Do banks crowd in business ethics? An indirect evolutionary analysis

Werner Güth*

Humboldt University of Berlin, Department of Economics, Institute for Economic Theory III, Spandauer Str. 1, D-10178 Berlin, Germany

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Abstract

Trustworthiness as a major aspect of business ethics can evolve when it can be signaled. If this is impossible, only opportunistic traders will survive. For the institution of banks, which can guarantee payment, it is investigated whether they can crowd in trustworthiness. The crucial feature is the bank’s ability to discriminate between trustworthy and unreliable debtors which, in our model, is formally captured by the probability difference of accepting their respective credit applications. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

The results of market interaction depend on rules which are only partly known (e.g., by empirical research). An especially difficult rule aspect are the preferences of the interacting parties. Indirect evolution (Güth & Yaari, 1992) allows deriving the rules instead of imposing them exogenously. In a two-step procedure, one first determines the behavior for all possible rule constellations and then studies the evolution of rules. In the long run, only the
evolutionarily stable rules should be expected. In case of preferences, only the evolutionarily stable business ethics will prevail when one neglects transitory phases.

Our analysis continues previous research by Guth and Kliemt (1994), who have analyzed the evolution of trustworthiness for the simple game of trust. In this game, a seller can trust the buyer or refrain from cooperation. Whereas the latter decision ends the game, it continues after “trust” with the buyer’s decision to pay or not. What is studied evolutionarily is whether or not a conscience evolves preventing the buyer from not paying.

The result depends crucially on what the seller knows about the buyer’s type: Only trustworthy buyers will survive if the seller can recognize the buyer’s type. If, however, only the buyer knows his type, the opposite is true: Only opportunistic exploiters, who do not pay the price, remain (see Guth & Kliemt, 1994). Perfectly signaling types or no type signaling are just the extremes. Inspired by Schils (2000), we introduce banks which can guarantee that the seller receives the sales price. Since this only transforms the problem of buyer reliability into one of debtor trustworthiness, banks can only survive when they do not make losses.

Introducing banks allows studying whether such an institution will crowd in business ethics1 in the form of trustworthy buyers and debtors. The crucial feature of banks will be their ability to distinguish between trustworthy and unreliable debtors. This ability is formally captured by the possibly different probabilities of granting a credit to trustworthy and unreliable applicants, respectively.

In section 2, the “trust game with bank,” whose equilibria are derived in section 3, is introduced. In section 4, the condition that the bank is making no loss is explored. The evolution of trustworthiness is discussed in sections 5 and 6. Section 7 concludes by summarizing our results and indicating possible lines of future research.

2. The trust game with bank

Let us start by introducing the basic game of trust in Fig. 1, where the non-negative payoff parameters (the upper/lower payoff is the one of the seller/buyer) must satisfy Eq. 1:

\[ p > r > 0 \quad \text{and} \quad v - p > s \geq 0. \] (1)

Here, \( N \) stands for \( N(\text{not trading}); \) \( T \) for \( T(\text{rust}). \) The buyer rewards seller’s trust by \( R(\text{eward}), \) namely by paying the price \( p. \) In case of \( E(\text{xploit}), \) he, however, keeps the commodity of value \( v \) to himself without paying. The terms \( r \) and \( s \) are the profits of the seller and the buyer, respectively, when not trading.

So far, all payoff parameters were representing monetary profits. This is, however, not true for payoff parameter \( m, \) which just represents the buyer’s feelings (of remorse) after exploiting the seller (for a more general discussion of such intrinsic motivation, see Frey, 1994). We will refer to \( m \) as the buyer’s conscience (parameter). Our task will be to derive the

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1 According to Schefold (1998) the hypothesis of crowding in has already been suggested by Hildebrand (1864 and 1922).
evolutionarily stable conscience where business ethics are restricted to whether \( m \) prevents exploitation or not.

