Vertical Cross–Shareholding
Theory and Experimental Evidence

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Abstract

This paper analyzes vertical cross-shareholding, that is, the mutual holding of a minority of shares between vertically related firms. We investigate the conditions under which cross-shareholding improves efficiency. First, we explore the issue in a game-theoretic model and find that cross-shareholding is sufficient to obtain the first-best solution. We then proceed by testing these predictions experimentally. Our findings are that the theory predicts the sellers' decisions accurately and to some extent the price bids of the buyers. Cross-shareholding appears to occur more frequently than predicted and it enhances efficiency even where not predicted.

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1 Introduction

Cross-shareholding usually refers to the holding of shares between two or more firms that gives each of them an equity stake in the others. Firms hold only a minority of shares or nonvoting shares; that is, cross-shareholding does not imply merger. Furthermore, the investments in other firms are passive so each firm retains fully its decision power.

Cross-shareholding has received a lot of attention in the industrial organization literature. However, this attention has been exclusively restricted to the case of horizontally related firms, i.e. firms operating in the same industry. The literature provides ample evidence for cross-shareholding in the United States, the European Union, Japan and elsewhere (e.g. see Gilo, 2000; Gilo, Mosse and Spiegel; 2005). Several theoretical papers argue that horizontal cross-shareholding softens competition.[1] This literature shows that horizontal cross-shareholding may increase static Nash equilibrium prices (unilateral effects) as well as the likelihood of collusion (coordinated effects).[2] Intuitively, when firms share profits to some extent, the incentives for competitive pricing are reduced.

The main novelty of this paper is to analyze cross-shareholding in vertical relations like those occurring between producers and retailers or sellers and buyers. Vertical cross-shareholding is as a phenomenon at least as common as horizontal cross-shareholding. Some of the worlds largest manufacturers like Toyota and Nissan in the car industry, Hitachi and Sony in the consumer-electronic industry belong to a web of vertically related firms known in Japan as *keiretsus* (Uryu et al., 1993). In Europe also several Swiss companies, including Swisscom and railway operator SBB, have cross-ownership agreements with input-good suppliers.

The analysis of vertical cross-shareholding and its effect on social welfare is also necessitated by the deregulation taking place in various sectors such as the energy and the media sector. For example, while a number of countries still retain strict restrictions to any form of shareholding between generators and transmitters of electricity (e.g. Argentina), others like Australia (State Government of Victoria, 2005), Belgium (Pepermans and Willems, 2005) and the European Commission (2004) are considering vertical cross-shareholding as a more efficient way of organizing the electricity sector. Vertical cross-shareholding avoids, to a large extent, the problem of double marginalization (see Tirole, 1988) without fully eliminating competition. Similarly, the U.S Federal Communication Commission recently abolished the cap in shareholding between cable firms and TV channels initiating debates about the effects of this decision, which also paved the way for the merger between AOL and Time-Warner[3]. The analysis of cross-shareholding is also important and expected to contribute to the ongoing debate for the cross-

[1] See Reynold and Snapp (1986), Farell and Shapiro (1990), Flath (1991, 1992), Bolle and Güth (1992), Malueg (1992), Reitmann (1994), Dietzenbacher, Smid and Volkerink (2000), and Gilo, Mosse and Spiegel (2005).

[2] Horizontal cross-shareholding has also been analyzed in the corporate finance literature. The main issue there is that cross-shareholding often serves as a means of preventing unsolicited takeovers. For a recent paper, see Arikawa and Kato (2004).

[3] See *The Guardian (*February 21st 2005)

ownership between airport operators and airlines (e.g. Serebrisky, 2003). Given the prevalence of vertical cross-shareholding and its potential influence on social welfare, we think it deserves more attention.

The first part of our paper is a game-theoretic analysis of vertical cross-shareholding. In the first stage of our model a buyer and a seller make a decision whether or not to invest in each other's firm. Then, in the second stage, the buyer makes an offer for a good whose value, however, is unknown to him. The seller, who knows the real value of the good, has simply to decide whether to accept or reject the buyer's offer. Trade improves welfare, because the seller's valuation of the good is smaller than the buyer's. However, due to the information asymmetry trade will often fail as the buyer will offer a price that does not cover the seller's valuation of the good. In such cases, we show that the resulting loss of efficiency under vertical separation does not occur with cross-shareholding. More precisely, vertical cross-shareholding is often necessary and always sufficient to guarantee trade. Efficiency can prevail in any case without a complete merger.[4]

The second part of the paper tests the hypotheses derived in the first part by using a laboratory experiment. Generally, experimental economics has successfully contributed to the understanding of vertical firm relations.[5] In our context, the data might, for example, indicate whether cross-shareholding supports vertical relations beyond the predicted strategic effects or even in the complete absence of them. Vertical cross-shareholding may help establishing and enforcing such business relations.We aim to provide an answer to the question why firms hold shares at a level which does not allow them directly to influence decisions. The reasons behind vertical cross-shareholding will differ from those for horizontal agreements, just like vertical mergers typically have other motives than horizontal mergers.

In section 2 we describe and analyze the market model. In section 3 we analyze the incentives for investing in cross-shareholding. The experimental design is introduced in section 4 before describing and analyzing the data in section 5. Section 6 concludes.

2 The Model

We analyze bargaining between a buyer and a seller. The model has two decision stages. In the first stage, the buyer and the seller can invest in shareholding. In stage two, the players decide about the trading of the product.

Player S is the majority shareholder of the seller firm and player B is the majority shareholder of the buyer firm. In the second stage, there is a share τ with $0 \leq \tau < 1/2$ which is B's share of the seller firm's profit, π_S, and a share t with $0 \leq t < 1/2$ which is S's share of the buyer firm's profit, π_B. The player holding the majority share of a firm is solely responsible for the decisions of that firm. That is, S alone

[4] In our setup, negative welfare effects from vertical corss-shareholding, e.g. due to foreclosure (Rey and Tirole, 2000; Martin, Normann and Snyder, 2001), cannot occur as we have only one downstream player. But vertical cross-shareholding can (at least in principle) cause foreclosure effects, and we intend to analyze this in future research.

[5] See Durham (2000), Mason and Phillips (2000); Martin, Normann and Snyder (2001); Kruse et al. (2003).

will decide for the seller firm and B alone will decide for the buyer firm.

Denote by $v \in (0,1)$ the buyer firm's value of the indivisible good. We assume that only the S knows the good's value v because S is in the possession of the good, and S cannot inform B about v.[6] But the seller firm evaluates the good only by qv with $q \in (0,1)$.[7] It follows that there is always a positive surplus $(1-q)v > 0$ from trade. B's beliefs concerning v are given by the uniform density on $(0,1)$ and this is commonly known. Thus the triple

$$(\tau, t, q) \in [0, 1/2) \times [0, 1/2) \times (0,1)$$

fully describes the market.

For all (τ, t, q) games the market decision process in the second stage is as follows. Not knowing v, buyer B determines a price offer $p \geq 0$. Knowing v and the price offer p, seller S accepts or rejects the offer. If the good is traded, the seller firm earns $\pi_S = p - qv$ and the buyer firm $\pi_B = v - p$. If there is no trade, both profits π_S and π_B are zero. Accordingly, S earns $U_S = (1-\tau)\,\pi_S + t\pi_B$ and B earns $U_B = \tau\pi_S + (1-t)\,\pi_B$.

