] Throughout, we analyze the conditions for trust from the *beginning* of the careers of a cohort or generation of agents. The conditions for trust become weaker as time progresses, since cheaters are gradually "weeded out" by having sold defective products.

opportunistic types cheat in all stages of their careers, as do inefficient opportunists (by definition). In case (a), if a player ever sells a low-quality product (which occurs with probability $\theta$ if he or she cheats), then he or she is revealed to be an inefficient opportunist. The expected payoff of buying from such an agent, given that he or she always cheats, is $1 - \theta - a\theta$, which is negative, by assumption. Therefore it will not be optimal to optimal to trust such an agent. Now consider case (b). If a player ever sells a low-quality product, he or she is revealed *not* to be a reciprocator. Again, the expected payoff of buying from such an agent, given that he or she always cheats, is $1 - \theta - a\theta$, which is negative, so that, again, it will not be optimal to trust such an agent. ¥

In the repeated market transaction game without loans, we will assume that buyers trust sellers as a pure strategy only if $\alpha \geq \alpha_{\text{min}}$. This condition will assure that the *unique* equilibrium of the repeated market transaction game is that buyers trust sellers, and *efficient* opportunistic as well as reciprocator types honor trust. This relatively severe equilibrium selection assumption, which ignores the existence of an equilibrium in which sellers are trusted even when $\alpha$ is less than $\alpha_{\text{min}}$,[10] is made in order to explain how a community with an arbitrarily small initial $\alpha$ can evolve to one in which $\alpha \geq \alpha_{\text{min}}$. As $\alpha \to 0$, the *only* equilibrium in the repeated market transaction game is one in which sellers are not trusted, provided that $\beta$ is not too low. A community whose $\alpha$ is initially too small to support trust seems unlikely to "jump" to an equilibrium supporting trust, if $\alpha$ were to increase sufficiently to support such an equilibrium, as long as the non-trust equilibrium still exists. Thus, in order to explain how a community whose proportion of reciprocators is too small to support trust can evolve into one with a larger $\alpha$ which supports trust, we ignore equilibria in which sellers are trusted if such equilibria are not unique. An implication of this assumption is: *known opportunists are not trusted.*

On the basis of Proposition 1, we can easily calculate the discounted expected payoffs, to an opportunistic seller, of either honoring trust or cheating throughout his or her career, assuming that he or she is trusted. The discounted expected payoff of honoring trust for an opportunist of type $i$ (where

[10] *If* efficient opportunists honor trust, a lower $\alpha$ will suffice to make it optimal for buyers to trust sellers. But this would not be the unique equilibrium. There would also be an equilibrium in which all opportunists cheat, and then (at this lower $\alpha$) it would not be rational to trust.

$i = 1$ for an efficient opportunist and 2 for an inefficient opportunist), is

$$E\pi(honor)_i = \delta^0(1-e_i) + \delta^1(1-e_i) + \delta^2(1-e_i) + \cdots = \frac{1-e_i}{1-\delta}, \quad (2)$$

since the stage payoff of honoring trust is $1-e_i$. The discounted expected payoff of cheating is

$$E\pi(cheat) = \delta^0(1-\theta)^0 + \delta^1(1-\theta)^1 + \delta^2(1-\theta)^2 + \cdots = \frac{1}{1-\delta(1-\theta)}, (3)$$

since there is a probability of $1-\theta$ that the opportunist's cheating at stage $t-1$ will not be detected, permitting him or her to continue cheating at stage $t$, and the stage payoff of cheating is $1$. If, at any stage, the seller sells a defective product, which occurs with probability $\theta$, he or she will not find buyers in the following stages (by Proposition 1). Therefore the probability that the seller who cheats will have a positive payoff at stage $t$ is $(1-\theta)^t$.

The critical $e$ that equates the r.h.s. of (2) to that of (3) is

$$\overline{e} \equiv \frac{\delta\theta}{1-\delta(1-\theta)}.$$

We assume that $e_1 < \overline{e} < e_2$. We then have

Proposition 2. *If $\alpha \geq \alpha_{min}$, all efficient opportunists (as well as reciprocators) will honor trust throughout their careers, in the unique stationary PBE of the repeated market transactions game without loans, and all inefficient opportunists will cheat.*

Proof. Since $e_1 < \overline{e}$, the r.h.s. of (3) is less than that of (2) for efficient opportunists. Therefore, the efficient opportunist will optimally honor trust, if he or she is trusted. The condition $\alpha \geq \alpha_{min}$ ensures that the seller will be trusted, even in a one-shot game. Thus efficient opportunists will honor trust, in equilibrium. Since $e_2 > \overline{e}$, the r.h.s. of (3) is greater than that of (2), and therefore inefficient opportunists will optimally cheat, in equilibrium. ■

## 2.2 The Loan Game

As noted in Section 1, the loan game, like the market transaction game, is a trust game. Thus, opportunistic agents will optimally default on their loans in a one-shot game. But if the game is repeated, it may be optimal to repay their debts, since by defaulting, they reveal their type as opportunists, and thus forgo future payoffs in market transactions as well as loans, given our assumption that agents are not trusted if they are known to be opportunists. Similarly, though in a one-shot game it is not optimal to give a loan, in the repeated game it may be optimal to do so, since an agent's refusal to give a loan to a "deserving" borrower signals that the agent is an opportunist.