The payoffs in Fig. 1 are the player’s cardinal utilities, which can be standardized by assuming Eqs. (2):

\[
p = 1 \text{ and } s = 0
\]

so that Eq. (1) becomes Eq. (3):

\[
v > 1 > r > 0.
\]

For case \( m = 0 \) of no conscience the buyer would exploit (choose \( E \)) so that the seller prefers \( N \) over \( T \). In case of \( m = m \) satisfying \( v + m < v - 1 \) or, as given in Eq. (4):

\[
m < -1
\]

the buyer would, however, pay the price. Restricting attention to the two possible types \( m = m \) and \( m = 0 \) the result is shown in Eqs. (5):

\[
\begin{align*}
(T,R) \text{ for } m = m < -1 \\
(N,E) \text{ for } m = 0
\end{align*}
\]

when the seller knows the buyer’s \( m \)-type.

Indirect evolution allows to distinguish utilities or preferences from profits or—in evolutionary terminology—(reproductive) success. When deriving the solution [Eq. (5)], we have used the players’ utilities. For our evolutionary analysis we will, however, always assume that profits or success decides whether \( m = m \) or \( m = 0 \) survives. According to Eq. (5), a trustworthy \( m \)-buyer earns the profit \( v - 1 \) whereas the unreliable \( m = 0 \) type gets only 0. Due to \( v > 1 \) the \( m \)-type buyer is thus more successful. Monotone adaptation dynamics (see Hammerstein & Selten, 1994, and Weibull, 1995, for surveys on dynamic and static stability concepts) will thus lead in the long run to an \( m \)-monomorphic seller population.\footnote{In this study, we are only interested in the final results of adaptation and not in the process itself.}
Let the population of buyers be composed of a $q$-share of $m$-types whereas the complementary share $1 - q$ are all $m = 0$ types. If the buyer’s $m$-type is private information, the seller will expect an $m = m$-type with probability $q$ and an $m = 0$ type with probability $1 - q$. Representing the seller’s incomplete information by a fictitious initial chance move (Harsanyi, 1967/1968) yields the situation in Fig. 2 relying on the standardized parameters Eq. (2). Endogenizing $m$ is transformed to determining endogenously the population share $q$ of trustworthy buyers by first solving all games with $q \in [0, 1]$ and then studying the adaptation of $q$.

Since $m \ (< - 1)$ chooses $R$ and $m = 0$ the move $E$, the (expected payoff maximizing) seller will rely on $T$ if, as Eq. (6) shows,

$$q > r.$$  

In the range of Eq. (6), an $m$-type earns $v - 1$ and the $m = 0$ type $v$. Thus $m = 0$ is more successful than $m = m$, implying a decline of $q$. For $q \leq r$, Güth and Kliemt (1994) rely on rare trembles (see Selten, 1975 and 1983) in the sense of unintentional choices of $T$ so that the decline of $q$ continues (more slowly) in the range $q \leq r$ till it reaches $q = 0$. Altogether, the evolutionarily stable population composition is $q^* = 1$ in case of Fig. 1 and $q^* = 0$ in case of Fig. 2.

Let us now introduce a bank which may help to engage in trade even when the trustworthiness of the buyer is uncertain. When representing the “trust game with bank,” we neglect the dominated move $E$ of $m = m$ and $R$ of $m = 0$ to simplify the game tree (see Fig. 3). Before engaging in trade, the buyer can ask for a credit guaranteeing that the seller will receive the price. The “game of trust with bank” in Fig. 3 does not introduce the bank as an additional player. Rather it is assumed that a credit application by $m = m$ will be granted.
with probability $x$ whereas an application by $m = 0$ is accepted with probability $y$ where, as given by Eq. (7),

$$1 > x \geq y > 0.$$  \hfill (7)

In case of $x > y$, the bank can better detect the buyer’s type than the seller. Such a better type detection can result from better sources of information (e.g., about debit accounts) for banks than for private traders. Sellers may also be more willing to reveal their financial situation to a bank than to a trading partner. In the limiting case $x = y$, the bank is as bad in type detection as the seller. The long-run existence of a bank presupposes, of course, that it does not make a loss.