3 The solution of the game

3.1 Price and trading decisions

We begin by analyzing stage two and examine the investment stage in the following section. Consider player S's decisions. S will accept the price offer p if and only if his payoff from trade is non-negative, that is, if and only if

$$(1-\tau)\,(p - qv) + t\,(v - p) \geq 0$$

or

$$(1 - \tau - t)\,p \geq [q\,(1-\tau) - t]\,v.$$

If $q\,(1-\tau) - t \leq 0$ or, equivalently,

$$q \leq \frac{t}{1-\tau},$$

this condition is always fulfilled since $1 - \tau - t > 0$. In this case, every price $p \geq 0$ would be accepted by all seller types $v \in (0,1)$. If, however, $q > t/\,(1-\tau)$, there will only be trade with values v satisfying

$$v \leq \frac{1-\tau-t}{q\,(1-\tau) - t}p. \tag{1}$$

Note that the factor of p exceeds 1 since $q \in (0,1)$.

[6] Even if S could communicate with B, his indication of the true value of the good would not be credible.

[7] This underevaluation of a good by its seller is a typical situation for any interaction in markets. Otherwise the seller would simply keep the good to himself.

We now consider player B's decision on the price p for the good. B earns $U_B = \tau\pi_S + (1-t)\,\pi_B$. Since $v < 1$ and using inequality (1), B will never bid more than

$$\overline{p} = \frac{q\,(1-\tau) - t}{1-t-\tau}.$$

We call $\overline{p}$ the border price. Biding $\overline{p}$ induces trade regardless of the realization of v. If $p < \overline{p}$, some high-value sellers will reject. Note $t = \tau = 0$ implies $\overline{p} = q$ as expected.

In order to derive the expected payoff of B, we have to distinguish the two cases relevant for player S's decision derived above. If $q \leq t/\,(1-\tau)$, B's expected payoff is

$$\begin{aligned} U_B &= \int_0^1 \left[\tau\,(p - qv) + (1-t)\,(v-p)\right] dv \\ &= \int_0^1 (1-t-q\tau)\,v dv - (1-t-\tau)\,p \end{aligned}$$

Due to $t, \tau < 1/2$, the factor $-\,(1-t-\tau)$ is negative and player B will thus choose $p^* = 0$. As noted above, this nevertheless induces trade. If $q > t/\,(1-\tau)$, from (1), B's expected payoff is

$$\begin{aligned} U_B &= \int_0^{\frac{1-\tau-t}{q(1-\tau)-t}p} \left[(1-t-\tau q)\,v - (1-t-\tau)\,p\right] dv \\ &= \frac{1-2q+t+\tau q}{2\left[q\,(1-\tau)-t\right]^2}\,(1-t-\tau)^2\,p^2. \end{aligned}$$

Provided

$$1 - 2q + t + \tau q > 0,$$

that is,

$$q < \frac{1+t}{2-\tau}$$

this expected payoff increases in p.

Note that the expected payoff increases in p only up to $\overline{p}$ since prices $p > \overline{p}$ do not increase the likelihood and profitability of trade any further. Hence, if $q < (1+t)/(2-\tau)$, B will choose the border price $p^* = \overline{p}$ which induces trade for all v. Since $(1+t)/(2-\tau) > t/\,(1-\tau)$ such q exists. If $q \geq (1+t)/(2-\tau)$, B's expected payoff decreases with p and hence $p^* = 0$. Here, $p^* = 0$ precludes trade although the surplus is positive.

The results are summarized in the following proposition.

Proposition 1. *If $q \leq t/\,(1-\tau)$, B bids $p^* = 0$ and S accepts. The seller firm's profit is $\pi_S = -qv$ and the buyer firm's profit is $\pi_B = v$. The payoffs of player S and player B are*

$$U_S = \left[t - (1-\tau)\,q\right] v \tag{2}$$

and

$$U_B = (1 - t - \tau q)\,v \tag{3}$$

respectively.

If $q > t/(1-\tau)$, *we distinguish two cases. (i) If* $q < (1+t)/(2-\tau)$, B *proposes* $p^* = \overline{p}$ *and* S *accepts the offer. The seller firm's profit is* $\pi = \overline{p} - qv$ *and the buyer firm's profit is* $u = v - \overline{p}$. *The payoffs of player* S *and player* B *are*

$$U_S = q(1-\tau) - t + [t - (1-\tau)q]v \tag{4}$$

and

$$U_B = -[q(1-\tau) - t] + (1 - t - \tau q)v \tag{5}$$

respectively. (ii) If $q \geq (1+t)/(2-\tau)$, B *bids* $p^* = 0$ *and* S *rejects. Profits and payoffs are zero.*

The payoffs in (2), (3), (4) and (5) are realized payoffs. Expected payoffs are obtained by replacing v with its expected value of $1/2$ in these equations.

Note that trade at $p^* = 0$ for any $v \in (0,1)$ is a novel bargaining phenomenon. This is possible only with cross-shareholding as it requires $t > 0$, that is, that the seller needs to participate in the buyer firm's profit. In the other case where trade occurs, the requirement $t/(1-\tau) < q < (1+t)/(2-\tau)$ causes all types $v \in (0,1)$ of seller S to accept the border price $\overline{p} = (q(1-\tau) - t)/(1-t-\tau)$. Without cross-shareholding, this is possible only if $q < 1/2$ and at the border price $\overline{p} = q$.

3.2 Cross-shareholding decisions

Proposition 1 deals with the effects of the different parameters on the trade decision of the buyer and the seller. In this section, we will look at the predictions of the model regarding the decision of the two parties whether or not to invest in cross-shareholding in the first stage.

Initially, we assume that $\tau = t = 0$, that is, S completely owns the seller firm and B owns the buyer firm. Further, we assume that S decides about shareholding before learning about v. Cross-shareholding can be achieved as follows. Player S determines

$\bar{\tau}$	the maximum share of the seller firm he is willing to give to B
$\underline{C}_S$	the minimum payment he requires for a share of at most $\bar{\tau}$
$\underline{t}$	the minimum share of the buyer firm he demands
$\bar{C}_B$	the maximum payment for a share of at least $\underline{t}$

Similarly B determines independently $\left(\underline{\tau},\ \underline{C}_B,\ \bar{t},\ \bar{C}_S\right)$ with the analogous interpretation.

These choices must satisfy

$$\bar{\tau},\ \underline{t},\ \underline{\tau},\ \bar{t} \in [0, 1/2) \text{ and } \underline{C}_S,\ \bar{C}_B,\ \underline{C}_B,\ \bar{C}_S \geq 0.$$

If $\bar{\tau} < \underline{\tau}$, $\bar{t} < \underline{t}$, $\bar{C}_B < \underline{C}_B$ or $\bar{C}_S < \underline{C}_S$ then $\tau = t = 0$ pertains and there is no monetary transfer from S to B or vice versa. In that case, the $(0,0,q)$ game as described above is played in stage two. If, however,

$$\underline{\tau} \leq \bar{\tau},\ \underline{t} \leq \bar{t},\ \underline{C}_B \leq \bar{C}_B \text{ and } \underline{C}_S \leq \bar{C}_S$$

then $\tau = \underline{\tau}$, $t = \underline{t}$ and S pays $\underline{C}_B$ to B and receives $\underline{C}_S$ from B and the (τ, t, q)-game is played in stage two.

Any equilibrium with $\tau > 0$ and $t > 0$ must satisfy $\underline{C}_S = \bar{C}_S$ and $\underline{C}_B = \bar{C}_B$ respectively. Otherwise a player giving away shares could earn more by demanding a higher payment. Similarly, $\tau > 0$ and $t > 0$ imply $\underline{\tau} = \bar{\tau}$ and $\underline{t} = \bar{t}$. Accordingly, we call *consistent* cross-shareholding any cross-shareholding where parameters ($\underline{\tau}$, $\bar{\tau}$, $\underline{t}$, $\bar{t}$, $\underline{C}_B$, $\bar{C}_B$, $\underline{C}_S$, $\bar{C}_S$) satisfy

$$\begin{aligned} \tau &= \underline{\tau} = \bar{\tau} > 0 \\ t &= \underline{t} = \bar{t} > 0 \\ C_B &= \underline{C}_B = \bar{C}_B \\ C_S &= \underline{C}_S = \bar{C}_S \end{aligned} \tag{6}$$

We henceforth restrict the analysis to consistent cross-shareholding and only use the notation τ, t, C_B and C_S.There exist further equilibria with both parties offering deals which would not allow an improvement for the other party. Such equilibria are payoff dominated by consistent shareholding equilibria improving both players' payoff upon the $\tau = 0 = t$ status quo and are therefore avoided (Harsanyi and Selten, 1988).

