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TRUST AND TRADE

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February, 2009

Abstract

This paper presents a model demonstrating how trust affects the volume of trade in a society. There are two ways in which this happens. First, at minimum, societies need a certain level of trust in order to observe trading activity. Second, once this minimum condition is satisfied, the probability of observing a larger volume of trade is high only if the level of trust is sufficiently high. Our results help explain empirical findings that demonstrate a positive relationship between trust and the volume of sales, or the value added of trade. The model also shows that institutions can compensate for low levels of trust—that is, societies with low levels of trust can achieve volumes of trade comparable to those of societies with high levels of trust by spending more resources on increasing the quality of the relevant institutions.

JEL Classification: A13, D00, Z13
Keywords: trust, volume of trade, social capital, contract enforcement.

♣ I thank Mariana Laverde for her assistance in reproducing the simulations used in section 5.

CONFIANZA Y COMERCIO

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Resumen

Este artículo presenta un modelo que muestra cómo los niveles de confianza afectan los volúmenes de comercio en una sociedad. Existen dos formas a través de las cuales dicho mecanismo funciona. Primero, las sociedades necesitan un mínimo de confianza para que se puedan observar transacciones comerciales. Segundo, una vez éste mínimo nivel se cumple, la probabilidad de observar mayor número de transacciones es alta si el nivel de confianza es suficientemente alto. Estos resultados ayudan a explicar algunos resultado empíricos que han mostrado una relación positiva entre confianza y volumen de ventas o valor agregado del comercio. El modelo también muestra que las instituciones pueden compensar bajos niveles de confianza. Es decir, las sociedades con bajos niveles de comercio pueden lograr volúmenes de comercio comparables a los que poseen las sociedades con altos niveles de confianza si asignan una mayor cantidad de recursos en mejorar la efectividad de las instituciones.

Clasificación JEL: A13, D00, Z13
Palabras Clave: confianza, volumen de comercio, capital social.

♣ Agradezco a Mariana Laverde por su labor de reproducir las simulaciones de la sección 5.

1. Introduction

Scholars in both the social sciences (Banfield, 1958; Putnam, Leonardi and Nanetti, 1993; Fukuyama, 1995; Putnam, 2000; Gambetta, 2000; Granovetter, 2005) and economics (see below) have called attention to the negative effects of losses in social capital—especially losses in the level of trust—on social and economic outcomes. The main claim in the literature is that economic activities are carried out at a lower cost if societies have high levels of trust. Conversely, lower levels of trust imply a higher cost for these activities and, consequently, a smaller volume of transactions. This paper presents a model capturing the relationship between the level of trust and the volume of trade.

The relationship between trust and certain economic outcomes has been also tested empirically using both micro and cross-country data. The evidence shows that societies with high levels of trust exhibit a higher value added of trade (Fafchamps and Minten, 2001), more volume of sales (La Porta et al., 1997), deeper financial systems (Guiso, Sapienza and Zingales, 2004; Calderon et al., 2002), and high rates of investment and growth (Knack and Keefer, 1997; Zak and Knack, 2001). However, some of these findings have yet to be explained from a theoretical perspective.

The relationship between trust and growth has already been explored by Zak and Knack (2001), as well as Somanathan and Rubin (2004). The former relate the level of trust explicitly to the level of investment and growth. Since brokers have more information about the return on investments than consumers, the latter will invest more heavily in assets when social and institutional environments foster a high level of trust. The latter are not as explicit as the former, but show how both honesty[1] and capital are co-determined within a growth framework. Using an endogenous growth model, they demonstrate that greater capital intensity increases the level of honesty, which increases the level of investment, and so forth.

Our model does not focus on the relationship between trust and growth, but rather that between trust and the volume of trade, which also matters for growth. Thus, it is able to explain why sales, financial transactions and the value added of trade have a positive correlation with the level of trust. This kind of relationship has not yet been explained from a theoretical perspective.

In the literature, there does not exist complete agreement as to a definition of (and measure for) trust. Almost all the references quoted above have used different definitions. Summarizing the views expressed by some of the authors of *Trust: Making and Breaking Cooperative Relations*, Gambetta (2000) gives the following definition: “trusting in a person means believing that when offered the chance, he or she is not likely to behave in a way is damaging to us”. We will utilize this type of belief as a measure of trust in this paper.

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[1] Although they concentrate on honesty, they argue that there must be a high correlation between this and trust.

Our model considers a society in which individuals are randomly matched into pairs, and have to decide whether or not to trade a given service or good. The transaction is carried out only if both individuals choose "trade" (that is, there exists an equilibrium with trade). Otherwise, the transaction is not carried out (that is, there exists an equilibrium without trade). Players only meet for one period, and there is no repeated interaction between them.

Individuals do not know whether a person is trustworthy or not, but they do have beliefs regarding the percentage of trustworthy people in society as a whole. Thus, each individual believes that there exists probability θ that he or she will be paired with a trustworthy partner, and probability $1-\theta$ that he or she will be paired with an untrustworthy one. As noted, these beliefs (θ) represent the measure of trust in society as a whole. Correspondingly, we can say that trust increases as θ increases. Untrustworthy people always have incentives to cheat and they actually do. This behavior affects the payoff for the players. Additionally, the payoffs for cheating and being cheated are linked to the level of contract enforcement in society.

The model predicts that in order to observe an equilibrium with trade, it is necessary that a minimum level of trust exists in society. This minimum level decreases as contract enforcement become more effective (i.e., the quality of the relevant institutions is higher). Nevertheless, when this level of trust is met, an equilibrium without trade can also be observed. Thus, the necessity of there being a level of trust above the minimum level in order to observe an equilibrium with trade does not necessarily assure trading activity.