If the buyer asks for a credit (the move $C$ in Fig. 3, the notation $C(x)$, respectively $C(y)$, means that the credit is granted only with probability $x$, respectively $y$. With probability $1 - x$ or $1 - y$, the result is as if the buyer would not have asked at all for the credit (i.e., as if move $\overline{C}$ would have been chosen). After $\overline{C}$, the seller with no bank guarantee (the seller agent $S$) plays the game of trust with no type information of Fig. 2. If, however, the credit is granted, the seller agent $s$ with a guaranteed price can choose between $r$ (trade) or $n$ (no trade). After $n$ the game ends whereas it continues with the $m$-types’ choices between $P$ (paying) and $\overline{P}$ (not paying).
The additional payoff parameters in Fig. 3 have the following interpretation:

- $I$ cost of credit guarantee
- $\bar{I}$ cost of credit use (including $I$)
- $D$ security deposit (which is lost for the buyer in case of not paying the price)

It will be assumed that, as shown in Eq. (8),

$$v > 1 + \bar{I}, \bar{I} > I > 0, 1 > I + D > 0, \text{and } D > 0$$

holds, implying $1 + \bar{I} > I + D$. Thus the $m = 0$ type of buyer uses $\bar{P}$ instead of $P$ whereas an $m$-type, satisfying Eq. (9),

$$m < I + D - 1 - \bar{I}(< 0),$$

chooses $P$ instead of $\bar{P}$. Furthermore, seller $s$ always prefers $t$ over $n$ since, after $t$, he is sure to receive the price. Eliminating all these dominated moves yields the “further reduced game of trust with bank” in Fig. 4.

In the following, this game with only three decision makers, namely the $m = m$—and the $m = 0$ type of buyer as well as the seller (agent) $S$ without price guarantee, will be analyzed, first by solving the game, and then by analyzing the dynamics of $q$, the relative share of trustworthy buyers or debtors.

3. Solutions

Let $\alpha$ and $\beta$ denote the probability by which $m = m$, respectively $m = 0$, chooses $C$. These probabilities determine the posterior probability of seller (agent) $S$ for confronting the $m$-type
of buyer according to Eq. (10):

\[ q(\alpha, \beta) = \frac{q[\alpha(1-x) + 1 - \alpha]}{q[\alpha(1-x) + 1 - \alpha] + (1-q)[\beta(1-y) + 1 - \beta]}. \]  

(10)

Now seller S prefers T over N if, as shown in Eq. (11):

\[ q(\alpha, \beta) > r \]  

(11)

whereas N is better if, as given in Eq. (12),

\[ q(\alpha, \beta) < r. \]  

(12)

In case of Eq. (11), both m-types of buyer would choose \( \bar{C} \) (i.e., \( \alpha = \beta = 0 \)), so that Eq. (11) becomes Eq. (13):

\[ q(0,0) = q > r. \]  

(13)

**Proposition 1:** In case of \( q > r \) there exists an equilibrium with no buyer-type asking for the credit and both seller agents S and s relying on trust (the move T, respectively t).

Consider now the case [Eq. (14)] when S uses N. Due to the parameter restriction of Eq. (8) the m-type of buyer prefers \( C(x) \) over \( \bar{C} \) (i.e., \( \alpha = 1 \)). Since the conditions in Eq. (8) imply that \( v > I + D \), also the \( m = 0 \) type of buyer avoids \( \bar{C} \) (i.e., \( \beta = 1 \)). Condition [Eq. (12)] thus becomes Eq. (14),

\[ q(1,1) = \frac{q(1-x)}{q(1-x) + (1-q)(1-y)} < r \]  

(14)

or Eq. (15):

\[ q < \frac{(1-y)r}{1 - yr - (1-r)x}. \]  

(15)
In case of $x = y$ (i.e., when the bank cannot differentiate at all between the $m = m^-$ and the $m = 0$ type of buyer), the right-hand side of Eq. (14) would equal $r$ whereas it is smaller than $r$ for $x > y$ proving Proposition 2:

**Proposition 2:**

a. If $(x = y$ and $q > r)$ or $[x > y$ and $r < q(1, 1)]$, both $m$-types do not ask for the credit (choose $C$) and seller agent $S$ relies on trust (the move $T$).

b. If $(x = y$ and $r > q)$ or $[x > y$ and $r > q(1, 1)]$, both $m$-types ask for the credit [choose $C(x)$ resp. $C(y)$] and seller agent $S$ relies on $N$.

c. If $x > y$ and $q(1, 1) < r < q$, both, the outcome in (a) as well as the one in (b) are pure strategy equilibria.