Cross-shareholding must improve both players' payoff upon the status quo, $\tau = t = 0$. To find the conditions under which consistent cross-shareholding does lead to such improvements, we will calculate the expected payoffs both with and without shareholding and then compare them.

From the analysis above and Proposition 1, when there is no shareholding, that is when $\tau = t = 0$, we have $q > t/(1-\tau) = 0$. In that case, whether or not trade occurs depends on $q \gtrless (1+t)/(2-\tau)$, that is, on $q \gtrless 1/2$. If $q < 1/2$, we have $p^* = \overline{p} = q$ and there will be trade. If $q \geq 1/2$, buyer B bids $p^* = 0$ and S rejects the offer. Therefore $\tau = t = 0$ implies expected payoffs of

$$U_S(0,0) = \begin{cases} 0 & \text{for} \quad q \geq 1/2 \\ q/2 & \text{for} \quad q < 1/2 \end{cases} \tag{7}$$

for player S and

$$U_B(0,0) = \begin{cases} 0 & \text{for} \quad q \geq 1/2 \\ \frac{1}{2} - q & \text{for} \quad q < 1/2 \end{cases} \tag{8}$$

for player B.

Whether cross-shareholding improves payoffs depends on the conditions in Proposition 1 and on $q \gtrless 1/2$. So, in order to calculate the expected payoff with shareholding we distinguish the following cases:

Case 1: $q < 1/2$.

These values of q induce trade even with $\tau = t = 0$ and the market outcome is always efficient. Therefore, it is impossible to improve both players' payoffs and so there will be no cross-shareholding agreements.

Case 2.1: $q \geq 1/2$ and $q \leq t/(1-\tau)$.

From Proposition 1, both S and B have a positive payoff with shareholding, $U_B(t,\tau) > 0$ and $U_S(t,\tau) > 0$. In particular, payoffs are

$$U_B(t,\tau) = [1 - t - \tau q]\, v$$

(or $[1 - t - \tau q]/2$ in expected payoff terms) for S, and

$$U_S(t,\tau) = [t - (1-\tau)\, q]\, v$$

(or an expected payoff of $[t - (1-\tau)\, q]/2$) for B. When $\tau = t = 0$, from (7) and (8), $U_B(0,0) = U_S(0,0) = 0$. To improve payoffs above this zero level, net payments $C_S - C_B$ and $C_B - C_S$ have to be smaller than the expected payoffs. Hence, consistent shareholding yields an improvement for both players if

$$-[t - (1-\tau)\, q]/2 \leq C_S - C_B \leq [1 - t - \tau q]/2$$

Note that positive net payments in either direction are possible, that is, $C_S - C_B \gtrless 0$.

Case 2.2: $q \geq 1/2$ and $t/(1-\tau) < q < (1+t)/(2-\tau)$.

In this case, player S earns an expected payoff of

$$U_S(t,\tau) = [q(1-\tau) - t] + [t - (1-\tau)\, q]/2$$

and, similarly, B earns an expected payoff of

$$U_B(t,\tau) = [1 - t - \tau q]/2 - [q(1-\tau) - t]$$

Both expected payoffs are positive due to $q > t/(1-\tau)$ and $q < (1+t)/(2-\tau)$ as seen above. For shareholding to improve payoffs of both players, the expected payoffs minus the net payment must be non-negative, that is,

$$-[q(1-\tau) - t] - [t - (1-\tau)\, q]/2 \leq C_S - C_B \leq [1 - t - \tau q]/2 - [q(1-\tau) - t]$$

Note that $t/(1-\tau) < 1/2$ still allows for shareholding agreements in case 2.2 although $\tau = t = 0$ does not work since $q < (1+t)/(2-\tau) = 1/2$ is violated. Again, positive net payments in either direction are possible.

Case 2.3: $q \geq 1/2$ and $q \geq (1+t)/(2-\tau)$.

From Proposition 1 and equations (7) and (8) payoffs are equal to zero for both $\tau = t = 0$ and consistent constellations with shareholding. Hence, there can be no shareholding agreements. Note that $(1+t)/(2-\tau) \geq 1/2$ so $q \geq 1/2$ is not binding here.

Proposition 2 summarizes these results.

Proposition 2. *Consistent shareholding improves both players' payoffs over* $t = \tau = 0$ if and only if $q \geq 1/2$ and

$q \leq t/(1-\tau)$, *provided payments* (C_B, C_S) *satisfy*

$$-[1-(t-\tau)q]/2 \leq C_S - C_B \leq (1-t-\tau q)/2,$$

or $t/(1-\tau) < q < (1+t)/(2-\tau)$, *provided payments* (C_B, C_S) *satisfy*

$$-[q(1-\tau)-t] - [t-(1-\tau)q]/2 \leq C_S - C_B \leq [1-t-\tau q]/2 - [q(1-\tau)-t]$$

Table 1 summarizes all possible outcomes as implied by propositions 1 and 2. Proposition 2 does not argue normatively which shareholding outcome we expect to occur. Generally, cross-shareholding with ($\underline{\tau}$, $\bar{\tau}$, $\underline{t}$, $\bar{t}$, $\underline{C}_B$, $\bar{C}_B$, $\underline{C}_S$, $\bar{C}_S$) can be a Nash equilibrium if it improves payoffs over $t = \tau = 0$ for both players (proposition 2) and if it is consistent in the sense of (6). Obviously, many parameters satisfy these requirements and so there will be many Nash equilibria.

Will players have conflicting interest or can we Pareto rank any of the outcomes? Note that players S and B can always chose the parameters t and τ such that either $q \leq t/(1-\tau) < (1+t)/(2-\tau)$ or $t/(1-\tau) < q < (1+t)/(2-\tau)$ is satisfied. To see this recall $q < 1$. Now, $\lim_{t,\tau\to 1/2} t/(1-\tau) = 1$ and $\lim_{t,\tau\to 1/2}(1+t)/(2-\tau) = 1$. In other words, both ranges of parameters in proposition 2 which yield payoff improvements are feasible for any $q < 1$ if parameters t and τ are sufficiently close to 1/2. Whereas firms' profits differ depending on $q \gtrless t/(1-\tau) < (1+t)/(2-\tau)$, the sum of profits (and the sum of players payoffs) is the same as there is trade in both cases. The distribution of payoffs depends on the payments (C_B, C_S) in either case. It follows that we cannot Pareto rank the outcomes implied by consistent shareholding.

There is still an important conclusion to be made from these arguments. Note that the limit argument in the last paragraph shows that the no-trade outcome implied by $q > (1+t)/(2-\tau) > t/(1-\tau)$ will never occur. Either we have $q < 1/2$ and there is trade anyway, or we have $q > 1/2$ and shareholding with t, τ will induce trade. The policy implication is that efficiency does in no case require a complete merger (which would occur at $t = \tau = 1/2$). Cross-shareholding as an incomplete merger where each player is still fully independent in its decision making yields efficiency.