Any stage $t$ of an agent's career has a probability $p$ of being a "bad" period. Asking for loans in such a period is always optimal, since the loan gives a net gain, evaluated at $t$, of $(1-\delta)c$ if all loans are repaid, and $c$ if they are not repaid.[11] Let us consider an equilibrium in which all agents who borrow never default, and all agents (who themselves are not undergoing bad periods) who are asked to lend to deserving borrowers grant loans. Thus a proportion $p$ of the agents in the community will ask for loans at any time period, and the remaining agents will be asked for loans, provided their previous periods were also normal periods. Agents falling into this category comprise a proportion $(1-p)^2$ of the community. Thus the value of loans requested, per period, from the average agent in the latter category is $cp/[(1-p)^2]$. The probability of being in a normal period that follows a normal period is $(1-p)^2$, so the expected per-period outlay on loans granted by agents who choose the strategy of granting loans is simply $(1-p)^2[cp/(1-p)^2] = cp$. Thus the discounted present value of the *cost of granting loans,* when requested, is $(1-\delta)cp[\delta^0+\delta^1+\delta^2+\cdots] = cp$, since the present value of the cost of granting a loan of $c$ that will be repaid is $(1-\delta)c$. Since the agent has a probability $p$ of being in a bad period in each stage of his or her career, and the present value of receiving a loan of $c$ and repaying it is $(1-\delta)c$, the discounted expected *value of receiving loans* is $(1-\delta)cp[\delta^0+\delta^1+\delta^2+\cdots] = cp$, which exactly equals the discounted present value of the cost of granting loans.

If the loan game is considered in isolation of the market transactions game, however, it is not optimal for an opportunist to *repay* loans, even when we take account of the effect of defaulting on his or her ability to receive loans in the future. At the agent's first bad period in the game, when he or she is deserving of receiving a loan, the benefit of receiving a loan and defaulting is simply $c$. Since the expected discounted value of taking loans (which becomes impossible after defaulting) exactly cancels the expected present value of the cost of giving loans, as we saw in the previous paragraph, there is a net gain of defaulting equal to $c$.

But given that the repeated loan game is played in conjunction with

[11] For simplicity of exposition, we will continue to treat an agent taking loans as if he or she were taking a single loan whose value is $c$.

the repeated market transaction game, the net expected benefit of granting loans and profiting from market transactions[12] may outweigh the net gain of defaulting, $c$. Suppose, for example, that all agents grant loans to deserving agents and repay their debts. If the agent honors trust in his or her market transactions, the expected present value of the market transactions is $(1 - e_i)/(1 - \delta)$, as calculated in Section 2.1, where $i = 1$ for efficient agents and 2 for inefficient sellers. Note, however, that this stream of benefits from repaying a loan begins only in time period following the stage at which the agent defaults. Thus the net present expected value to an efficient opportunist of granting loans, repaying them, and honoring trust, will be non-negative if and only if

$$E\pi(honor \wedge loan)_1 = \frac{\delta(1 - e_1)}{1 - \delta} - c \geq 0,$$

or, equivalently,

$$c \leq \frac{\delta(1 - e_1)}{1 - \delta}. \tag{4}$$

Let us define (4) as *Condition A*.

In order for it to be rational for an efficient opportunist to grant loans, repay them, and honor trust, Condition A must hold. Since the inefficient opportunist's expected present value of cheating is (as shown in Section 2.1) $1/[1 - \delta(1 - \theta)]$, and this stream of benefits begins in the period following the stage at which the agent defaults, inefficient opportunists will optimally grant loans if and only if

$$E\pi(cheat \wedge loan) = \frac{\delta}{1 - \delta(1 - \theta)} - c \geq 0. \tag{5}$$

Let us denote (5) as *Condition B.*

Conditions A and B, however, are not quite sufficient to establish the existence of a PBE in which all agents grant and repay loans. It also must be rational to trust (with probability one)[13] a randomly drawn agent in market transactions, which presupposes (given our assumption that trust will be

[12] Recall that an agent who defaults on a loan, or refuses to grant a loan to a deserving borrower, reveals that he or she is an opportunist, and thus will not be trusted in market transactions.