In order to see under which circumstances we are more likely to observe an equilibrium with trade in a given society (once the minimum level of trust is met), Quantal Response Equilibria are computed. This kind of refinement allows us to make statistical rather than deterministic predictions regarding equilibrium strategies. Simulations show that if the level of trust is sufficiently high or contract enforcement is working appropriately—and individuals predict their payoffs relatively well—the probability of observing trading activity is one. However, the relationship between this probability and the level of trust is not always a positive one.

In sum, our model is able to replicate the observation that trust matters vis-à-vis the volume of trade. Moreover, we show that if the level of trust is above the minimum level necessary to observe an equilibrium with trade in a given society, then this type of equilibrium is always socially desirable.

Our model can be understood as being derived of one of Akerlof's (1970) ideas: when there exists in a given society people selling services or goods in a dishonest manner--and there is incomplete information concerning those activities—then market qualities are affected. As expressed by Akerlof: "It is this possibility that represents the major cost of dishonesty – for dishonest dealings tend to drive honest dealings out of the market."

The rest of the paper is organized into 6 sections. Section 2 describes the game, section 3 discusses the first best solution, section 4 characterizes and describes the Bayes-Nash Equilibrium, and section 5 analyzes certain refinements. Welfare considerations are discussed in section 6, and the last section concludes. All the proofs are in the appendix.

2. Game

Consider a society with n individuals, indexed by $i = 1,...,n$. There is one single period during which they are randomly matched into pairs in order to trade a specific service or good. Individuals in this society are of two types (t_i): trustworthy ($t_i = t$) and untrustworthy ($t_i = u$). An individual's type is private information. However, all individuals believe that proportion $\theta \in (0,1)$ of people in their society are trustworthy. As we discussed in the introduction, θ measures the level of trust in this society. Thus, trust increases as θ increases.

Untrustworthy individuals always cheat when they trade. In other words, they find it profitable to mimic the quality of the good/service, or the payment made for it. For instance, if the buyer is an untrustworthy individual, he or she will exaggerate to the seller the quality of the good/service. If the seller is an untrustworthy individual, he or she will not pay a part or even the total of the amount due (or might pay with a check without funds or using false money).

After being randomly paired, each individual in each pair has to decide whether to "trade" (T) or "not-trade" (N) the good/service with his or her partner. The trade is carried out only if both players choose T. We call this outcome an equilibrium with trade. Otherwise, there is no trade for the match. We call this outcome an equilibrium without trade. The payoffs in the game are normalized to lie in the interval $[-1,1]$, and correspond to the surplus in monetary units obtained by each individual.

If two trustworthy individuals are paired, nobody cheats. Therefore, if they both choose T, each will receives his or her full valuation of the good/service. In this case, we set the payoff for each individual as zero. If a trustworthy player is paired with an untrustworthy player, the latter will cheat. If under this scenario both players choose T, the trustworthy player receives a payoff of $a \in [-1,0)$, while the untrustworthy one receives a payoff of $-a$. In words, the untrustworthy player is able to capture part of the surplus of the trustworthy player.

If two untrustworthy individuals are paired, both will cheat. If under this scenario both players choose T, each receives a payoff of αa, with $\alpha \in [0,1]$. This payoff entails two issues. First, as we explain below, a is directly linked to the degree of contract enforcement that exists in society. Writing down this payoff in terms of a then allows us to associate all the relevant payoffs in the game with the degree of contract enforcement.

Second, the assumption with respect to α implies that the loss that an untrustworthy player experiences—when paired with an individual of the same type and where both choose T— is smaller or equal to the loss that a trustworthy player experiences when paired with an untrustworthy type and where both choose T. Since a trustworthy player cheats and an untrustworthy one does not, it makes sense to assume that the behavior of the latter allows him or her to experience a loss relatively smaller than that experienced by the former when both are cheated.

Finally, if one or both individuals in the pair chooses N, then the good/service is not traded. When this happens, each individual has to face a transaction cost equal to $\mu < 0$, regardless of his or her type. The respective payoffs are summarized in tables 1, 2 and 3.

Table 1
Payoffs: Pair with two trustworthy (*t*) players.

t \ *t*	T	N
T	0,0	μ,μ
N	μ,μ	μ,μ

Table 2
Payoffs: Pair with a trustworthy (*t*) and an untrustworthy (*u*) player.

t \ *u*	T	N
T	$a,-a$	μ,μ
N	μ,μ	μ,μ

Table 3
Payoffs: Pair with two untrustworthy (*u*) players.

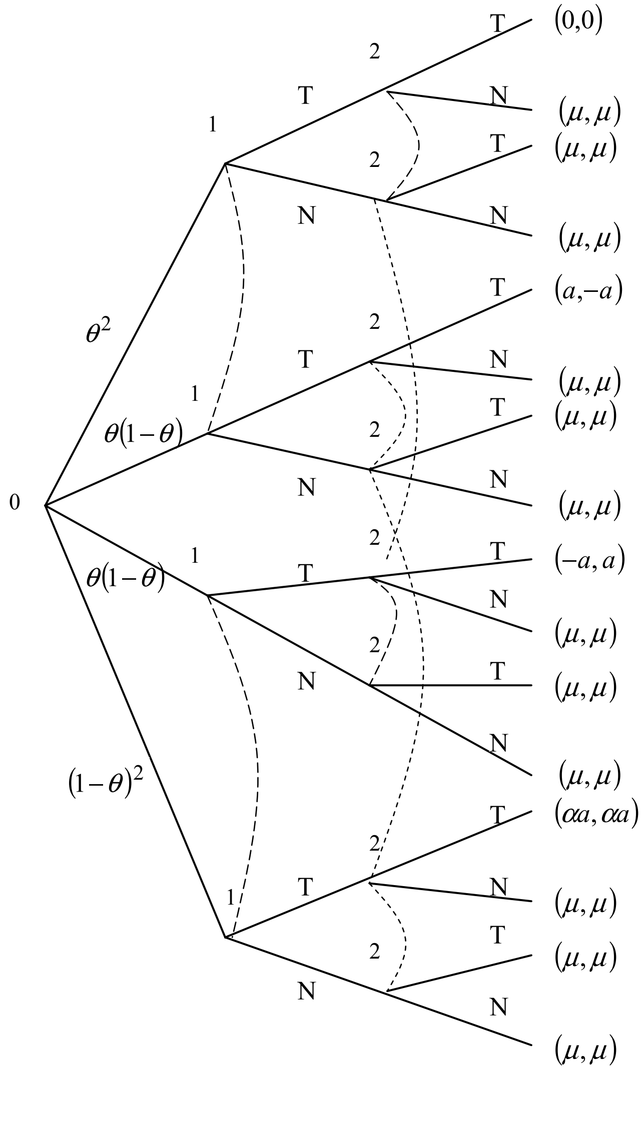
u \ *u*	T	N
T	$\alpha a,\alpha a$	μ,μ
N	μ,μ	μ,μ