Proposition 3. *For any* q, $0 < q < 1$, *there will trade between the seller and the buyer if cross-shareholding is allowed but complete merger is ruled out. If* $q > 1/2$, *cross-shareholding is both necessary and sufficient to ensure trade.*

Finally, note that one-sided shareholding is not always sufficient to guarantee trade. Recall that there is no trade if $q > (1+t)/(2-\tau)$. One-sided shareholding either implies $t = 0$ and $\tau \in (0, 1/2)$ and hence

$(1+t)/(2-\tau) < 2/3$. Or it implies $\tau = 0$, $t \in (0, 1/2))$ and hence $(1+t)/(2-\tau) < 3/4$. In either case q values higher than 2/3 and 3/4, respectively, exist and in these cases trade will fail.

4 Experimental design and procedures

Our experiment is designed to test the predictions of the model. In total we ran four treatments, labelled T1, T2, T3 and T4. Treatments T1 and T2 correspond to case 1 above, and T3 and T4 correspond to cases 2.1 and 2.2 respectively.[8] All treatments are divided into two parts each of which lasts 20 periods.

Part A (periods 1-20) tests the predictions of the model regarding the bargaining stage only and keeps the level of shareholding fixed. Participants directly encounter the bargaining stage knowing the predetermined level of shareholding.[9] In T1, shareholding is fixed at $t = \tau = 0$, whereas in T2, T3 and T4, at $t = \tau = 0.4$. The parameters of the four treatments and the predictions for each of them are shown in Table 2. Note that although in both T1 and T2 one has $q = 0.3$, the different t, τ parameters lead to a different price prediction. T2 and T3 test (with q parameters other than those in T1) the prediction that trade is possible even at a price of zero, whereas T1 and T4 test the predictive power of the border price $\overline{p}$.

Part B (periods 21-40) implements also the shareholding stage of the model although in a simplified manner. Instead of allowing the participants to agree on some level of shareholding, we present them with a binary option: they can either exchange 40% of their firm's profit or keep the whole profit of their firm. Shareholding is implemented only if both players agree to the proposed agreement. As in part A, there are no payments for cross-shareholding, so, implicitly, $C_B = C_S = 0$. The reward for giving a percentage of one's own shares is the same percentage of shares of the other firm. Our parameters ensure shareholding is consistent in the sense of (6). In T1 and T2 no shareholding is predicted whereas in T3 and T4 it should occur. By comparing T1 and T2 we can control for a sequencing effect, that is, we can check whether experience with or without shareholding affects the choices made in part B. The simplification at the shareholding stage aims at making the experiment more readily accessible to the participants, as well as at creating enough homogeneous data for the subsequent analysis. After the shareholding decisions, subjects play the bargaining stage as in part A knowing whether or not cross-shareholding is implemented.

At the end of each period, the buyer and the seller are informed about the following: buyer's valuation of the good, the seller's valuation of the good, the price bid, the decision of the seller and individual profits (but not the other player's profit). If players agree on shareholding, they were reminded of that too and the payoff information would show how much payoff the buyer player received due to holding shares of

[8] We decided not to run any treatments in where no trade is the equilibrium as this would only cause frustration of participants. In particular, the case $(1+t)/(2-\tau) \le q$ is not analyzed in any treatment.

[9] As our setup is somewhat complex, we thought it useful to let subjects learn about the second stage of the experiment before deciding on shareholding.

the seller firm.

The value of the good is randomly chosen from a uniform distribution between 0 and 100. The price offered by the buyer can also vary between 0 and 100.

As the shareholding decisions in part B might violate the theoretical predictions (e.g. a buyer and a seller might engage in cross-shareholding even though this is against the predictions) we also need the predicted price and trade decisions for these cases. In T1 and T2 if players do invest in shareholding against the prediction, trade at a price of $p = 0$ should occur. In T3 and T4, if players do not invest in shareholding against the prediction, no trade at a price of $p = 0$ should occur.

The experiments were conducted in the laboratory at Royal Holloway, University of London, between October 2004 and January 2005. We ran eight sessions (two for each treatment) using a fixed matching protocol. We intended to have ten subjects per session but due to two subjects not showing up, the second session for treatment T4 had only eight participants. This gives us ten seller-buyer pairs for treatments T1, T2 and T3, nine pairs for T4, and a total of 78 participants. Exchange rates were different for each treatment and were chosen to yield similar earnings in Nash equilibrium. Each session lasted approximately an hour and a half and the average payment was £11.70 (including a £3 show-up fee).

5 Results

We will first consider the behavior of the buyers before turning our attention to that of the sellers and the effect of vertical cross-shareholding on social welfare. In the last part of this section we discuss the shareholding decisions.

5.1 Buyers' price bids

Table 3 summarizes the results of the bargaining stage by presenting, separately for parts A and B, the average price bids and the average prices accepted. In part B, due to the different predictions, we distinguish between price bids when firms are engaged in cross-shareholding and when they are not.[10]

As indicated by the large standard deviations, behavior is quite dispersed. Comparing across treatments and counting each seller-buyer pair as one observation, a Kruskal-Wallis test does not detect any significant price differences in part A. Figure 1 reveals that large differences between groups (that is, seller-buyer pairs) are accountable for this failure. The difference between the smallest and the largest group average is at least 22 in each treatment. The observed differences between average prices cannot be significant given this dispersion.

[10] As the shareholding decisions in part B often violate the predictions (e.g. a buyer and a seller might engage in cross-shareholding even though this is against the predictions), table 3 also contains the predicted price and trade decisions for these cases. In T1 and T2 if players do invest in shareholding against the prediction, trade at a price of $p = 0$ should occur. In T3 and T4, if players do not invest in shareholding against the prediction, no trade at a price of $p = 0$ should occur.

A general aspect of the data in all treatments is that, unsurprisingly, average accepted prices are significantly higher than price bids[11]. A further common aspect of all treatments is that there is a significant decrease in prices over time (Pearson's r, $p < 0.05$) in part A (but not in part B). In the last five periods of part A, average price bids are 17.48 in T1, 22.44 in T2, 21.08 in T3 and 26.04 in T4.

This first look at the data does not suggest strong support for the theory. By going through the various predictions, we will argue that the dispersion arises mainly from the weak equilibrium properties and less from violations of behavioral assumptions of the theory as they typically occur in bargaining experiments like the ultimatum game.

Let us consider first the treatments where trade at a price larger than zero is predicted. In T1 and T2, when there is no shareholding, the prediction is $p^* = 30$. Consider T1 part A. Figure 1 reveals that 3 our of 10 groups have average price around 30 and one group at 35 which is consistent with the theory. But four groups have an average at or below 15. In part B when there is no shareholding, average prices are 27.42 in T1 and 28.72 in T2, and average accepted prices are 32.88 (T1) and 31.67 (T2). These averages are relatively close to the prediction. Nevertheless, price bids are below the prediction and the dispersion among group remains (differences between the smallest and largest group average are around 35 in part B when there is no shareholding).

What may account for the deviations from the prediction? We believe that it might be difficult for buyers to learn in this environment. Consider a price bid of $p \leq 30$ in the first part of T1. The seller will accept if $p \geq qv = 0.3v$. This implies an expected value of the good of $5p/3$ and an expected payoff of $2p/3$ for the buyer. A price bid of $p > 30$ implies an expected buyer payoff of $50 - p$. This suggests that, around the equilibrium price of $p^* = 30$, incentives are relatively flat. Perhaps more importantly, losses occur both in and out of equilibrium. For price bids $p < 30$, losses occur in 30% of the cases and positive payoffs with 70%—just as in equilibrium. Boundedly rational buyers who (mistakenly) try to draw conclusions about their bids from frequencies of negative and positive payoffs do not receive a signal that they are out of equilibrium. Similarly, sellers' accept/reject decisions do not constitute a unambiguous signal that a buyer is out of equilibrium. We suspect that some buyers get stuck with out-of-equilibrium bids for these three reasons (flat incentives, and losses and rejections both in and out of equilibrium).