[13] The parenthetical qualification is inserted here in order to allow for less-than-probability-1 trusting to optimal even when $\alpha < \alpha_{min}$, as will be shown below.

granted only if the equilibrium in which agents trust and honor trust is the unique PBE of the market transactions game) that $\alpha \geq \alpha_{\mathsf{min}}$. We then have

Proposition 3. *If $\alpha \geq \alpha_{\mathsf{min}}$ and Conditions A and B hold, there exists a PBE in which all agents grant loans and repay them.*

This, however, is the unique PBE of the combined loans-market transactions game only if $\alpha \geq \alpha_{\mathsf{min}}$ and Conditions A and B hold. If either Condition A or Condition B does not hold, we obtain different equilibria. We consider the possible cases in turn.

- If only *efficient* opportunists grant loans in equilibrium (together with all reciprocators), the subpopulation of agents who will grant loans is $[\alpha + (1-\beta)(1-\alpha)](1-p)^2$, rather than $(1-p)^2$ as we calculated when all agents were assumed to grant loans. Any agent who does not grant loans will not be able to request them,[14] so that the proportion of agents requesting loans in an average time period is $[\alpha + (1-\beta)(1-\alpha)]p$. Thus the cost to the average agent asked for a loan is $cp/(1-p)^2$, as in the case analyzed above. As before, the agent's probability of being in the second of two consecutive normal periods (and thus being obligated to grant loans) is $(1-p)^2$, so that the expected per-period cost of granting loans is still $cp$. Thus the discounted expected *cost* of the strategy of granting loans (assuming all borrowers repay loans) remains equal to $\sum_{t=0}^{\infty} \delta^t (1-\delta) cp = cp$. The discounted expected *benefit* of honoring trust, granting loans, and repaying them is $cp + \delta(1-e_1)/(1-\delta)$, so that the discounted expected payoff of this strategy (netting out the one-time benefit of taking a loan and defaulting) is

$$E\pi(honor \wedge loan)_1 = \frac{\delta(1-e_1)}{1-\delta} - c,$$

which will be non-negative if Condition A holds. In order for inefficient opportunists *not* to grant loans in equilibrium, however, we also require that

$$E\pi(cheat \wedge loan) = \frac{\delta}{1-\delta(1-\theta)} - c < 0$$

[14] We are here abstracting from the possibility that an agent will not be asked for a loan for a number of time periods, and thus will not reveal the fact that he or she is not willing to grant loans. The population of agents asking for and granting loans will take some time to contract to the proportion $[\alpha + (1-\beta)(1-\alpha)]$ of the entire community. We are thus analyzing the equilibrium that is reached after this "contraction" process is completed.

or, equivalently,

$$c > \frac{\delta}{1 - \delta(1 - \theta)}. \tag{6}$$

Denote (6) as *Condition C.*

Finally, in this case, we require that the reciprocators and efficient opportunists, who grant loans, be trusted in their market transactions with probability 1. Since the fact that an agent grants loans now reveals that he or she is not an inefficient opportunist, this will allow players to revise their prior probability $\alpha$ that the agent is not an opportunist. Using Bayes' Theorem, the buyer's posterior probability that an agent, who gives loans, is a reciprocator is $\alpha/[\alpha + (1 - \alpha)(1 - \beta)]$. We thus obtain

**Proposition 4.** *If Conditions A and C hold, and if*

$$\frac{\alpha}{\alpha + (1 - \alpha)(1 - \beta)} \geq \alpha_{\min}, \tag{7}$$

*then there is a PBE in which reciprocators and efficient opportunists, but not inefficient opportunists, grant and repay loans, and are trusted in their market transactions.*

Note that (7) will hold if and only if

$$\alpha \geq \frac{\alpha_{\min}(1 - \beta)}{1 - \alpha_{\min}\beta}. \tag{8}$$

Let us denote the r.h.s. of (8) as $\overline{\alpha}$.

Note that the opposite case, in which Condition B holds, but

$$E\pi(honor \wedge loan)_1 = \frac{\delta(1 - e_1)}{1 - \delta} - c < 0, \tag{9}$$

cannot occur, since

$$\frac{1 - e_1}{1 - \delta} > \frac{1}{1 - \delta(1 - \theta)}. \tag{10}$$

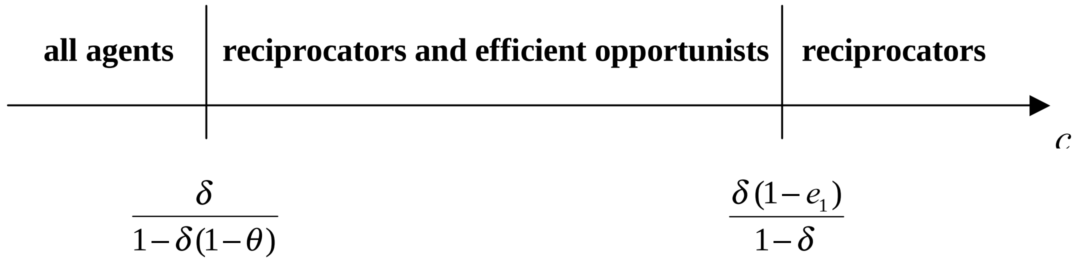


Figure 3: Agents granting and not granting loans in equilibrium

- Let us denote (9) as *Condition D*. If Conditions C and D hold, only reciprocators grant loans in equilibrium. In this equilibrium, the fact that an agent grants loans is a clear signal that he or she is a reciprocator, so that there is no restriction, regarding $\alpha$, for this equilibrium to exist. We thus have

  **Proposition 5.** *If Conditions C and D hold, only reciprocators grant loans, repay them, and are trusted in their market transactions, in equilibrium.*

Figure 3 summarizes our results so far. The figure, which assumes that $\alpha \geq \alpha_{\mathsf{min}}$, illustrates the dependence of the equilibrium in the loan game on the size of the standard loan, $c$.