Assumption 1: $a < \mu$.

Assumption 1 states that the loss experienced by a trustworthy player when she or he engages in trading with an untrustworthy player, is greater than the loss he or she experiences when choosing N in the same pairing. Notice that if a were larger than μ, then the individuals involved would always have an incentive to choose T. By the way, this assumption implies that **when** the type of each player **is** known, a trustworthy type would never willingly trade with an untrustworthy type.

Notice that αa can be either smaller or greater than μ. No assumption is made in this regard. The scenario represented by $\alpha \geq \mu/a$ is designated an "untrustworthy high-costs case." Correspondingly, the scenario represented by $\alpha < \mu/a$ is designated a "non-trustworthy low-costs case." The extensive form of the game is displayed in figure 1.

Figure 1.
Extensive form of the game.



As anticipated above, the degree of contract enforcement in this society is measured by a. If contract enforcement works perfectly, a player who has been cheated can force his or her partner to honor the contract, and thus acquire the contracted payoff. In this case, a tends to be zero. However, if contract enforcement does not work adequately, a tends to be high in absolute terms (i.e., it goes to -1). Thus, improvements in contract enforcement are related with smaller values (in absolute terms) of a.

3. First-Best Surplus

In order to identify the efficient level of surplus, in this section we consider the case in which there is perfect information. Under these circumstances, each individual in a pair is able to observe whether his or her partner is trustworthy or untrustworthy. However, in order to isolate only the effect of the information on the equilibrium outcome, we still maintain that individuals are randomly paired.

The Nash equilibrium (NE) assuming perfect information depends on the profile of each pair. The equilibria can be summarized as follows:

Profile 1: If two trustworthy individuals are paired, then $NE = \{(T,T),(N,N)\}$.
Profile 2: If a trustworthy individual is paired with an untrustworthy one, then $NE = \{(N,T),(N,N)\}$.
Profile 3a: If two untrustworthy individuals are paired, and $\alpha \geq \mu/a$, then $NE = \{(N,T),(T,N),(N,N)\}$.
Profile 3b: If two untrustworthy individuals are paired, and $\alpha < \mu/a$, then $NE = \{(T,T),(N,N)\}$.

First, let us consider the untrustworthy high-costs case (i.e., $\alpha \geq \mu/a$). Since $\mu < 0$, the efficient equilibrium under profile 1 is $\{(T,T)\}$. Thus, if two trustworthy individuals are paired, then the observed outcome is an equilibrium with trade. The surplus generated for each pair under this profile is zero. Under profile 2, the achieved outcome is always an equilibrium without trade. The surplus generated for each pair under this profile is 2μ. The same thing happens under profile 3a. In this case then, the social expected surplus is given by:

$$S_h^* = (1-\theta^2)n\mu \qquad (1)$$

Notice that S_h^* increases as θ increases. In other words, when $\alpha \geq \mu/a$, the efficient surplus increases as the level of trust increases.

Let us now consider the untrustworthy low-costs case ($\alpha < \mu/a$). The only difference vis-à-vis the previous case occurs when two untrustworthy individuals are paired (profile 3b), which occurs with a probability of $(1-\theta)^2$. In this case, since $\alpha < \mu/a$, the efficient equilibrium is $\{(T,T)\}$. The surplus generated for each pair under this profile is $2\alpha a$. In this case then, the social expected surplus is given by:

$$S_l^* = (1-\theta)n[(1-\theta)\alpha a + 2\theta\mu] \qquad (2)$$

S_l^* increases as θ increases if and only if $\theta > \dfrac{\alpha a - \mu}{\alpha a - 2\mu} \in (0,1)$. If this inequality holds in the opposite direction, then S_l^* decreases as θ increases.

4. Equilibria

We concentrate on Bayes-Nash Equilibria (BNE) in pure strategies. TN denotes the strategy whereby player i plays T if $t_i = t$, and N if $t_i = u$. TT, NT and NN are defined accordingly. The payoffs for the strategic representation of the game between players i and j are displayed in table 4.