The prediction of $p^* = 25$ in T4 has more predictive power. The lowest group average is 24.95 and in total five groups (out of nine) have an average around 25 in part A. Average prices, 32.86 (part A) and 28.20 (part B-with cross-shareholding), are higher than predicted but still rather close to 25 in part B. One reason why some buyers bid above the prediction is that, as above, sellers are more likely to accept these higher bids (see section 5.2). Since some part of the higher prices are returned to buyer via shareholding, buyers might be more inclined to bid high compared to T1 and T2 without shareholding.

Consider next the treatments in which trade is predicted at $p^* = 0$. Up-front, let us mention that

[11] Two-tailed related-sample Wilcoxon test, using one average price and one average price accepted for each seller-buyer pair in part A (T1: $p = 0.01$; T2: $p = 0.09$; T3: $p = 0.02$; T4: $p = 0.02$).

only 1.09% (17 out of 1,560) of our observations across all treatments had a buyer proposing a price of zero. Six of those zero bids were equilibrium bids by one single buyer in T2 part A and they were all accepted. The remaining eleven instances were out-of-equilibrium and rejected. This shows that buyers did not consider price bids of zero as a real option. In T1 and T2, the prediction $p^* = 0$ fails entirely with average bids of 25.37, 22.95, and 16.66, in T2 part A, T1 part B (shareholding) and T2 part B (shareholding), respectively. The same holds for T3 part A and T3 part B (shareholding). The $p^* = 0$ prediction fails here with average bids of 24.09 and 26.86, respectively.

To understand the deviations from the equilibrium prediction in these cases, note first that decision errors are possible only in one direction. Second, we will see below that also in these cases sellers were more likely to accept higher bids—in contrast to the prediction. Hence, part of the deviation from the prediction $p^* = 0$ can be attributed to seller behavior. However, even when we take sellers' decision into account, buyer bids seem too high. We calculate the actual profits buyers realized contingent on their bids, taking sellers' irrational rejections into account. It turns out that the highest expected buyer profits were realized for bids in the price bracket between 0 and 5. For higher price bids, average profits are moderately declining. Hence, we must conclude that the prediction of trade at a price of zero fails.

Finally, consider T3 and T4 in part B and without shareholding. Again the prediction is $p^* = 0$ but here no trade is predicted. Average prices are 21.69 (T3) and 24.04 (T4). Accepted prices average at 25.62 and 33.57 in T3 and T4, respectively. As in the previous paragraph, we must conclude that the prediction fails. Since trade is not predicted in this case, explanations for out-of-equilibrium behavior differ from those given above.

To understand why buyers bid in violation of the prediction, recall the underlying theory. Suppose in T3 part B (no shareholding) a buyer makes an out-of-equilibrium bid of $p > 0$. The seller's value is $qv = 0.6v$ so only sellers with $v < p/0.6$ will accept, implying an expected value of $(p/0.6)/2 = 5/6p$. This gives the buyer an expected profit of $5p/6 - p = -p/6$. Hence, a risk neutral seller should bid zero. In the experiment, risk loving subjects might be willing to play this gamble, hoping that the seller has a v close to $p/0.6 > v$. In fact, the actual realized profits in this subgame were only -0.1 in T3 and -2.7 in T4. Although buyers would have been better off by bidding $p = 0$ out-of-equilibrium bids of $p > 0$ are not entirely unreasonable. Note in particular that higher p are not less reasonable than p closer to the zero prediction. The expected loss from the gamble is $-p/6$, so, subjects choosing a higher p were simply willing to invest a higher amount of money. In this sense, the average prices of 21.69 (T3) and 24.04 (T4) do not violate the theory more drastically than bids closer to zero.

We summarize

Result 1. *Buyers' price bids are not well explained by the prediction except in T4. Buyers' deviations from equilibrium behavior can be explained by sellers' rejections and weak equilibrium properties in the sense of minor deviation losses of the setup.*

5.2 Seller decisions

Table 4 summarizes the sellers' acceptance decisions. Consider part A. In equilibrium, all buyer bids should be accepted. We saw above that many buyers bids are out of equilibrium, so, one would also expect that sellers might reject some bids as this is indeed the case. A relatively clear pattern emerges from the data: there are more "accept" decisions in treatments with shareholding (T2 90%, T3 85%, T4 74%) as opposed to T1 without shareholding where only 54% are accepted. A binomial test rejects the hypothesis that accept and reject decisions are equiprobable for T2, T3 and T4, but not for T1.[12] Comparing across treatments, χ^2 tests reject the hypothesis that accept decisions are equally likely in T1 compared to T2, T3 and T4 (pair wise comparisons). There are no significant differences between T3 and T4 in pair wise comparisons according but the T3 and T4 are significantly different in comparison to T2.[13]

The same observation can be made in part B. Comparing acceptance rates with and without shareholding in table 4, we observe 96% vs. 65% in T1, 86% vs. 60% in T2, 86% vs. 51% in T3 and 76% vs. 41% in T4. Again, cross-shareholding improves acceptance rates. The difference is significant (related-sample Wilcoxon, $p < 0.05$, two-tailed). Here, a crucial difference to part A is that no trade is predicted in T3 and T4 without shareholding. In this sense, there are more accept decisions than predicted.

In order to learn something about seller rationality, we have to check how the accept/reject decisions relate to the theory. This is done in table 5. The table reports acceptance decisions conditional on whether or not the seller was predicted to accept a (usually out-of-equilibrium) bid. For each treatment there is an acceptance threshold $\widehat{p}$ which depends on whether or not there was shareholding[14]. If $p \geq \widehat{p}$, the seller should accept and reject otherwise.

Table 5 shows that seller decisions are largely consistent with the theory. Acceptance rates if $p \geq \widehat{p}$ are at least 76% in all cells[15], and acceptance if $p < \widehat{p}$ are 27% at most. For all treatments and both contingencies ($p \geq \widehat{p}$ and $p < \widehat{p}$), binomial tests reject that accepting and rejecting are equiprobable (all $p < 0.05$). That is, if $p \geq \widehat{p}$ there are significantly more accept decisions and if $p < \widehat{p}$ sellers significantly reject more often.

Relatively high acceptance rates of 18% and 27% occur for T4 if $p < \widehat{p}$ and if there is shareholding, indicating some inconsistency with the theory. Note however that T4 is the only treatment where ac-

[12] For T1, $p = 0.289$, while for T2, T3 and T4 $p < 0.001$, based on ten seller-buyer observations for T1, T2 and T3; nine for T4.

[13] T1 vs. T2, $\chi^2 = (45.34, 1, p < 0.001)$; T1 vs. T3, $\chi^2 = (22.33, 1, p < 0.001)$; T1 vs. T4, $\chi^2 = (16.15, 1, p < 0.001)$; T2 vs. T3, $\chi^2 = (4.65, 1, p = 0.05)$; T2 vs. T4, $\chi^2 = (7.24, 1, p = 0.01)$.

[14] The threholds $\widehat{p}$ are drived as follows. In all treatments, if there is no shareholding, an out-of-equilibrium bid should be accepted if and only if it is at least as large as the seller's valuation of the good, that is, if and only if $p - qv \geq 0$. If there is shareholding, in T1, T2 and T3 the equilibrium bid is zero and the seller should also accept out-of-equilibrium bids larger than zero. In T4, (1) implies for our experimental setup that bids satisfying $p - v/4 \geq 0$ should be accepted.