Finally, we must consider the case in which agents who grant loans are *not* trusted with probability 1, since $\alpha$ is too low to support such trust. In this case, we have a mixed-strategy equilibrium, in which opportunists grant loans with probability less than one, and agents who grant loans are trusted with probability less than one. To see why a pure-strategy equilibrium cannot exist in this case, suppose that initially only reciprocators grant loans. Then the act of granting loans would be a sure sign that the lender is a reciprocator, and opportunists as well would optimally grant loans,[15] in order to acquire the trust of buyers—trust which they would not otherwise obtain, since $\alpha < \alpha_{\mathsf{min}}$. But then the act of granting loans would no longer be a signal that the lender is not an opportunist, and buyers would not trust sellers even if they grant

[15] We are assuming here that Condition A and either Condition B or Condition C hold.

loans. Again, the only lenders would be reciprocators, and we return to where we started. Thus a pure-strategy equilibrium would not exist.

Suppose first that Conditions A and B both hold. Let $\rho$ be the probability that agents are trusted if they grant loans, in a mixed-strategy equilibrium. Then the net discounted expected payoff to the efficient opportunists of granting loans, repaying them, and honoring trust becomes

$$E\pi(honor \wedge loan)_1 = \frac{\delta(1 - e_1)\rho}{1 - \delta} - c. \tag{11}$$

Similarly, the corresponding net discounted expected payoff to the inefficient opportunists is

$$E\pi(cheat \wedge loan) = \frac{\delta\rho}{1 - \delta(1 - \theta)} - c. \tag{12}$$

In a mixed strategy equilibrium, one of these expressions is zero, so that the opportunist of the relevant type is indifferent between granting loans and not granting them (and thus receiving a zero payoff). The other expression will then be either positive—in which case the relevant type of opportunist always grants loans in equilibrium—or negative, in which case he or she never grants loans.

Given inequality (10), there are, in general, two mixed strategy equilibria, one of which making (11) equal to zero and (12) negative, and the other making (11) positive and (12) equal to zero. For each of these equilibria, there is a critical probability that an opportunist of each type (efficient or inefficient) grants loans, such that the posterior probability that an agent, who grants loans, is not an opportunist makes the r.h.s. of (1) equal to zero, where $\alpha$ in that equation is replaced by the relevant posterior probablity. Then buyers are indifferent between trusting and not trusting, allowing them to randomize in their decision whether to trust, in equilibrium. Let $\gamma_1$ be the probability that efficient opportunists grant loans in this equilibrium, and $\gamma_2$ be the corresponding probability that inefficient opportunists grant loans. Denote the probability that an opportunist of unknown type (efficient or inefficient) will grant a loan as

$$\Pr(loan\,|O) \equiv \gamma_1(1 - \beta) + \gamma_2\beta. \tag{13}$$

Then the buyer's posterior probability that the seller is a reciprocator, if the seller grants loans, is equal to $\alpha_{\min}$ if and only if

$$\frac{\alpha}{\alpha + (1 - \alpha)\Pr(loan\,|O)} = 1 - \frac{1}{\theta(1 + a)},$$

or, equivalently,

$$\Pr(loan\,|O) = \frac{\alpha}{(1-\alpha)[\theta(1+a)-1]}. \tag{14}$$

Recall that $\theta(1+a) > 1$ by assumption, so that $\Pr(loan\,|O)$ is positive. Thus, if $\gamma_1 = 1$ [efficient opportunists always grant loans, which would occur in equilibrium if (11) is positive and (12) is zero], we have [substituting the r.h.s. of (13) into (14) and solving for $\gamma_2$]

$$\gamma_2 = 1 - \frac{1}{\beta}\left(1 - \frac{\alpha}{(1-\alpha)[\theta(1+a)-1]}\right). \tag{15}$$

Denote the r.h.s. of (15) as $\overline{\gamma_2}$. Note that, for sufficiently small $\beta$, the r.h.s. of (15) will be negative, making this equilibrium unattainable. The other equilibrium is where $\gamma_2 = 0$ [i.e., (11) is zero and (12) is negative] and, by a similar calculation,

$$\gamma_1 = \frac{\alpha}{(1-\alpha)(1-\beta)[\theta(1+a)-1]}. \tag{16}$$

Denote the r.h.s. of (16) as $\overline{\gamma_1}$.