Proposition 2 considers only pure strategy equilibria and neglects the multiplicity of best replies in unreached information sets what can be easily justified by perfection considerations (Selten, 1975) or by requiring sequential rationality (Kreps & Wilson, 1982). In a mixed strategy equilibrium seller agent $S$ as well as one of the buyer’s types engage in random choice behavior. If $m = m$ is randomizing, $S$ must use $T$ with probability $\gamma(m) = (v - 1 - T) / (v - 1)$; if $m = 0$ randomizes, this probability must be $\gamma(0) = (v - 1 - D) / v$. Thus at most one $m$-type of buyer can engage in random choice behavior. For seller agent $S$ to be indifferent between $T$ and $N$ one needs, as given in Eq. (16),

$$q(\alpha, 1) = r \text{ or } \alpha = \frac{q - r + yr(1 - q)}{xq(1 - r)} \text{ with } \alpha'(q) > 0$$

when $m = 0$ uses $\beta = 1$, whereas one must have

$$q(0, \beta) = r \text{ or } \beta = \frac{r - q}{y(1 - q)r} \text{ with } \beta'(q) < 0$$

when $m = m$ relies on $\alpha = 0$. The possible equilibria as depending on the population share $q$ of trustworthy $m$-types are graphically represented in Fig. 5.

In the interval $0 < q < (1 - y)r/(1 - yr)$, the only equilibrium is $[C(x), C(y), N]$. In the neighboring interval $(1 - y)r/(1 - yr) < q < r$, this equilibrium coexists with both mixed strategy equilibria $[\alpha, \beta = 1, \gamma(m)]$ and $[\alpha = 0, \beta, \gamma(0)]$. Only the mixed strategy equilibrium $[\alpha, \beta = 1, \gamma(m)]$ remains when $q$ increases to $r < q < (1 - y)r / [1 - yr - (1 - r)x]$, where it coexists with both pure strategy equilibria $[C(x), C(y), N]$ and $(\overline{C}, \overline{C}, T)$. For $1 \geq q > (1 - y)r/(1 - yr - (1 - r)x)$ the only equilibrium is $(\overline{C}, \overline{C}, T)$.

Mixed strategy equilibria, which as nonstrict equilibria are less stable and will be neglected in the following, allow for a more continuous transition from one pure strategy equilibrium to another when $q$ changes. Here we wanted to illustrate that such a transition is only possible via adjusting the probability $\alpha$ or $\beta$, respectively. Only in case of $\alpha \neq \beta$ intentional-type signaling results. For the two strict solutions $(\overline{C}, \overline{C}, T)$ and $[C(x), C(y), N]$ one either has $\alpha = \beta = 0$ or $\alpha = \beta = 1$ (i.e., no intentional type signaling). For $x > y$ and $\alpha = \beta > 0$, a credit is nevertheless an important signal as can be seen from Eq. (10) defining the
corresponding posterior beliefs of seller agent \( S \). For \( \alpha = \beta > 0 \) and \( x > y \), there is unintentional signaling of the buyer’s \( m \)-type.