[15] In T2, one seller rejected even very high bids of 60 almost all the time. In questionnaires, this seller indicated that the rejections were meant to punish the buyer for not agreeing at the shareholding stage of the game. If this subject is excluded from the analysis, the acceptance rate for $p \geq \widehat{p}$ in T2 increase from 76% to 80%.

ceptance requires a strictly positive price even if there is shareholding. We conjecture that acceptance of $p < \widehat{p}$ bids in T4 might be due to efficiency concerns. Note, however, that acceptance rates for $p < \widehat{p}$ are smaller when there is no shareholding. Hence, this shows that shareholding can increase efficiency beyond the predicted strategic effect.

To gain further insight into how sellers' behavior depends on shareholding, we ran probit regressions which relate the sellers' decisions to accept to the magnitude of buyers' bids in part B conditional on whether there was shareholding or not.[16] The probit specification and the regression results are reported in the appendix. The results of the probit are shown in figure 2 which illustrates the acceptance probabilities as a function of p, separately for all treatments and for both shareholding and no shareholding.

Figure 2 shows that sellers' behavior crucially depends on whether or not the buyer and the seller are mutually holding shares. In all treatments, even very low bids close to zero are accepted with a probability of at least 58% when there is cross-shareholding. By contrast, acceptance rates of very low prices are at most 12% when there is no shareholding. Moreover, the curves with cross-shareholding stochastically dominate those without in all treatments. Finally, the estimated coefficients underlying the figure significantly differ when we compare a treatment with and without shareholding (see appendix).

Figure 2 also reveals a few more things about the predictive power of the theory. Recall that in T1, T2 and T3 all bids should be accepted if there is shareholding.[17] As mentioned, sellers are willing to accept even very low prices but figure 2 shows that this is not perfectly the case. Acceptance rates are increasing in the price in all treatments (see appendix). Whereas this behavior is inconsistent with the prediction in T1, T2 and T3 when there is shareholding, it is hardly surprising that players accept better deals with a larger probability in a bargaining game. As noted above, this seller behavior may explain some deviations from the theory of buyer behavior. A second observation is that in T1 and T2 all bids $p \geq 30$ should be accepted if there is no shareholding. Acceptance rates of 82% (T1) and 93% (T2) show that seller behavior is pretty consistent again with the theory in these cases.

We summarize

Result 2. *Sellers' decisions are by and large consistent with theory as sellers accept and reject to a large extent when they are predicted to. One inconsistency with the prediction in T1, T2 and T3 is that acceptance rates are positively correlated with price bids when there is shareholding.*

One of the most important policy issues is whether vertical mutual shareholding will improve welfare. In our setup, welfare is the sum of seller and buyer payoff, and trade creates a positive surplus due to the seller's undervaluation of the product. Shareholding, therefore, leads to an increase in welfare if it increases the amount of trades. As we saw, shareholding does increase the likelihood of trade in all

[16] We also ran probits for part A. As the main point of the probits is to see how sellers behavior differs depending on the shareholding decisions, we decided not to report the regressions for part A where shareholding is predetermined.

[17] In T4, sellers should accept only if $p \geq v/4$, so, some correlation of acceptance decisions and price is consistent with the theory.

treatments—even in T1 and T2 where such an effect is not predicted. In T4, in 27 % of cases, sellers are willing to accept bids even when they would have been better off rejecting them. A similar effect was not observed without shareholding.

Table 6 reports average profits sellers and buyers realized. To highlight profit differences due to shareholding, the table does not report the results separately for part A and part B but rather according to shareholding/no shareholding across parts. Confirming the results in the previous paragraph, the sum of seller and buyer payoff (welfare) is higher throughout if there is shareholding. Hence, we conclude

Result 3. *Shareholding improves welfare, even in treatments where this is not predicted.*

Table 6 also reveals an interesting bargaining effect in our treatments. Buyers earn less than predicted in all treatments and for both shareholding and no shareholding. Sellers earn more than predicted in all treatments if there is shareholding and in T3 and T4 without shareholding. Moreover, in T1 and T2 without shareholding, sellers may earn less than predicted but their earnings are a much higher percentage of the predicted payoff (90% and 83% in T3 and T4 respectively) than the buyers' (26% and 14%). It follows that

Result 4. *Sellers' bargaining power is stronger than predicted.*

5.3 Shareholding Decisions

The second part of each treatment was aimed at studying the predictions of our subjects regarding the shareholding decisions. The results are can be obtained from table 4. Shareholding rates are 122 out of 200 cases or 61% in T1; 110 out of 200 cases or 55% in T2; 151 out of 200 cases or 75.5% in T3; and 107 out of 180 cases or 59.4% in T4**.**

In T1 and T2 participants do not behave in line with the theory. The buyer and the seller often do agree to hold shares whereas theory would say they should not because trade occurs even without shareholding. As we saw above, shareholding nevertheless improve acceptance rates and efficiency in T1 and T2. Therefore, the shareholding decisions in these treatments seem reasonable.

In T3 and T3 participants do not behave in line with the theory either. We should observe 100% shareholding but subjects agree to hold shares less frequently.

Table 7 shows that shareholding decisions are quite polarized among seller-buyer pairs. Most pairs seem to agree to shareholding in most cases whereas others seem to never agree. Even treatments T3 and T4 have some pairs agreeing to hold shares in 10% or less of the cases, and T1 and T2 have some pairs shareholding in 90% or more of the cases.

We summarize

Result 5. *Shareholding decisions are not consistent with the theory. There is more shareholding than predicted in T1 and T2 and less than predicted in T3 and T4.*

6 Conclusions

One of the keys in understanding vertical relations between firms are vertical externalities (see, e.g., Tirole, 1988). The industrial organization literature has shown that vertical relations suitable to internalize the externalities can be contractual and rather complicated, but they can also be informal and solely relying on trust acquired from good business relations (see e.g. McLaren, 2000).

We analyze a model with an externality between a seller and a buyer, and we propose vertical cross-shareholding—a form of vertical relations based on mutual ownership but falling short of vertical merger—to overcome the efficiency loss due to the externality. Our game-theoretic analysis suggests that vertical cross-shareholding improves efficiency as it is sufficient to enable trade between buyers and sellers whereas a complete merger is not necessary to obtain efficiency. Without vertical mutual cross-shareholding, trade often fails. Our analysis further suggested the possibility of trade at a price of zero—a novel bargaining phenomenon. The seller gives away the good for free because he participates in the buyer's profit.

Our experimental data provide some moderate support for the theory. Sellers' behavior changes significantly depending on whether or not there is cross-shareholding. Whereas sellers' decisions are largely consistent with the theory, buyers' price bids are poorly predicted by our model. Our main experimental result shows that vertical cross-shareholding improves welfare. To some extent this is predicted but cross-shareholding also leads to higher welfare where the theory does not predict this effect. In our context, the policy conclusion about vertical cross-shareholding is that it unambiguously improves welfare.

7 References

Arikawa, Y, and Kato, A. (2004). Cross Shareholding and Initiative Effects, RIETI Working Paper.

Bolle, F. and W. Güth (1992). Competition Among Mutually Dependent Sellers, Journal of Institutional and Theoretical Economics 148, 209-239.

Kruse, J. B., S. R. Elliott and R. Godby, (2003). An Experimental Examination of Vertical Integration and Cost Predation, International Journal of Industrial Organization 21, 253-281.

Dietzenbacher, E., Smid, B. and B. Volkerink (2000). Horizontal Integration in the Dutch Financial Sector, International Journal of Industrial Organization 18, 1223-1242.

Durham, Y. (2000). An experimental examination of double marginalization and vertical relationships, Journal of Economic Behavior and Organization 42, 207-229

Farrell, J. and C. Shapiro (1990). Asset Ownership and Market Structure in Oligopoly, Rand Journal of Economics 21, 275-292.