Table 4.
Game in strategic form.

i \ j	TT	TN	NT	NN
TT	$(1-\theta)^2\alpha a$, $(1-\theta)^2\alpha a$	$(1-\theta)(\mu-\theta a)$, $(1-\theta)(\mu+\theta a)$	$a(1-\theta)[\theta+\alpha(1-\theta)]+\theta\mu$, $a(1-\theta)[-\theta+\alpha(1-\theta)]+\theta\mu$	μ,μ
TN	$(1-\theta)(\mu+\theta a)$, $(1-\theta)(\mu-\theta a)$	$(1-\theta^2)\mu$, $(1-\theta^2)\mu$	$-(1-\theta)\theta(\mu-a)+\mu$, $-(1-\theta)\theta(\mu+a)+\mu$	μ,μ
NT	$a(1-\theta)[-\theta+\alpha(1-\theta)]+\theta\mu$, $a(1-\theta)[\theta+\alpha(1-\theta)]+\theta\mu$	$-(1-\theta)\theta(\mu+a)+\mu$, $-(1-\theta)\theta(\mu-a)+\mu$	$(1-\theta)^2(\alpha a-\mu)+\mu$, $(1-\theta)^2(\alpha a-\mu)+\mu$	μ,μ
NN	μ,μ	μ,μ	μ,μ	μ,μ

The BNE depend on both the level of trust and the value of α. There are two relevant thresholds with respect to the level of trust: $\tilde{\theta}_1 = -(\mu-\alpha a)/(a(1+\alpha))$, and $\tilde{\theta}_2 = (a-\mu)/a$. It is easy to see that when $\alpha \geq \mu/a$, then $\tilde{\theta}_1 \in [0,1)$. However, if $\alpha < \mu/a$, then $\tilde{\theta}_1 < 0$. In this case, it becomes an irrelevant threshold. On the other hand, $\tilde{\theta}_2$ always falls in the interval $(0,1)$. Note also that $\tilde{\theta}_1$ is always smaller than $\tilde{\theta}_2$.

The equilibria are computed for all possible cases. These cases can be summarized as follows: (1) $\alpha \geq \mu/a$, and $\theta \in (0, \tilde{\theta}_1)$; (2) $\alpha \geq \mu/a$, and $\theta \in [\tilde{\theta}_1, \tilde{\theta}_2)$; (3) $\alpha \geq \mu/a$, and $\theta \in [\tilde{\theta}_2, 1)$; (4) $\alpha < \mu/a$, and $\theta \in (0, \tilde{\theta}_2)$; and (5) $\alpha < \mu/a$, and $\theta \in [\tilde{\theta}_2, 1)$. Table 5 shows the BNE of the game. For each of the five cases mentioned above, multiple equilibria exist; some of them predict an equilibrium with trade, and some predict an equilibrium without trade.

Table 5.
Bayes-Nash Equilibria in pure strategies

	$\theta \in (0, \tilde{\theta}_1)$	$\theta \in [\tilde{\theta}_1, \tilde{\theta}_2)$	$\theta \in [\tilde{\theta}_2, 1)$
$\alpha \geq \frac{\mu}{a}$	(NN,TT), (TT,NN), (NN,NT), (NT,NN), (NN,NN)	(NN,NT), (NT,NN), (NN,NN)	(TT,TT), (NN,NT), (NT,NN), (NN,NN)
$\alpha < \frac{\mu}{a}$	(NT,NT), (NN,NN)		(TT,TT), (NT,NT), (NN,NN)

Consider the untrustworthy high-costs case ($\alpha \geq \mu/a$). Based on the BNE, the following results are obtained:

a) Society requires a minimum level of trust in order to observe an equilibrium with trade. This minimum level of trust is $\tilde{\theta}_2$.
b) If $\theta \geq \tilde{\theta}_2$, equilibrium with trade is not the only possible outcome. Equilibrium without trade could also be observed.
c) The minimum level of trust required to observe trade in a given society ($\tilde{\theta}_2$) decreases as contract enforcement (a) improves. Moreover, the closer to perfect it is, the more the minimum level approaches zero.

Results (a) and (b) imply that when $\theta \in (0, \tilde{\theta}_2)$, the outcome will be an equilibrium without trade. An equilibrium with trade can only be observed when $\theta \in [\tilde{\theta}_2, 1)$. However, even where $\theta \geq \tilde{\theta}_2$, some equilibria predict an outcome without trade. Actually, only one of the four possible equilibria predicts an outcome with trade (TT,TT). Result (c) follows from the fact that $\partial \tilde{\theta}_2 / \partial a < 0$, and $\lim_{a \to \mu} \tilde{\theta}_2 = 0$.[2] This last result implies that if contract

[2] Only for this case, this result requires that $\alpha = 1$. Perfect contract enforcement has some restrictions in this model. From assumption 1, we have $a < \mu < 0$. Moreover, in the case under consideration, $\alpha \geq \mu/a$. Thus, for this case, it only makes sense to take into account values of a smaller or equal to $\alpha\mu$. Actually, if contract enforcement were perfect (or more generally, if a were larger than μ), then individuals would always have an incentive for choosing T.

enforcement works well enough, an equilibrium with trade may yet be observed, regardless of the level of trust.

Now, consider the untrustworthy low-costs case ($\alpha < \mu/a$). From the BNE, the following results are obtained:

a) An equilibrium with trade can be observed under any level of trust. However, since there are multiple equilibria, most of them predicting no-trade, this cannot be the only observed outcome.
b) If $\theta \in \left(0, \tilde{\theta}_2\right)$, and there exists an equilibrium with trade in a given society, then the case can only involve untrustworthy individuals. More specifically, under this scenario, trustworthy types will always choose N.
c) The minimum level of trust required to observe trading in a given society that involves trustworthy types is $\tilde{\theta}_2$.

Unlike with the untrustworthy high cost case, in this case, there is no required minimum level of trust in order that we observe trading activity in the given society. However, if trust is low enough, only untrustworthy individuals will be willing to trade. Under such a scenario, trustworthy types are outside of the market (as in Akerlof, 1970). Trustworthy players are only willing to trade if the level of trust is sufficiently high (i.e., larger or equal to $\tilde{\theta}_2$). As we already know, this threshold decreases as contract enforcement improves.