4. Survival conditions for bank

Even when the bank is not formally included as an active player, its existence, especially over an evolutionary time span, presupposes that it does not incur a loss. Since the solution described in Proposition 1, does not actually involve credit applications, the bank is not endangered. The solution in part (b) of Proposition 2, however, involves active bank participation so that one has to check the no-loss constraint of this solution for Eq. (18),

\[
x = y \quad \text{and} \quad r > q
\]

or Eq. (19):

\[
x > y \quad \text{and} \quad r > q(1,1).
\]

According to this solution, the bank grants the credit to \( m = m \) with probability \( qx \) and to \( m = 0 \) with probability \( (1 - q)y \). Its “no expected loss-constraint” is given by Eq. (20):

\[
qxI + (1 - q)y(I + D - 1) \geq 0
\]

since it earns \( I \) in case of encountering \( m = m \) and loses \( [1 - (I + D)] \) in case of \( m = 0 \) when it has to pay the price and receives only \( I + D \). The lower bound for \( q \) implied by Eq. (20) is given by Eq. (21):

\[
q \geq \frac{y(1 - I - D)}{xI + y(1 - I - D)}.
\]

Due to Eq. (8), the right-hand side of Eq. (21) is positive and smaller than 1. For \( x = y \) it becomes as shown by Eq. (22):

\[
q \geq \frac{1 - I - D}{1 + I - I - D}.
\]
In case of $x > y$, the right-hand side of Eq. (21) is smaller than the one of Eq. (22). Better banks (in the sense of larger differences $x - y$) are profitable under more general circumstances. Our conclusions are summarized by Proposition 3:

**Proposition 3:** The solution prescribing the C-choice for both buyer types $m = m^\dagger$ and $m = 0$ and the N-choice for seller agent $S$ involves no expected loss by the bank if, as given by Eq. (23):

$$r > q \geq \frac{1 - I - D}{1 + I - I - D} \text{ for } x = y$$

and, as given by Eq. (24):

$$r > q(1, 1) \text{ and } q \geq \frac{y(1 - I - D)}{xI + y(1 - I - D)} \text{ for } x > y.$$ (24)

Using inequality [Eq. (21)], condition [Eq. (24)] can be expressed as Eq. (25):

$$\frac{(1 - y)r}{1 - yr - (1 - r)x} := R > q \geq \frac{y(1 - I - D)}{xI + y(1 - I - D)} =: L.$$ (25)

To illustrate condition [Eq. (25)], one can look at the extreme case $x = 1$ and $y = 0$ when the bank accepts the credit application by $m = m^\dagger$ and rejects the one by $m = 0$ with certainty. For this case, Eq. (25) becomes $1 > q \geq 0$ and implies no essential restriction at all. Since Eq. (23) is just the limiting case in the sense of $|x - y| \to 0$, all our results are summarized by Theorem 4:

**Theorem 4:** The “further reduced game of trust with bank” has two strict and sustainable equilibria, namely

a. one with both m-types choosing $\overline{C}$ and the seller agent $S$ the move $T$ when, as shown in Eq. (26),

$$q > r,$$ and

b. one with both m-types choosing $C(x)$ and $C(y)$, respectively, and the seller agent $S$ the move $N$ when, as shown in Eq. (27),

$$R > q \geq L,$$ (27)

where $R$ and $L$ are defined in Eq. (25).
The interval [Eq. (27)] for \( q \in [0,1] \) may, of course, be empty. The interval is non-empty if as shown by Eq. (28):

\[
\frac{x}{1-x} \cdot \frac{1-y}{y} > \frac{1-r}{r} \cdot \frac{1-I-D}{I}.
\]  

(28)

For inequality [Eq. (28)], the result of Theorem 4 is graphically illustrated in Figs. 6 and 7, visualizing the \( q \)-interval \([0,1]\). Since \( x \geq y \) the left-hand side of Eq. (27), the parameter \( R \) defined in Eq. (25), is larger than \( r \). Fig. 6 illustrates the case where

\[
R > r > \frac{y(1-I-D)}{xI+y(1-I-D)}
\]  

(29)

whereas Fig. 7 assumes that

\[
r < \frac{y(1-I-D)}{xI+y(1-I-D)} < R.
\]  

(30)

If inequality [Eq. (28)] is reversed, the equilibrium prescribing the credit application \( C(x) \), respectively \( C(y) \) by both \( m \)-types of buyer together with \( N \)-choice of the seller agent \( S \) does not exist as a sustainable solution, since it implies an expected loss for the bank.