Flath, D. (1991). When is it Rational for Firms to Acquire Silent Interests in Rivals?, International Journal of Industrial Organization 9, 573-583.

Flath, D. (1992). Horizontal Shareholding Interlocks, Managerial and Decision Economics 13, 75-77.

Gilo, D., Mosse, Y. and Y. Spiegel (2005). Partial Cross Ownership and Tacit Collusion, mimeo, Tel Aviv University.

Harsanyi, J. C. and R. Selten (1988). A General Theory of Equilibrium Selection in Games. MIT Press, Cambridge MA - London.

Malueg, D. (1992). Collusive Behavior and Partial Ownership of Rivals, International Journal of Industrial Organization 10, 27-34.

Martin, S., Normann, H.T., and C. Snyder (2001). Vertical Foreclosure in Experimental Markets, RAND Journal of Economics 32:3, 466-496.

Mason, C. F. and O. R.Phillips (2000). An Experimental Analysis of the Effects of Vertical Integration, International Journal of Industrial Organization, March 2000, pp. 471-496.

McLaren, J. (2000). Globalization and Vertical Structure, American Economic Review 90, 121-138.

Reitman, D. (1994). Partial Ownership Arrangements and the Potential for Collusion, Journal of Industrial Economics 42, 313-322.

Rey, P. and J. Tirole (2000). A Primer on Foreclosure, Handbook of Industrial Organization, forthcoming.

Reynold R. & B. Snapp (1986), The Competitive Effects of Partial Equity Interests and Joint Ventures , International Journal of Industrial Organization 4, 141-153.

Tirole, J. (1988). The Theory of Industrial Organization, MIT Press.

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity, Econometrica 8, 817–838.

Appendix A: Instructions

Instructions: Part A

You are now taking part in an economic experiment. If you read the following instructions carefully, you can, depending on your decisions, earn a considerable amount of money. It is, therefore, important that you take your time to understand the instructions.

Please do not communicate with the other participants during the experiment. Should you have any questions please ask us. All the decisions you will make during the experiment will be treated anonymously.

During the experiment we shall use Experimental Currency Units (ECU). Your entire earnings will be calculated in ECU. At the end of the experiment, your earnings in ECU will be converted to Sterling at the rate of 1 ECU =2 p and will be immediately paid to you in cash. In addition, in the beginning of the experiment you will receive a one-off lump sum payment of £3 (i.e. 150 ECU) for your participation.

The experiment is divided in two parts. Each one of them lasts 20 periods. These are the instructions for the first part. Once this part of the experiment is over you will receive additional information for part 2.

This is what the first part of the experiment is about

Two parties, a seller and a buyer negotiate in each period about the sale of a product. Whether you act as seller or a buyer is determined randomly at the beginning of the experiment. You will keep your role for the whole experiment. You will bargain with the same person in every period.

The product under negotiation has a value for the buyer that varies between 0 and 100. In each period, the computer will randomly draw a new value from this interval, with all values being equally likely. Only the seller will be informed about the value of the product and the cost for producing it.

Before the seller sells the product to the buyer he has to produce it. The cost of producing the product is equal to 30% of the buyer's valuation of the product. For example, if the value randomly drawn is 60 ECU i.e. the product is worth 60 ECU to the buyer, the seller's cost for producing it is 18 ECU in order to produce it (60*30% = 18 ECU). Note that the cost will be rounded to the nearest integer i.e. if the buyer's valuation is 52 ECU, then the cost for producing the product will be 16 ECU and not 15.6 ECU.

Trade takes place according to the following rules:

The buyer can offer a price to the seller for the product without knowing however the value of the product. The price can vary between 0 and 100. The seller knowing the cost for producing the product has to decide whether to accept or reject the offer.

If the seller accepts the offer, he receives as a payoff the difference of the price he accepted minus the cost of production (30% of buyer's value), whereas the buyer receives the difference of his value minus the price she offered. If the seller rejects, both parties receive zero payoffs. Note that the seller produces the good only if an agreement is reached.

Example: Assume that the value that was drawn is equal to 80 ECU. This means that the product is worth 80 ECU to the buyer. It also means that if the seller wants to produce the product he has a cost of 24 ECU (80*30%). Now suppose that the buyer offers 42 ECU to the seller for the product. If the seller accepts the offer then he will receive 42-24= 18 ECU, whereas the buyer will receive 80-42= 38 ECU. If the seller rejects, both the buyer and the seller get zero.

If you do not have any questions please answer the following questions.

Control Questions

1. The value of the product drawn is 10 ECU. The buyer offers a price of 20 ECU. Assuming that the seller accepts it, what is:

a. the seller's cost of production .....

b. the buyer's earnings .....

c. the seller's earning ......

2. The value of the product drawn is 100 ECU. The buyer offers a price of 20 ECU. Assuming that the seller accepts it, what is:

a. the seller's cost of production .....

b. the buyer's earnings .....

c. the seller's earning .....

Instructions: Part B

This is the second and final part of the experiment, which again lasts 20 periods. Your role will be the same as in the first part of the experiment and so will your partner.

In this part of the experiment, every period is divided into two stages. The second stage is identical to part 1. As in part 1, the product has a value for the buyer that varies between 0 and 100. The seller has to produce the product before he sells it and the cost of doing so is 30% of the buyer's value. In each period, there will be a new value drawn from this interval, with all values being equally likely.

In the first stage, the seller and the buyer are given the option to exchange 40% of the profits they will make in the end of the period. The decision to exchange 40% of their perspective profits will be taken before the value of the product is drawn, so neither the seller nor the buyer will know how much the product will be worth. In order for this exchange to take place both the buyer and the seller have to agree in the exchange. Otherwise, the exchange does not occur. After this decision is taken the experiment proceeds in stage two, where the seller and the buyer negotiate about the sale of a product.

Example: Assume that the seller alone earns 40 ECU from the product's trade and the buyer alone 30 ECU. If they agreed in the first stage to exchange 40% of their profits then the seller's earnings will be equal to 60% of what he would earn alone (100% minus the 40% that the buyer acquires) plus 40% of the amount the buyer earned alone. So if they exchanged 40% of their profits the seller would earn

60%*40ECU + 40%*30ECU = 24 ECU + 12 ECU = 36 ECU. The same rationale applies for the buyer who would therefore earn: 60%*30ECU + 40%*40ECU = 18 ECU + 16 ECU = 34 ECU.

If you do not have any questions please answer the following question.

Control Question

The Seller would earn alone at the end of the period from the product's trade 20 ECU and the Buyer alone 40 ECU. What will their earnings be if they agreed to exchange 40% of their profits in the first stage?

a. the seller earns .....

b. the buyer earns ......