So far, these results show that the level of trust affects the volume of trade in a given society. However, even when the level of trust is high enough, it is possible to observe an equilibrium without trade. These results raise the following questions. Assuming that the level of trust is high enough to observe trading activity, under what conditions are we more likely to observe an equilibrium with trade? In particular, how do trust and contract enforcement affect the probability of observing trade in a given society? These issues are considered in the next section.

5. Refinement of Equilibria

From section 4, we already know that when $\alpha \geq \mu/a$, the only equilibrium that predicts trading activity is (TT, TT). On the other hand, when $\alpha < \mu/a$, there are two equilibria wherein trade is observed: (TT, TT), (NT, NT). However, under this last equilibrium, only untrustworthy individuals are willing to trade. What we are interested in knowing is under which circumstances are we more likely to observe an equilibrium wherein trade exists for every pair (i.e., (TT, TT)). Note that this equilibrium is only observed when $\theta \geq \tilde{\theta}_2$.

In order to see this, we use Quantal Response Equilibria (QRE). As with other types of refinements, the idea behind QRE is that players make infinitesimal errors in choosing best strategies. With this type of refinement, best response functions become probabilistic. This allows us to make statistical rather than deterministic predictions regarding equilibrium strategies. In other words, by using QRE, it is possible to compute the probability that an individual will play a certain strategy. Actually, these probabilities represent the QRE. A detailed description of the QRE can be found in McKelvey and Palfrey (1995, 1998).

Since analytical solutions of the QRE are not easily tractable, we use some simulations in order to see how the probability of observing the strategy profile (TT, TT) at equilibrium (hereafter, $\pi_{i,TT}$) is affected as either trust or contract enforcement change. We assume a logistic distribution in the error term of the payoffs, and use the following set of parameters in the simulations: $a = -.5$, $\mu = -0.35$, and $\alpha = 1$. Notice that under these parameters, $\tilde{\theta}_2 = .3$. This level of trust is a little bit below the average measure of trust computed from the *World Values Surveys 1990-1993*, which is 0.35.[3] Notice also that these parameters restrict our case to one where $\alpha \geq \mu/a$. The results of the simulation do not change in any important way for the case where $\alpha < \mu/a$. Additionally, these results are not affected in any important way when we use a different set of parameters. Gambit-Version 0.2007.01.30 was used to obtain the QRE (McKelvey, McLennan, and Turocy, 2007).[4]

Figures 2 and 3 depict how $\pi_{i,TT}$ changes as the parameter λ in the logistic function changes, for different values of trust and contract enforcement. Parameter λ is inversely related to the error that players accumulate in predicting their payoffs. Therefore, $\lambda = 0$ means that players' actions consist of all error (In this case $\pi_{ij} = 1/J_i$, where J_i is the number of pure strategies of player i), and $\lambda = \infty$ means that there is no error. Consequently, high values for λ are related to the experience or the learning of players in the game (McKelvey and Palfrey, 1995).[5]

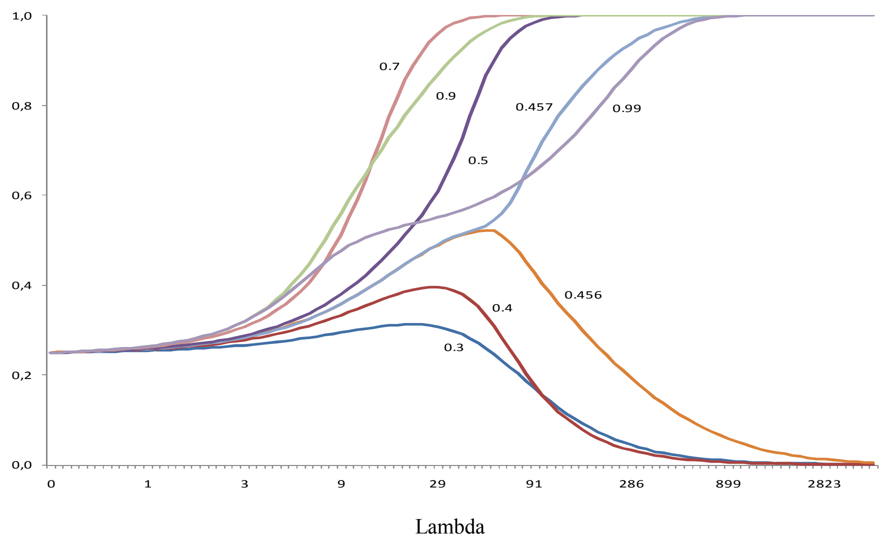
Figure 2 shows how $\pi_{i,TT}$ changes as θ goes from $\tilde{\theta}_2$ to 1. The following results are obtained:

a) If θ is high enough (and only if θ is high enough), then $\pi_{i,TT} \to 1$ as $\lambda \to \infty$. Otherwise, $\pi_{i,TT} \to 0$ as $\lambda \to \infty$.
b) If θ is high enough, then $\pi_{i,TT}$ always increases as λ increases.
c) If we hold λ constant, $\pi_{i,TT}$ does not always increases with θ.

[3] This measure represents the fraction of people in each of 40 countries that answered in favor of the first choice to the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful when dealing with people?"
[4] The normal form of the game reported in Table 4 was used for the simulations. It is important to take into account that McKelvey and Palfrey (1998) showed that the QRE for extensive form games makes predictions that contradict the invariant principle.
[5] Our game is played for only one single period. Individuals can learn by playing the same game several times. In this case, it is necessarily to assume that the probability of being paired with the same partner over more than one period is zero. This avoids building-reputation issues.