Now suppose that only Conditon A holds, but Condition B does not (i.e., Condition C holds). Then, by Proposition 4, if $\alpha \geq \overline{\alpha}$, there is a pure-strategy equilibrium in which only reciprocators and efficient opportunists grant loans. If, on the other hand, $\alpha < \overline{\alpha}$, we again obtain a mixed-strategy equilibrium, but one in which $\gamma_2 = 0$. Thus, by the above argument, $\gamma_1 = \overline{\gamma_1}$ in this equilibrium.

We then have

Proposition 6. *If $\alpha < \alpha_{\min}$ and Conditions A and B hold, there is at least one mixed-strategy equilibrium. In one such equilibrium, $\gamma_1 = \overline{\gamma_1}$ and $\gamma_2 = 0$. There may be an additional equilibrium in which $\gamma_1 = 1$ and $\gamma_2 = \overline{\gamma_2}$. If $\alpha < \overline{\alpha}$ and Conditions A and C hold, there is a unique mixed strategy equilibrium in which $\gamma_1 = \overline{\gamma_1}$ and $\gamma_2 = 0$.*

## 3 Endogenizing the Proportion of Reciprocators

We now investigate how the proportion of reciprocators, $\alpha$, is determined endogenously in the framework of an "indirect" evolutionary model.[16] The

[16] The idea of using an evolutionary process to determine the preferences of individuals seems to have been suggested first by Michael and Becker (1973) and Becker (1976). Formal

term "indirect" distinguishes the type of evolutionary model developed here from conventional evolutionary models, in the tradition of Axelrod (1981), which define agent types in terms of "wired-in" strategies. The indirect evolutionary approach, in contrast, assumes that agents choose strategies that maximize their expected payoffs, as in standard economic models. Agent types are defined by the preferences, not by their strategies, and the evolutionary process determines the proportions of these types in the population given their relative material success (fitness). Thus a given agent has wired-in *preferences*—again, as in standard economic models—and not a wired-in strategy.

We assume that agents raise children in the first $T$ stages of their careers, and that the probability that a child will acquire a given type (reciprocator or opportunist) depends on the relative undiscounted *material* expected payoffs of the two types.[17] Let $r_g$ be the proportion of reciprocators in generation $g$. Let $E\pi_i$ ($i = R, O$) denote the undiscounted expected material payoff of type $i$ over the first $T$ stages of the agent's career, where $R$ denotes the reciprocator type, and $O$ denotes the opportunist type. [We use *undiscounted* payoffs for these calculations, since agents' discounting reflects their subjective time preference,[18] and this is irrelevant to their "fitness" (time preference is an aspect of utility functions, not material payoffs).] Then our assumption is that

$$r_g - r_{g-1} = f(E\pi_R - E\pi_O),$$

where $f(0) = 0$ and $f'(\cdot) > 0$.

models adopting this approach include Frank (1987, 1988), Hansson and Stuart (1990), Güth and Yaari (1992), Rogers (1994), Güth (1995), Bester and Güth (1998), Fershtman and Weiss (1998), Huck and Oechssler (1999), Guttman (2000, 2001, 2003).

[17] See Guttman (2003) for a brief discussion of the two basic mechanisms by which this evolutionary selection process may operate. They are: (a) biological selection [which assumes that relatively (materially) successful parents raise relatively large numbers of children] and (b) cultural evolution, in which parents try to instill preferences in their children that lead to higher lifetime material payoffs, or children "wire themselves" into such preferences. On the latter, see Boyd and Richerson (1985).

[18] The discount parameter $\delta$ may also measure the agent's probability of surviving into the next time period. For simplicity we assume that the probability of survival is close to unity, so that this aspect of discounting may be ignored. For an evolutionary model of how time preferences are determined, see Rogers (1994). For a non-evolutionary approach, see Becker and Mulligan (1997). Both approaches suggest that time preferences will not be neutral.

Since reciprocators and *efficient* opportunists both honor trust, they will receive identical expected payoffs if the efficient opportunists—like the reciprocators—grant and repay loans. If, on the other hand, the opportunists default on the first loan that they take (and this will be optimal—given their non-neutral time preference—if it is optimal to default at all), then the opportunists will have a different expected payoff. This expected payoff can be calculated as follows. In each stage, the opportunist has a probability $p$ of having a bad year. In the first such bad year that the agent undergoes, he or she takes loans and defaults, giving a payoff of $c$. In the periods preceding the agent's first bad year, he or she lends to other agents (in order to maintain his or her reputation for being a reciprocator). According to our calculations of the previous section, the per-period expected cost of lending is $(1-\delta)cp$, assuming that borrowers repay loans. (We ignore the possibility that the borrower defaults, since the effect of such defaulting on the lender's lifetime payoff will be identical for the reciprocators and opportunists, and thus does not affect $E\pi_R - E\pi_O$.) However, we are now interested in the agent's *undiscounted* expected payoffs, which are equivalent to setting $\delta = 1$. Thus, since the agent will not lend in his or her first bad period (after which he or she defaults), the undiscounted expected cost of lending is zero. The payoff of an efficient opportunist in each stage that he or she honors trust in his or her market transactions is $1 - e_1$. Finally, the opportunist's payoffs after defaulting are zero, since he or she will not find buyers or lenders, having revealed his or her type as an opportunist. Thus the undiscounted expected payoff of this strategy, for $T$ periods, is