Appendix B: Probit regression

The probit regressions underlying figure 2 were run as follows. The dependent variable was one if the seller accepted and zero otherwise. In part B, the sharehoding and no shareholding can occur in each treatment. Accodingly, we introduce a variable SH which is equal to one if buyer and seller agreed to mutually hold shares. Similarly $NSH = 1 - SH$ indicated that they did not agree to do so. For both contingencies, SH and NSH, we need intercation terms with the price p. Hence, we have four variables for each treament i: $Ti \times SH$, $Ti \times NSH$, $Ti \times SH \times p$, and $Ti \times NSH \times p$. The constant was omitted to avoid collinearity. Standard errors are White (1980) robust and are corrected for possible dependence of observations within a seller-buyer pair.[18]

Table 8 reports the regression results for part B. Most variables are significant at $p < 0.01$ but some are not ($T2 \times SH$, $T3 \times SH$, $T3 \times SH$, $T2 \times SH \times p$, $T4 \times SH \times p$, $T3 \times NSH \times p$). As argued in the main text, the central question is whether or not seller behavior differs depending on shareholding within each treatment. To analyze this, we test whether $Ti \times SH \neq Ti \times NSH$ and $Ti \times SH \times p \neq Ti \times NSH \times p$. We find $T1 \times SH \neq T1 \times NSH$ ($\chi^2 = 22.96$, d.f.=1, $p < 0.001$), $T2 \times SH \neq T2 \times NSH$ ($\chi^2 = 8.09$, d.f.=1, $p = 0.005$), $T3 \times SH \neq T3 \times NSH$ ($\chi^2 = 4.83$, d.f.=1, $p = 0.028$), and $T4 \times SH \neq T4 \times NSH$ ($\chi^2 = 12.06$, d.f.=1, $p < 0.0005$). These test suggest imply the probability of getting a bid of zero accepted is significantly higher in al treatments. Further, $T1 \times SH \times p \neq T1 \times NSH \times p$ ($\chi^2 = 12.06$, d.f.=1, $p = 0.0005$) and $T4 \times SH \times p \neq T4 \times NSH \times p$ ($\chi^2 = 4.66$, d.f.=1, $p = 0.031$). These test imply that sellers responsiveness to a price change differs significantly in T1 and T4. In other treatments, $T2 \times SH \times p = T2 \times NSH \times p$ ($\chi^2 = 1.95$, d.f.=1, $p = 0.122$) and $T3 \times SH \times p = T3 \times NSH \times p$ ($\chi^2 = 0.61$, d.f.=1, $p = 0.414$) cannot be rejected.

[18] We excluded one seller in T2 from the analysis. Since this seller has a disproportional share of rejections of very bids, the probit results would be biased if we include him. See also see footnote ().

	$q < \frac{1}{2}$	$q \geq \frac{1}{2}$		
shareholding	any	$q \leq \frac{t}{1-\tau}$	$\frac{t}{1-\tau} < q < \frac{1+t}{2-\tau}$	$\frac{1+t}{2-\tau} \leq q$
agree	no	yes	yes	no
price	$p^* = q$	$p^* = 0$	$p^* = \overline{p}$	$p^* = 0$
trade	yes	yes	yes	no

Table 1: Overview of outcomes

Treatment	T1	T2	T3	T4
value of q	$q = 0.3$	$q = 0.3$	$q = 0.6$	$q = 0.75$
shareholding in Part A	$t = \tau = 0$	$t = \tau = 0.4$	$t = \tau = 0.4$	$t = \tau = 0.4$
price	$p^* = 0.3$	$p^* = 0$	$p^* = 0$	$p^* = 0.25$
trade	yes	yes	yes	yes
shareholding in Part B?	no	no	yes	yes

Table 2: Treatments

treatment		T1	T2	T3	T4
			part 1		
prediction	price	30.00	0.00	0.00	25.00
	trade	yes	yes	yes	yes
average price		20.74	25.37	24.09	32.86
(std. dev.)		(12.84)	(18.26)	(15.19)	(17.69)
average accepted price		27.56	26.21	25.99	35.94
(std. dev.)		(10.90)	(19.10)	(15.50)	(17.83)
			part 2		
			when cross-shareholding		
prediction	price	0.00	0.00	0.00	25.00
	trade	yes	yes	yes	yes
average price		22.95	16.66	26.86	28.20
(std. dev.)		(16.97)	(12.46)	(14.20)	(12.46)
average accepted price		27.42	17.76	28.21	28.63
(std. dev.)		(12.37)	(12.57)	(14.36)	(11.36)
			part 2		
			no cross-shareholding		
prediction	price	30.00	30.00	0.00	0.00
	trade	yes	yes	no	no
average price		28.49	28.72	21.69	25.62
(std. dev.)		(11.36)	(15.27)	(7.86)	(14.04)
average accepted price		32.88	31.67	24.04	33.5714.46)
(std. dev.)		(9.57)	(12.16)	(9.50)	

Table 3: Summary statistic of average prices

treatment	T1	T2	T3	T4
		part 1		
total	200	200	200	180
accepted	54.0 %	85.0 %	76.5 %	73.9 %
		part 2 when cross-shareholding		
total	122	110	151	107
accepted	95.9 %	86.4 %	86.1 %	75.7 %
		part 2 no cross-shareholding		
total	78	90	49	73
accepted	65.4 %	60 %	51.0 %	41.1 %

Table 4. Sellers' acceptance decisions by treatment

treatment	T1	T2	T3	T4
	part A			
acceptance threshold $\widehat{p}$	$0.3v$	0	0	$v/4$
acceptance rate if $p < \widehat{p}$	6%	–	–	18%
acceptance rate if $p \geq \widehat{p}$	78%	85%	77%	82%
	part B: with cross-shareholding			
acceptance threshold $\widehat{p}$	0	0	0	$v/4$
acceptance rate if $p < \widehat{p}$	–	–	–	27%
acceptance rate if $p \geq \widehat{p}$	95%	86%	86%	81%
	part B: no cross-shareholding			
acceptance threshold $\widehat{p}$	$0.3v$	$0.3v$	$0.6v$	$0.75v$
acceptance rate if $p < \widehat{p}$	0%	0%	8%	14%
acceptance rate if $p \geq \widehat{p}$	86%	76%	100%	96%

Table 5: seller acceptance rates conditional on theoretical thresholds

		T1	T2	T3	T4
shareholding					
buyer	prediction	24.00	24.00	18.00	10.00
	realized	19.96	16.44	8.14	6.43
seller	prediction	11.00	11.00	2.00	2.50
	realized	15.70	11.99	6.31	2.48
welfare	prediction	35.00	35.00	20.00	12.50
	realized	35.64	28.43	14.45	8.91
no shareholding					
buyer	prediction	20.00	20.00	0.00	0.00
	realized	5.14	2.73	-0.10	-2.67
seller	prediction	15.00	15.00	0.00	0.00
	realized	13.44	12.40	4.92	5.41
welfare	prediction	35.00	35.00	0.00	0.00
	realized	18.56	15.13	4.82	2.74

Table 6: players' payoffs in part B

	group										
	1	2	3	4	5	6	7	8	9	10	mean
$T1$	55%	25%	85%	65%	60%	90%	90%	15%	40%	85%	58%
$T2$	40%	0%	40%	90%	65%	80%	100%	75%	10%	50%	57%
$T3$	90%	90%	90%	80%	65%	45%	85%	75%	40%	90%	74%
$T4$	80%	75%	45%	65%	80%	35%	5%	55%	95%	NA	59%

Table 7: Shareholding decisions by seller-buyer pair

$T1 \times SH$	1.11^{***}
	(0.45)
$T1 \times SH \times p$	0.04^{***}
	(0.01)
$T1 \times NSH$	-2.54^{***}
	(0.55)
$T1 \times NSH \times p$	0.11^{***}
	(0.02)
$T2 \times SH$	0.53
	(0.52)
$T2 \times SH \times p$	0.04^{***}
	(0.03)
$T2 \times NSH$	-1.94^{***}
	(0.73)
$T2 \times NSH \times p$	0.12^{***}
	(0.03)
$T3 \times SH$	0.21
	(0.20)
$T3 \times SH \times p$	0.04^{***}
	(0.01)
$T3 \times NSH$	-1.16^{**}
	(0.53)
$T3 \times NSH \times p$	0.06^{**}
	(0.02)
$T4 \times SH$	0.52
	(0.51)
$T4 \times SH \times p$	0.01
	(0.02)
$T4 \times NSH$	-1.58^{***}
	(0.49)
$T4 \times NSH \times p$	0.05^{***}
	(0.01)
N	760
Pseudo R^2	0.28

Table 8: Seller acceptance probits in part B