In the simulation, if the level of trust is smaller or equal to 0.456, then $\pi_{i,TT}$ goes to zero as λ approaches infinity. Nevertheless, this probability goes to one as λ approaches infinity if the level of trust is higher or equal to 0.457. Statement (a) follows from this result. In other words, it states that if the level of trust is high enough, and players accumulate experience playing the game, strategy TT will be chosen with a probability of 1. Under such a scenario, one will observe an equilibrium with trade for every pair. Result (b) states that if the level of trust is high enough (i.e., above 0.456 in the simulation), then the probability that player i will choose TT will always increase as his or her experience playing the game increases.

Figure 2.
Quantal Response Equilibrium: changes in $\pi_{i,TT}$ as θ changes.



Result (c) indicates that for the same level of experience (λ), $\pi_{i,TT}$ does not necessarily increase as the level of trust increases. For instance, consider the case in the simulations wherein $\lambda = 29$. If θ goes from 0.5 to 0.7, then $\pi_{i,TT}$ increases. However, if θ goes from 0.7 to 0.9, $\pi_{i,TT}$ decreases. Thus, it is not necessarily the case that the probability of observing an equilibrium with trade in a given society increases as the level of trust increases. This only happens for intermediate values of θ.

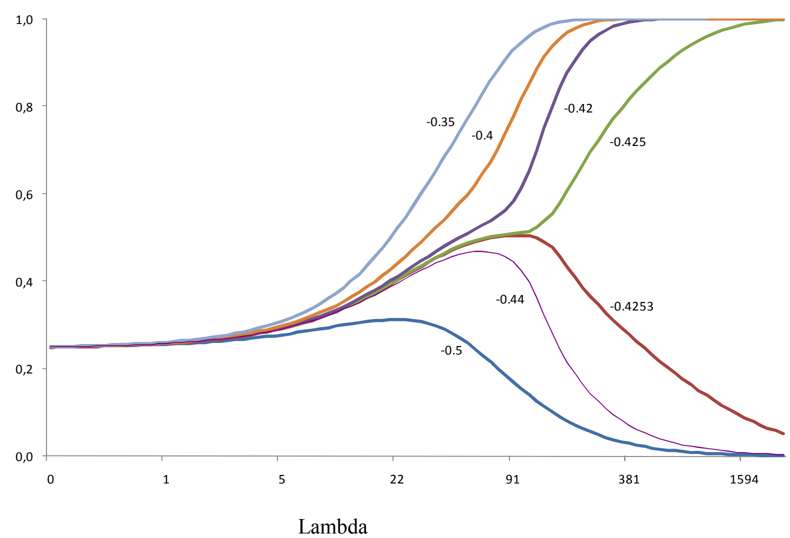
Now, let us consider the effects of contract enforcement on $\pi_{i,TT}$, which are illustrated in Figure 3. In this simulation, $\theta = 0.3$. The following results are obtained:

a) If a is low enough, then $\pi_{i,TT} \to 1$ as $\lambda \to \infty$; otherwise, $\pi_{i,TT} \to 0$ as $\lambda \to \infty$.
b) If a is low enough, then $\pi_{i,TT}$ always increases as λ increases.

These results are similar to those reported for the effect of θ on $\pi_{i,TT}$. When $a \leq -0.4253$ in the simulation (i.e., law enforcement works relatively badly), then $\pi_{i,TT}$ approaches zero as λ approaches infinity. For any $a > -0.4253$, the probability approaches one.[6] In other words, if law enforcement works relatively well, and players accumulate experience in the game, then they will choose strategy TT with a probability of 1. Under such a scenario, one observes an equilibrium with trade for every pair.

Result (b) indicates that if contract enforcement works relatively well, then the probability with which player *i* chooses TT always increases as his or her experience playing the game increases. Unlike with the simulation reported in figure 2, here $\pi_{i,TT}$ always increases as a decreases for any given value of λ. However, this result cannot be generalized. If we hold λ constant, it happens in some simulations that $\pi_{i,TT}$ decreases as a decreases for low values of a.

Figure 3.
Quantal Response Equilibrium: changes in $\pi_{i,TT}$ as a changes.



6. Welfare considerations

As we have seen in section 5, the combination of individual experience (λ high) with a high level of trust can lead to a scenario whereby there is an equilibrium with trade for every pair (i.e., $\pi_{i,TT} = 1 \;\; \forall i$) in a given society. On the other hand, low levels of trust (though still larger than $\widetilde{\theta}_2$) can lead to the opposite scenario, i.e. one without trade for

[6] The simulations where $a = -0.4252$ are not shown in figure 3 for presentation reasons. In this case, $\pi_{i,TT}$ only approaches one for very high values of λ.

every pair. In this section, we analyze whether high levels of trust, which lead to an equilibrium with trade for every pair, are socially desirable or not.

First, let us compute the total social surplus when there is an equilibrium with trade for every pair. If two trustworthy individuals are paired, the total generated surplus for this match is zero. If a trustworthy individual is paired with an untrustworthy individual, the total generated surplus for this pair is also zero. Finally, if two untrustworthy individuals are paired, the total generated surplus is $2\alpha a$. Thus, the social expected surplus if everybody chooses T is given by:

$$S_T = \alpha(1-\theta)^2 na \qquad (3)$$

Notice that S_T increases as the level of trust increases.

Second, let us consider the expected surplus achieved when everybody chooses a strategy whereby there is an equilibrium without trade for every pair. If this happens, the social expected surplus is given by:

$$S_N = n\mu \qquad (4)$$

First comparing S_T and S_N, we obtain the following results:

a) For an untrustworthy high cost case ($\alpha \geq \mu/a$): if $\alpha = \mu/a$, then $S_T > S_N$ for every $\theta \in (0,1]$. If $\alpha > \mu/a$, then there always exists a unique $\overline{\theta} \in (0,1)$ for which, if $\theta > \overline{\theta}$, then $S_T > S_N$. Moreover, $\overline{\theta} < \widetilde{\theta}_2$.
b) For an untrustworthy low cost case ($\alpha < \mu/a$): in this case $S_T > S_N$ for every $\theta \in [0,1]$.