$$\begin{aligned}\overline{E\pi}(\textit{honor} \wedge \textit{default}) &= (1 - e_1 + cp)[(1-p)^0 + (1-p)^1 + (1-p)^2 + \cdots + (1-p)^T] \\ &= \frac{(1 - e_1 + cp)[1 - (1-p)^T]}{p}.\end{aligned}$$

(The bar above $E\pi$ indicates that this is an undiscounted expected payoff.) The reciprocator's expected payoff, over the same $T$ periods, is simply $(1 - e_1)T$, since the expected costs and benefits of lending and borrowing (and repaying) cancel out, as noted in Section 2.

$E\pi(\textit{default} \wedge \textit{honor})$ is an increasing, but concave function of $T$, asymptotically approaching a limit of $(1 - e_1 + cp)/p$. In contrast, the reciprocator's expected payoff, over the same $T$ periods, increases linearly with $T$. Thus there is a maximum $T$, above which the reciprocator's undiscounted expected payoff exceeds that of the efficient opportunist who defaults at his or her first opportunity.

Similarly, if the opportunist cheats in his or her market transactions, but lends, borrows, and repays loans, he or she receives a payoff of unity with a probability of $(1-\theta)^t$ in stage $t$. The net expected cost of lending, borrowing, and repaying loans, is zero, as noted above. Thus the opportunist's undiscounted expected payoff is

$$\begin{aligned}\overline{E\pi}(cheat \wedge loan) &= (1-\theta)^0 + (1-\theta)^1 + (1-\theta)^2 + \cdots + (1-\theta)^T \\ &= \frac{1-(1-\theta)^T}{\theta},\end{aligned}$$

which approaches a limit of $(1/\theta)$. Therefore there is a maximum $T$, above which a reciprocator who honors trust, lends, and repays loans, has a higher expected payoff than an opportunist who cheats but lends and repays loans.

Finally, the undiscounted expected payoff of an opportunist who cheats in his or her market transactions, and defaults at the first opportunity to do so, is

$$\begin{aligned}\overline{E\pi}(cheat \wedge default) &= (1+cp)[(1-p)^0(1-\theta)^0 + (1-p)^1(1-\theta)^1 \\ &\quad + \cdots + (1-p)^T(1-\theta)^T] \\ &= \frac{(1+cp)[1-(1-p)^T(1-\theta)^T]}{1-(1-p)(1-\theta)},\end{aligned}$$

which approaches a limit of $(1+cp)/[1-(1-p)(1-\theta)]$.

Therefore, for sufficiently large $T$, reciprocators will have higher undiscounted expected payoffs than opportunists who cheat in their market transactions, default on their debts, or both. Opportunists optimally cheat and/or default due to their discounting of future payoffs, but the evolutionary fitness of an agent depends on his or her undiscounted payoffs.

Observe that under none of the conditions studied in Section 2 (which cover all the logical possibilities), do *all* opportunists honor trust in their market transactions, grant loans, and repay their debts, in equilibrium. Inefficient opportunists either (a) are not trusted in their market transactions (after having defaulted on the first loans that they take) and do not grant loans, or (b) they are trusted since they repay loans, but cheat in their market transactions. If $\alpha < \alpha_{\min}$ and Condition A holds, inefficient opportunists may mix between strategies (a) and (b) (Proposition 6). If Conditions C and D hold, efficient opportunists, as well, do not repay loans and thus are not trusted after they default. Therefore the undiscounted *average* expected payoff of the opportunists (i.e., averaged over the two types of opportunists) is always less than that of the reciprocators, for sufficiently large $T$. We thus obtain

**Proposition 7.** *In the combined free-loan/market-transaction game, for sufficiently large T,* $E\pi_R > E\pi_O$, *implying that* $\alpha$ *will approach unity over time.*

