Public Versus Private Exchanges

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Abstract

We study the structure of markets when traders are given the opportunity to create their own market, as on the internet. On the internet, public exchanges have in many cases been replaced by private exchanges. We use experiments to investigate possible reasons for the failure of public exchanges. In our experimental markets, when traders make an offer, they decide whom to inform about the offer. Participants typically inform all traders on the other side of the market, but not on their own side, resulting in a private, not a public exchange. This private exchange leads to the same outcomes in terms of prices and efficiency as a double auction. When we impose transaction costs on the buyers, only the sellers make private offers, which results in an inefficient market. When we provide incentives for sellers to inform each other, most of the sellers reveal a strict preference to hide offers from rivals. However, when sellers do share price information, they attain a higher price and benefit collectively.

Keywords: market institution, information structure, efficiency

JEL-classification: C9, D4, L1

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1. Introduction

This paper investigates the structure of emerging markets when traders are given the possibility to create their own private markets. Using experimental methods we study the features of the resulting market and its efficiency properties. In addition we inquire the robustness of traders' choices with respect to transaction costs and with respect to costs for concealing information from competitors.

These experiments shed light on one of the puzzling phenomena of the recent boom in internet markets. In the last two years, an industry emerged that tried to create new trading institutions. Public business to business (B2B) exchanges, where traders would reach scores of potential trading partners was the promise of the Internet.[1] The idea was to "create marketplaces where buyers and sellers could utilize the Internet's powers of connectivity and aggregation to provide instantaneous market information and price visibility, to facilitate transactions with optimal economic efficiency" (Draenos 2001). "Such market places would act as matchmakers between buyers and sellers in particular industries, and take a small fee in return" (the Economist 2001). Furthermore, public B2B exchanges not only offered the potential for new trading partners, but also for new sorts of transactions, from auctions to direct sales without middlemen or brokers.[2]

However, most of the public exchanges have disappeared. "Of the thousand or so B2B exchanges launched in the past 18 months, only about 100 are handling any genuine transactions. The doctrine was "build and they will come", but almost nobody came. Not only are there only a few public exchanges remaining, but those that do survive play at best only a minor role. Instead the action in B2B turns out to be elsewhere: in industry specific consortia and in private exchanges sponsored by large companies" (the Economist 2001).

The advantage of consortia is that at least the founding companies are (presumably) interested in trading in this exchange. Hence the coordination issue of which of the many markets to go to in order to find trading partners is mitigated. Jupiter Media Metrix Inc., a New York Internet-Research firm, counts about 60 industry consortia marketplaces in the U.S. One of the most promising consortia is Covisint, an online exchange for the automobile industry, where (ideally)

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[1] "1999 was the year of the public exchange", Bruce D. Temkin, analyst of Forrester Research in Strauss (2001).
[2] For an overview on Business-to-Business Electronic Commerce see Lucking-Reiley and Spulber (2001).

auto manufacturers and suppliers meet to trade through electronic auctions and catalogs.[3] Covisint was founded and later joined by 6 leading auto makers.[4]

Apart from such large designed markets, there are many companies that establish their own private trading networks. Sometimes with the help of public sites, sometimes on their own. "While not attracting the attention of public exchanges, which have languished, private business-to-business exchanges are thriving" (Strauss 2001).[5] Unlike public exchanges which bring together many suppliers and sellers, private exchanges allow a single firm to deal with its customers or suppliers directly, and to control who sees what. The preference for private exchanges seems not to be the result of a lack of public exchanges. For example, in the seafood industry, GoTradeSeafood.com, a leading business-to-business Internet seafood trading site, offers two ways of trading seafood. They have a public exchange "Open Market Place" where traders can post offers "to the world" and "find new suppliers from all over the world". Furthermore, they also offer a private exchange, or "Partner Management Program". Here traders can form private networks, effectively deciding to which of their trading partners the offers apply to. Specifically, when posting an offer traders decide which other traders are able to see this offer. This private exchange has been added only recently (influenced by demand of their customers) and turns out to attract many of the leading trading companies.[6] [7]