5. The evolution of trustworthiness

An evolutionary game (see the survey of evolutionary game theory by Hammerstein & Selten, 1994, as well as by Weibull, 1995) is defined by its strategy set \( M \) as well as by its (reproductive) success function \( R(m, \tilde{m}) \) specifying for all pairs \( m, \tilde{m} \) in \( M \) the success of an \( m \)-type when confronting an \( \tilde{m} \)-type. For the case at hand we assume Eq. (31),

\[
M = \{m, 0\} \text{ with } m \text{ satisfying Eq. (9)}.
\]  

(31)
The success of an $m$-type buyer is just the profit implied by the solution. The payoff component $m$ in Fig. 3 can determine the buyer’s success only indirectly, namely via influencing the buyer’s solution behavior. For the “further reduced game of trust with bank” of Fig. 4, this distinction does not really matter. The $m$ type of buyer neither chooses $E$ nor $P$ so that $m$ never enters the solution payoff of $\hat{m}$. For $\hat{m}$, furthermore, it vanishes by definition.

For the case at hand we have to adapt $R(m,\hat{m})$ to the case of incomplete information (see originally Güth, 1995) by relying on the expected success function, as given by Eq. (32):

$$R(m, q) \text{ for } m \in M = \{m, 0\}$$

where $R(m, q)$ is the expected material payoff of an $m$-type buyer. In case of the solution $(\overline{C}, \overline{C}, T)$ one obtains Eq. (33):

$$R(m, q) = \begin{cases} v - 1 & \text{for } m = m \\ v & \text{for } m = 0 \end{cases}$$

in the range $q < r$. As before, we assume that the population share $q$ of trustworthy buyers or debtors is a function $q(t)$ of time $t$ which increases (decreases) with $t$ when $R[m, q(t)] > R[0, q(t)]$ (respectively vice versa). Since $R(m = 0, q) > R(m = m, q)$ for all $q > r$ where the solution $(\overline{C}, \overline{C}, T)$ exists, $q$ decreases in the interval $q < r$.

Proposition 5: According to the solution $(\overline{C}, \overline{C}, T)$ the population share $q$ of trustworthy buyers will decrease in the interval $q > r$.

Let us now turn to the solution $[C(x), C(y), N]$ under assumption [Eq. (28)] guaranteeing that it exists for all $q$ in the generic $q$-interval [Eq. (27)]. This solution implies Eq. (34):

$$R(m, q) = \begin{cases} x(v - 1 - I) & \text{for } m = m \\ y(v - I - D) & \text{for } m = 0 \end{cases}$$

The condition $R(m, q) > R(0, q)$ is equivalent to Eq. (35):

$$v(x - y) > x(1 + T) - y(I + D).$$
In view of Eqs. (6) and (7), the right-hand side of inequality [Eq. (35)] is positive [i.e., Eq. (35) does not hold when \( x - y \) is small].

**Proposition 6:** If the q-interval [Eq. (27)] for the solution \([C(x), C(y), N]\) is non-empty, the population share \( q \) of trustworthy buyers will increase in case of inequality [Eq. (35)], whereas it will decrease when, as shown in Eq. (36),

\[
v(x - y) < x(1 + T) - y(I+). \tag{36}
\]

We will rely on Propositions 5 and 6 when demonstrating the possible crowding in of trustworthiness. When doing so, we encounter two major problems, namely

- the existence of two pure strategy solutions for the same generic parameter region in the \( q \)-interval from \( r \) to \( R \) of Fig. 6, and
- the non-existence of any pure strategy solution which, in view of Proposition 2, is solely due to the survival conditions of the bank (see the interval from 0 to \( L \) in Fig. 6 and from 0 to \( r \) in Fig. 7).

The first problem has been resolved by applying the theory of equilibrium selection (see Güth & Ockenfels, 1998, who apply the theory of Harsanyi & Selten, 1988). Here we simply will rely on an ad hoc selection of the solution candidate when justifying crowding in business ethics.