Results (a) and (b) can be understood in the following way. They indicate that if the level of trust is above $\widetilde{\theta}_2$, then the surplus generated in a given society whereby everybody is trading is always larger than the respective surplus when nobody is trading. Thus, a high enough level of trust combined with relatively high players' experience is always preferred over a low level of trust.

Let us now compare the efficient expected surplus with S_T and S_N respectively. First, we consider the untrustworthy high cost case ($\alpha \geq \mu/a$). Under these circumstances, the efficient expected surplus is represented by S_h^* (see equation 1). The following results are obtained:

a) $S_N < S_h^*$, for every $\theta \in (0,1]$.
b) If $\alpha = \mu/a$, then $S_T > S_h^*$ for every $\theta \in (0,1)$.

c) If $\alpha > \mu/a$, then there always exists a unique $\breve{\theta} \in (0,1)$ for which, if $\theta > \breve{\theta}$, then $S_h^* < S_T$. Moreover, $\breve{\theta} < \widetilde{\theta}_2$.

On the one hand, result (a) indicates that an equilibrium where nobody trades is always inefficient, regardless of the level of trust. Thus, a relatively low level of trust (though still larger than $\widetilde{\theta}_2$), can lead a given society to achieve an equilibrium without trade, which is undesirable. On the other hand, results (b) and (c) indicate that if the level of trust is above $\widetilde{\theta}_2$, an equilibrium with trade for every pair is always socially desirable. This is so, because $S_T > S_h^*$ for any $\theta > \widetilde{\theta}_2$.

Finally, let us consider the untrustworthy low cost case ($\alpha < \mu/a$). Under these circumstances, the efficient is represented by S_l^* (see equation 2). The following results are obtained:

a) $S_N < S_l^*$ for every $\theta \in [0,1]$.
b) $S_T > S_l^*$ for every $\theta \in (0,1]$.

Result (a) indicates that an equilibrium where nobody trades is always inefficient, regardless of the level of trust. Result (b) indicates that an equilibrium with trade is always socially desirable.

From our discussion in this section, we conclude that an equilibrium with trade for every pair (i.e., where $\pi_{TT} = 1 \ \forall i$) is always socially desired if the level of trust is above the threshold $\widetilde{\theta}_2$. Since this is a necessary condition in order to observe a scenario where everybody is trading, then $\pi_{TT} = 1$ is always desirable.

7. Conclusions

This paper shows that the level of trust affects the volume of trade. There are two ways in which this happens. First, societies need a minimum level of trust in order to observe trading activity. If this minimum level is not satisfied, then an equilibrium without trade is always observed. Second, once the level of trust is above this minimum level, the probability of observing an equilibrium with trade approaches one, if both the level of trust and players' experience are high enough. Otherwise, the probability tends towards zero. These results explain the empirical findings showing a positive relationship between the level of trust and the volume of sales and the value added of trade.

The paper also shows that institutions can compensate for low levels of trust. There are two channels through which this operates. First, when contract enforcement works perfectly, the minimum level of trust required to observe trading activity in a given society approaches zero. Second, given a certain level of trust, the probability of observing an equilibrium with trade approaches one when contract enforcement works relatively well. These results imply that, in order to achieve similar volumes of trade, societies with low levels of trust must spend a higher amount of resources on increasing the quality of institutions than societies that have high levels of trust.

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Appendix

Bayes-Nash Equilibria

Consider the strategic representation of the game presented in table 4. Best response arguments are used in order to find the BNE in pure strategies. The following thresholds for the level of trust are used: $\tilde{\theta}_1 = (\mu - \alpha a)/(-a(1+\alpha))$, and $\tilde{\theta}_2 = (a-\mu)/a$.

Untrustworthy high-costs case ($\alpha \geq \mu/a$). Consider a pair consisting of players i and j. First, let us assume that player j adopts strategy TT. Player i will then prefer strategy TT to TN if and only if $\theta \geq \tilde{\theta}_1$, TT to NT if and only if $\theta \geq \tilde{\theta}_2$, TN to NN if and only if $\theta \geq \tilde{\theta}_2$, and NT to NN if and only if $\theta \geq \tilde{\theta}_1$. From here, we conclude that if j adopts strategy TT, then player i's best response will be NN if $\theta \in (0, \tilde{\theta}_1)$; NT if $\theta \in [\tilde{\theta}_1, \tilde{\theta}_2)$; and TT if $\theta \in [\tilde{\theta}_2, 1)$.

Second, let us assume that player j adopts strategy TN. Under such a scenario, player i's best response is TT. This result follows from the following comparisons. First, player i prefers strategy TT to TN if and only if $-a \geq \mu$, which is always satisfied. Second, player i prefers strategy TT to NT if and only if $-\theta^2 \mu \geq 0$, which also is always satisfied. Finally, player i prefers strategy TT to NN if and only if $-(1-\theta)a \geq \mu$, which again, is always satisfied.

Third, let us assume that player j adopts strategy NT. In this case, player i's best response is NN. We obtain this result using the following reasoning. First, player i prefers strategy NN to TT if and only if $\theta \geq (\alpha a - \mu)/(-a(1-\alpha))$. Since $-a(\alpha - 1) > 0$, and from assumption 1 it follows that $\alpha a - \mu \leq 0$, then $(\alpha a - \mu)/(-a(1-\alpha)) \leq 0$. Thus, this inequality always holds because $\theta \in (0,1)$. Second, player i prefers strategy NN to TN if and only if $\mu \leq a$, which is always satisfied. Finally, player i prefers strategy NN to NT if and only if $\alpha a \leq \mu$, which is the actual case we are analyzing.