In order to understand the effect of the free-loan system on the evolutionary stability of the reciprocator type, let us consider again a community in which this loan system is absent, and the market transactions game is the only game played by the members of the community. In Section 2, we found that if $\alpha < \alpha_{min}$, no agents are trusted in the game without loans. In contrast, by Proposition 2, if $\alpha \geq \alpha_{min}$, only reciprocators and efficient opportunists honor trust, while inefficient opportunists cheat, in equilibrium. The undiscounted expected payoff of the inefficient opportunists would then be

$$\overline{E\pi}(cheat) = (1-\theta)^0 + (1-\theta)^1 + (1-\theta)^2 + \cdots + (1-\theta)^T = \frac{1-(1-\theta)^T}{\theta},$$

which approaches a limit of $1/\theta$ as $T \to \infty$. Since the undiscounted payoff of the reciprocators (and efficient opportunists) is $(1-e_i)T$, which increases linearly with $T$, we again find that the average undiscounted payoff of the reciprocators will be higher than that of the opportunists for sufficiently large $T$. We thus obtain

**Proposition 8.** *In a community which plays only the repeated market transactions game, for sufficiently large T, if* $\alpha \geq \alpha_{min}$, *then* $E\pi_R > E\pi_O$, *while if* $\alpha < \alpha_{min}$, $E\pi_R = E\pi_O = 0$. *Therefore,* $\alpha$ *will increase over time if it is initially at least equal to* $\alpha_{min}$, *for sufficiently large T.*

Comparing Propositions 7 and 8, we find that the difference in the evolutionary dynamics occurs only when $\alpha < \alpha_{min}$. In this region, without loans, all agents are not trusted and therefore have equal expected payoffs. When the free-loan system is introduced, $\alpha$ increases over time even in this region, since there is then a mixed-strategy equilibrium in which reciprocators receive higher average expected payoffs than opportunists, for sufficiently large $T$. We conclude that the institution of a prohibition on interest unambiguously enhances the evolutionary stability of the reciprocator type, if $T$ is sufficiently large.

Since Propositions 7 and 8 focus on the "large-$T$" case, two questions naturally arise. The first question is, can $T$ realistically be made arbitrarily large simply by reducing the length of time defined as one period? The answer to this question is negative. In Section 1, the time period was defined as the amount of time required for information of an agent's defaulting on loans, or selling defective products, to become known to the entire community. This suggests that, as information flows in the community become more rapid and thus the time period becomes shorter, $T$ will increase. There is a limit to this increase of $T$, however, posed by our implicit assumption that the event of a "bad" time period is statistically independent from one period to the next. This assumption becomes less realistic as the time period becomes shorter, since the various factors that lead to bad periods are not instantaneous: they continue over some period of time. Thus a more satisfactory definition of the length of a time period is the minimum of (a) the amount of time required for information of past defaulting or selling defective products to spread to the entire community, and (b) the minimum time period for which the event of having a bad period is statistically independent from one period to the next. Part (b) places an upper limit on $T$, even if information flows in the community are assumed to be instantaneous.

The second question is, how large must $T$ be, for reasonable parameter values, in order for Propositions 7 and 8 to apply? The answer, after considerable experimentation with parameter values, appears to be in the range of 5 to 15. Thus, if a time period is interpreted to be a year [and this seems fairly reasonable when we take account of factor (b) above], the reciprocators survive if the time period over which parents raise children is about 15 years or more. To illustrate, Figure 4 shows $\overline{E\pi}(cheat \wedge loan)$ as well as the expected payoff of the reciprocators, $(1 - e_i)T$, as functions of $T$ and $\theta$. The assumed value of $e_i$ is 0.5, implying that the payoff of exerting the "high" effort level, $1 - e_i$, is half the payoff of exerting the low effort level, 1. The sloped plane shows the expected payoff of the reciprocators. Note that $E\pi_R$ rises above $E\pi_O$ at fairly low levels of $T$, unless $\theta$ is extremely small.

The critical $T$ is not much different if we compare $\overline{E\pi}(cheat \wedge default)$ to the expected payoffs of the reciprocators, using the same assumed value for $e_i$. Figure 5 does this. The sloped plane is, again, the expected payoff of the reciprocators. Here, we must assume additional parameter values. The additional parameters are: $c = 2$ and $p = 0.2$. These parameters were chosen for a rather "pessimistic" scenario:[19] there is a 20 percent chance of having a bad period, and the loans that one can obtain if one is deserving

[19] That is, pessimistic for the chances of reciprocators to survive in competition with inefficient opportunists, who optimally cheat and default.

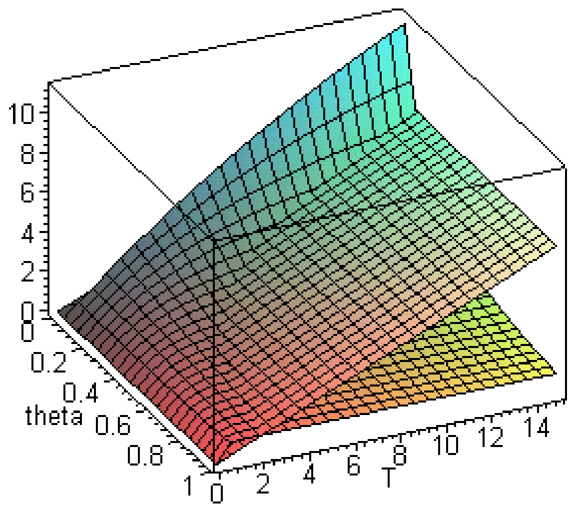


Figure 4: Payoffs of reciprocators and $cheat \wedge loan$

amount to twice the value of market transactions if one is trusted and cheats. The higher is $\theta$, the lower is the $T$ required to make $E\pi_{\mathsf{R}} > E\pi_{\mathsf{O}}$, but if $T$ exceeds approximately 13, the reciprocators receive higher expected payoffs for all values of $\theta$.