The second problem of no pure strategy equilibrium simply states that the banking system, as captured by our model, cannot exist when such circumstances prevail. We can capture such situations by the basic game of trust without type information and without a bank (see Fig. 2), where \( q \) decreases over the whole range (for the range \( q \leq r \) this presupposes that \( T \) is sometimes chosen by mistake).

Keeping this in mind, we can return to Figs. 3 and 8 and indicate the dynamics of \( q = q(t) \) by horizontal arrows for the respective \( q \)-intervals. Here an arrow above the \( q \)-axis indicates the direction in which \( q \) moves in view of the solution \((\bar{C}, \bar{C}, T)\), whereas the arrows below refer to the solution \([C(x), C(y), N]\).

The dotted arrow in the left interval above the \( q \)-axis indicates the slow decline of \( q \) in case of rare mistakes by the seller who wants to use \( N \) in the interval \( q \leq r \), but occasionally fails to do so (see Selten, 1983). Arrows below the \( q \)-axis and outside the \( q \)-interval between \( L \) and \( R \) result from the non-existing bank where \( q \) must always decline. Of course, this decline is fast in the range \( q > r \) and slow (dotted arrows) in the range \( q \leq r \).

Fig. 9. The case [Eq. (28)] and [Eq. (30)].
In the $q$-interval between $L$ and $R$, the direction of the arrows below the $q$-axis depends on whether condition [Eq. (35)] or [Eq. (36)] holds. In view of Proposition 6, the $q$-share of trustworthy buyers increases in case of Eq. (35) and decreases if Eq. (36) holds.

What remains is the case where inequality [Eq. (28)] is reversed [i.e., where the interval [Eq. (27)] or [Eq. (25)] is empty. Here, the arrows below the $q$-axis are simply the same as the ones above the $q$-axis (see Fig. 10) since we interpret this situation as the basic game of trust without type information.

6. A case of crowding in

To provide a case of crowding in trustworthiness one obviously must rely on the equilibrium $[C(x), C(y), N]$ together with inequalities [Eq. (28)] and [Eq. (35)] implying a generic region $\subset (0,1)$ where $q$ increases (see Figs. 8 and 9). Clearly, for any initial population composition $q_0$ with $L < q_0 < R$ the share $q$ of trustworthy types will increase till it reaches the evolutionarily stable bimorphism $q = R$ for Eq. (28) and Eq. (35). Thus, depending on the initial conditions, crowding in of trustworthiness in the sense of an increase of $q$ is possible. In the following, we want to compare the result $q = R$ with the situation where no banking system exists.

Without the bank, only $q^* = 0$ is evolutionarily stable. Thus for crowding in it suffices to specify a case satisfying conditions [Eq. (28)], [Eq. (27)], and [Eq. (35)]. Let us explore the three conditions for Eq. (37):

$$x = 1 - \varepsilon \text{ and } y = \varepsilon$$

with $\varepsilon$ being small, but positive. Substituting Eq. (37) into Eqs. (28), (27), and (35) yields Eqs. (38), (39), and (40),

$$\left(\frac{1 - \varepsilon}{\varepsilon}\right)^2 > \frac{1 - r}{r} \cdot \frac{1 - I - D}{I},$$

$$\frac{(1 - \varepsilon)r}{\varepsilon(1 - r) + (1 - \varepsilon)r} > q \geq \varepsilon \cdot \frac{1 - I - D}{(1 - \varepsilon)I + \varepsilon(1 - I - D)},$$
and
\[ v > \frac{1 - \epsilon}{1 - 2\epsilon} (1 + I) - \frac{\epsilon}{1 - 2\epsilon} (I + D), \] (40)

respectively. The limiting inequalities for \( \epsilon \to 0 \) are shown in Eqs. (41), (42), and (43):
\[ \infty > \frac{1 - r}{r} \cdot \frac{1 - I - D}{I}, \] (41)
\[ 1 > q \geq 0, \] (42)

and
\[ v > 1 + I. \] (43)

The latter condition holds due to Eq. (8). Thus, crowding in of trustworthiness is possible and, furthermore, generic: The smaller the \( \epsilon \), the larger the \( q \)-interval [Eq. (39)] over which \( q \) will increase according to the solution \([C(x), C(y), N] \).