Finally, if player j adopts strategy NN, then any player i 's strategy is a best response. From this analysis, we conclude that:

1) If $\theta \in (0, \tilde{\theta}_1)$, then $BNE = \{(NN,TT),(NN,NT),(TT,NN),(NT,NN),(NN,NN)\}$;
2) If $\theta \in [\tilde{\theta}_1, \tilde{\theta}_2)$, then $BNE = \{(NN,NT),(NT,NN),(NN,NN)\}$; and
3) If $\theta \in [\tilde{\theta}_2, 1)$, then $BNE = \{(TT,TT),(NN,NT),(NT,NN),(NN,NN)\}$.

Untrustworthy low-costs case ($\alpha < \mu/a$). Consider a pair consisting of players i and j. First, let us assume that player j adopts strategy TT. Player i will then prefer strategy TT

to TN, and NT to NN. This happens because $\alpha a > \mu$. Additionally, player i prefers strategy TT to NT if and only if $\theta \geq \widetilde{\theta}_2$; and TN to NN if and only if $\theta \geq \widetilde{\theta}_2$. From here, we can conclude that if j adopts strategy TT, then i's best response is NT if $\theta \in (0, \widetilde{\theta}_2)$, and TT if $\theta \in [\widetilde{\theta}_2, 1)$.

Second, let us assume that player j adopts strategy TN. The same arguments presented for the scenario wherein $\alpha \geq \mu/a$ can be use to show that, in this case, player i's best response is *TT*.

Third, let us assume that player j adopts strategy NT. In this case, player *i*'s best response is NT. We obtain this result using the following reasoning: first, since $a > \mu$, player i prefers strategy NT to TT. Second, player i prefers strategy NT to NN if and only if $\alpha a > \mu$, which is always satisfied. Finally, player i prefers strategy NN to TN if and only if $a < \mu$, which is also always satisfied. By transitivity, it follows that player i always prefers strategy NT to TN.

Finally, if player j adopts strategy NN, then any player i 's strategy is a best response. From this analysis, one can conclude that:

1) If $\theta \in (0, \widetilde{\theta}_2)$, then $BNE = \{(NT, NT), (NN, NN)\}$; and
2) If $\theta \in [\widetilde{\theta}_2, 1)$, then $BNE = \{(TT, TT), (NT, NT), (NN, NN)\}$.

Efficiency considerations

Comparing S_T and S_N. Consider the expressions for S_T and S_N given in equations 3 and 4. On the one hand, notice that $\partial S_T / \partial \theta > 0$, $\lim_{\theta \to 0} S_T = n\alpha a$, and $\lim_{\theta \to 1} S_T = 0$. On the other, S_N equals $n\mu$ for every θ. Therefore, if $\alpha = \mu/a$, then $S_T > S_N$ for every $\theta \in (0,1]$; and if $\alpha < \mu/a$, then $S_T > S_N$ for every $\theta \in [0,1]$.

Only when $\alpha > \mu/a$ is $S_T < S_N$ for small values of θ. More exactly, this happens when $\theta < 1 - \sqrt{\mu/\alpha a} = \overline{\theta}$, with $\overline{\theta} \in (0,1)$. Thus, $S_T > S_N$ for every $\theta > \overline{\theta}$. Notice that $\widetilde{\theta}_2 > \overline{\theta}$ if and only if $\alpha\mu/a < 1$, which is always satisfied.

Comparing S_h^* and S_N. Using equations 1 and 4, we get $S_h^* > S_N$ if and only if $(1 - \theta^2) < 1$. This inequality is always satisfied for every $\theta \in (0,1]$.

Comparing S_h^* and S_T. Consider equations 1 and 3. Notice that $\partial S_T / \partial \theta > 0$, $\partial^2 S_T / \partial^2 \theta < 0$, $\lim_{\theta \to 0} S_T = n\alpha a$, $\lim_{\theta \to 1} S_T = 0$, and $\lim_{\theta \to 0} \partial S_T / \partial \theta > 0$. On the other hand, $\partial S_h^* / \partial \theta > 0$, $\partial^2 S_h^* / \partial^2 \theta > 0$, $\lim_{\theta \to 0} S_h^* = n\mu$, $\lim_{\theta \to 1} S_h^* = 0$, and $\lim_{\theta \to 0} \partial S_h^* / \partial \theta = 0$.

Remember that in this case, $\alpha > \mu / a$. Thus, if $\alpha = \mu / a$, based on the previous properties of S_T and S_h^*, we find that $S_T > S_h^*$ for every $\theta \in (0,1)$. In actual fact, these functions only take the same value at their limits. If $\alpha > \mu / a$, there is a unique root, $\breve{\theta} \in (0,1)$, at which these functions cross. This root is given by $\breve{\theta} = \frac{\mu - \alpha a}{-\mu - \alpha a} \in (0,1)$. Notice that $\breve{\theta} < \tilde{\theta}_2$ if and only if $(2 - \alpha)a < \mu$, which is always satisfied, since $\alpha > \mu / a$.

Comparing S_l^* and S_N. Using equations 2 and 4, $S_l^* > S_N$ if and only if $(1-\theta)^2 \alpha a > (1 - 2\theta(1-\theta))\mu$. Since $(1-\theta)^2 > 1 - 2\theta(1-\theta) > 0$, and $0 > \alpha a > \mu$, this inequality is satisfied for every $\theta \in [0,1]$.

Comparing S_l^* and S_T. Using equations 2 and 3, $S_l^* < S_T$ if and only if $2\theta\mu < 0$. This inequality is satisfied for every $\theta \in (0,1]$.