This emergence of different market institutions, ones that are designed like public exchanges and consortia, and also ones that simply consist of private exchanges, leaves many open questions. Foremost the failure of public exchanges was not predicted. Ex post many explanations have emerged. Maybe there were too many public exchanges, which made it difficult for traders to coordinate on one exchange, and hence to find each other. Other critics argue that the problem was

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[3] Other examples include Worldwide Retail Exchange, an e-marketplace founded by more than 50 large retailers – including Target, J.C. Penney Co. and Safeway Inc.; Transora, a market place created last year by 50 consumer-products companies, including Kraft Foods Inc., Procter & Gamble Co. and General Mills Inc.; and Pantellos, a consortium of 21 energy and utility companies, including Entergy Corp. and PG&E Corp.

[4] Covisint was founded by General Motors Corp., Ford Motor Co. and DaimlerChrysler AG. Later the automakers Renault SA, Nissan Motor Corp. and just recently PSA Peugeot-Citroen joined.

[5] The article has the colorful title "I Know You, You Know Me, Let's Sell Goods Online Privately".

[6] Private communication with Jerry ten Brink, CEO of GoTradeSeafood.com.

[7] For the construction industry, Lawrence Shorter, vice president for business development and founder of B2build, sees private trading networks as the core of the model. This allows sellers to filter what buyers see, or have different price lists for each customer. (Talacko 2001).

that many exchanges allowed competition on price only, whereas most business deals involve differentiated goods and services, turning on factors like quality, convenience and reliability as well a price. “Price isn’t everything. In fact it’s rarely the most important thing” (Paul Milgrom, cited in Redburn (2000)). However, more sophisticated auction software has emerged, that allows for multiple attributes (Milgrom 2000), though this is not yet widely used by exchanges. Arguments for private exchanges are that “you deal with your steady partner. You tighten collaboration with those partners, and that is where efficiencies come in and relationships are continued” (Bruce T. Temkin, analyst of Forrester Research in Strauss (2001).) Maybe “people like private exchanges because they keep control of customers and suppliers. They don’t have to make things public that they don’t want to” (Tim Clark, analyst of Jupiter research, in Strauss (2001)).

The recent evolution of market institutions on the internet seems to suggest that traders do not like public exchanges, but rather form private exchanges. One possible reason may be that private exchanges allow traders to control the flow of information. On the other hand, sometimes traders on one market side try to commit themselves to use an exchange that provide themselves and their competitors that participate in the consortium with lots of information. It may be that an open price policy increases the possibility of collusion and the expected gains are high enough to overcome the concerns of revealing information to competitors.[8]

In this paper we study in a controlled environment the choices traders make concerning the market structure. We consider an environment where each trader can trade a single homogenous good. We first investigate two extreme market institutions in terms of information that confirm its importance on efficiency. One market is the continuous double auction (DA), which we take as representing the public exchanges. This institution allows traders to make bids (offers to buy) and asks (offers to sell) and to accept other traders' offers at any moment. Hence, all traders are informed about all outstanding bids and asks as well as about all realized trades. As a consequence, the process of price formation and matching is a public and multilateral process.[9]

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[8] Industry consortia are mostly built by firms on only one market side. Covisint, for example, is built by buyers. However, consortia raise the prospect of collusion between members to the disadvantage of their suppliers (The Economist 2001). One way in which collusion may occur is through information transmission. The question about the harm or benefit of price communication between competitors, is old and still not completely resolved. (The prospect of collusion raises of course the interest of the FTC. Covisint received tentative antitrust clearance in September 11, 2000.)

[9] However the way in which a double auction generates efficient outcomes is not well understood.

This type of trading institution seems to mostly generate outcomes consistent with the predictions of the competitive model (see Smith 1962, 1964). At the opposite extreme is a market with decentralized matching and private bilateral bargaining. This is the institution originally employed by Chamberlin (1948) in the very first experimental market study (see also the so-called "telephone markets" in Grether and Plott, 1984, and Hong and Plott, 1982). Under this institution traders are restricted to contact other traders only one by one, and the offers, counteroffers and contracts made in these bilateral encounters are not revealed to other traders. This decentralized bargaining market (DBM) was found to generate inefficient outcomes, incongruent with the competitive model.