**Corollary 7:** If \( x < y \) crowding in of trustworthiness is possible and generic in view of the solution \([C(x), C(y), N] \).

The result is visualized by Fig. 11: Whenever the initial \( q \) satisfies \( L < q < R \), the population share \( q \) of \( m \)-types increases fast between \( L \) and \( R \). For \( q < L \), the solution \([C(x), C(y), N] \) would imply a loss of the bank so that one must rely on the solution \((\overline{C}, \overline{C}, T) \) with rare unintended choices of \( T \) or must fall back on the game of trust without type information and without a bank (i.e., \( q \) declines slowly). The attraction set of \( q^* = R \) is thus the interval from \( L \) to \( I \), whereas for the alternative stable configuration \( q^* = 0 \), it is the interval from \( 0 \) to \( L \).

In view of the equilibrium \((\overline{C}, \overline{C}, T) \) only \( q = 0 \) is evolutionarily stable. Thus crowding in is impossible if solution \((\overline{C}, \overline{C}, T) \) is played. The equilibrium \((\overline{C}, \overline{C}, T) \) does not deny the existence of the banking system, but implies its factual irrelevance. If inequality [Eq. (36)] holds, both pure strategy equilibria (i.e., \((\overline{C}, \overline{C}, T) \) and \([C(x), C(y), N] \)) imply that \( q \) declines over the whole range (see Figs. 8 and 9). Thus, in case of [Eq. (36)] crowding in is impossible for \([C(x), C(y), N] \).

**7. Conclusions**

Business ethics are specified as the trustworthiness of buyers, respectively debtors, where we distinguish two \( m \)-types, the trustworthy ones, who would pay the price, and the opportunistic exploiters who are unreliable as buyers and as debtors. Trade is modeled by the game of trust with the interpretation that delivery precedes payment. To guarantee that the price will be paid after the delivery the buyer can ask for a credit. We refer to this situation as the “game of trust with bank.”
In our indirect evolutionary analysis, the game is first solved, which then allows us to study the evolution of \( q \), the share of trustworthy buyers, respectively debtors. Our way of demonstrating crowding in of trustworthiness is to introduce path dependence (i.e., an initial share \( q_0 \) of trustworthy types), and to show that \( q \) will become larger (crowding in) than \( q_0 \).

A major simplification of our analysis is that we investigate the ethical impact of banks without including the bank as a player. Thus, our results do not depend on more or less arbitrary assumptions of what the bank decides when, on what it knows when deciding, and on how it evaluates the various possible outcomes. What essentially matters is the bank’s ability to distinguish between trustworthy and unreliable debtors (in our model, the difference \( x - y \)). For \( x = y \), there is no multiplicity of strict equilibria \{for \( x = y \) one has \((1 - y)r/[1 - yr - (1 - r)x] = r\), see Fig. 10\}. According to \([C(x), C(y), N]\), the share \( q \) would always decline in case of \( \bar{I} > I + D \) [check Eq. (36) for \( x = y \)]. For \((\bar{C}, \bar{C}, \bar{T})\) Proposition 2 states similar results for \( x = y \) as for the basic game of trust with no type information and no bank. More interesting results require \( x > y \), and thus the bank’s ability to distinguish between \( m \)-types. What is required from a bank is that it can inquire more thoroughly than a seller about whether a customer is reliable.

The bank’s fees for the credit guarantee \((I)\), the credit use \((\bar{I})\), and the deposit \(D\), which it requires, are influential, too. But with regard to crowding in of trustworthiness the essential parameter seems to be the discrepancy between the probabilities of granting a credit to the trustworthy or the unreliable debtor, respectively. One can easily include the additional risk of meeting a buyer, respectively debtor, who is unable to pay. Since an untrustworthy \( m = 0 \) type does not pay anyway, this would reduce the probability of trustworthy \( m \)-types (i.e., the interval [Eq. (27)] would shrink).

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References