Finally, we compare $\overline{E\pi}(honor \wedge default)$, which is relevant for the expected payoffs of the *efficient* opportunists, relative to the expected payoffs of the reciprocators. Let us assume the same parameter values, but now $\theta$ does not enter into the expected payoffs, so we let $p$ vary from zero to 0.5.[20] Figure 6 shows the result. The sloped plane again shows the expected payoffs of the reciprocators. The figure shows that, under the assumed parameter values, $E\pi_{\mathsf{R}} > E\pi_{\mathsf{O}}$ for $T$ larger than approximately 8, for all values of $p$.

## 4 Concluding Remarks

We have found that the prohibition of the taking of interest in traditional societies can be understood as a way of enhancing the evolutionary stability

[20]Recall that $p$ cannot exceed 0.5; otherwise, the free-loan system would be financially infeasible.

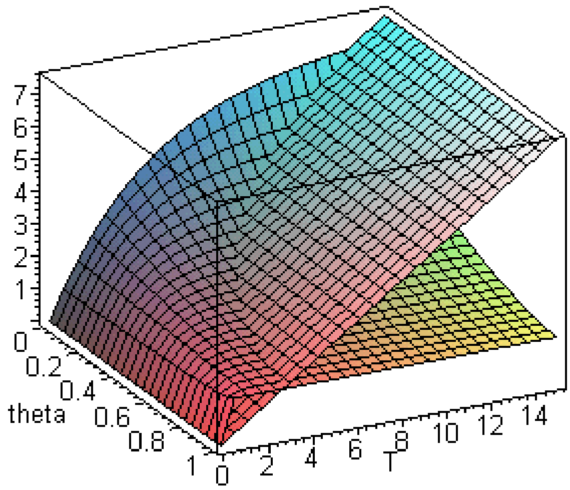


Figure 5: Payoffs of reciprocators and *cheat* ∧ *default*

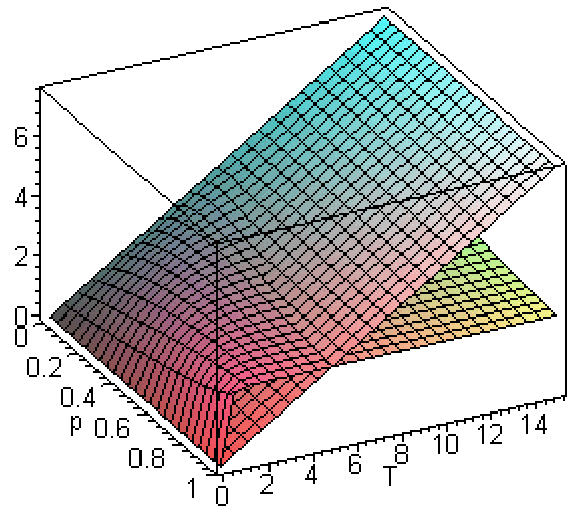


Figure 6: Payoffs of reciprocators and *honor*∧ *default*

of the reciprocator type, thus enabling trust in market transactions. If the proportion of reciprocators in a community is sufficiently high, buyers will trust sellers. If the size of the "standard" loan is not too large, the remaining, opportunistic types will optimally honor trust as well, in order to avoid revealing their type, which would entail losing the trust of buyers. In any case, however, the granting of interest-free loans (and the repaying of them) serves as a signal that permits the screening out of opportunists (with some positive probability), thus enhancing trust.

At the same time, the model developed here explains how an infinitely repeated game can ensure the repayment of loans. A defaulting agent signals that he or she is an opportunist, thus losing trust in market transactions. The multiplicity of equilibria typical of infinitely repeated games is avoided by introducing a small number of player types: in particular, there is a two-fold, binary partition of players: reciprocator/opportunist and efficient/inefficient. The "cooperative" nature of the resulting equilibria is supported not by an arbitrary punishment strategy such as the trigger strategy, but by the rational refusal of buyers to trust sellers who have revealed themselves to be opportunists.

Thus cooperation in the loans game and the market transaction game is mutually reinforcing. Loans are granted and repaid in the loans game in order to obtain the trust of buyers in the market transaction game. And, conversely, sellers are trusted in the market transaction game because reciprocators are a sufficiently large proportion of the population of the community, and this population proportion is supported, in evolutionary equilibrium, by the signaling role of the loans game.

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