Then we endogenize the information structure and matching procedure of the market. We give individual traders the possibility to create their own markets, possibilities that traders have thanks to the internet technology. When a trader submits an offer, she decides who will be informed about this offer and to whom it applies. She can choose to inform any number of traders from both the own and the other market side about her offer. If a potential trading partner is informed about an offer, this offer also applies to her. Hence, if each trader always chooses to inform every other trader about her offer, the information structure of the market is identical to that of a double auction, or a public exchange, - every trader is always informed about all outstanding offers and every offer applies to every potential trading partner. In that case the market mechanism is in effect a double auction with a centralized information and matching structure. If, on the other hand, each trader always chooses to inform only one other trader about her offer, price formation and matching are a completely decentralized process as in Chamberlin's experiment.

The results of the choices of participants reveal that offers were made by both market sides and typically transmitted to each potential trading partner. This was to be expected, since each trader could only trade at most one unit, hence arguments for price discrimination do not apply. However, the prediction regarding the information traders submit towards their competitors is less clear. On the one hand, traders may want to conceal an offer from competitors in order to prevent or delay being overbid (respectively undercut) by competitors. On the other hand, traders may want to inform rivals about their prices in an attempt at collusion. When competitors know each others' offers, secret rebates are excluded. The incentive to outbid or undercut may be reduced when rivals can perfectly observe and follow them. After all, "the policing of a price agreement involves an audit of the transaction prices" (Stigler, 1964, p. 47). In this case the resulting institution would be equivalent to a standard double auction. In our experiments, even though subjects did transmit their offers typically to each potential trading partner they chose to hide them from their competitors. This market institution which endogenously resulted from the participants choices is best described as a 'double sided private exchange.'

In the emerging 'double sided private exchange' traders receive less information about other traders decisions and realized transaction prices than in the double auction, though more than in the decentralized bargaining market. Nonetheless, the resulting institution turned out to share the properties of the DA in terms of efficiency and price convergence, which are significantly different from the DBM.

Next we investigate whether the decisions of individual traders adjust to the introduction of exogenous transaction costs, and whether this adjustment is efficient. Efficiency requires, firstly, that avoidable transaction costs are in fact avoided, and, secondly, that the market institution serves its function to inform and match potential trading partners such that potential gains from trade are realized.[10]

Specifically, we consider a treatment with one-sided transaction costs. Whereas sellers have no transaction costs to bear, a buyer has to bear small, but positive costs for every other trader he informs about an offer she makes. Note that one-sided transaction costs allow in principle for the possibility that trade takes place without traders incurring any costs. This allows for an unambiguous assessment of the efficiency of the market outcome. Furthermore, transaction cost can be avoided by the emergence of a one sided institution, where only sellers make offers, but buyers refrain from making bids. Hence, one sided costs allow for a clear prediction of the institution if its emergence is shaped by the transaction costs. The experiments show that indeed only sellers made offers, and these asks were transmitted to each buyer, but

[10] In order to assess the performance of endogenously emerging market institutions one could of course investigate field data and historical evidence. However, environmental factors like demand and supply structure, product characteristics, transactions costs etc. which are decisive for the assessment of trading outcomes are often not well-documented. These problems, arising from the lack of control and observability can be overcome by an experimental investigation where the experimenter can design and control the environment. Therefore, the properties of trading institutions can be easily evaluated in a market experiment.

hidden from the other sellers. This institution can be characterized as a ‘one sided private exchange.’ This emerging institution was less efficient than the DA. A possible reason being the further reduction of information available to sellers, the active market side. Hence, we can conclude that transactions costs can indeed shape the emergence of institutions, but the endogenously emerging market need not lead to efficient outcomes.

We find that even in an environment where there is a homogenous good, traders opted to conceal their prices and not to inform their competitors, i.e. for private exchanges and not public exchanges. In the case where both market sides were active, this lead to an outcome as efficient as the double auction. However in the transaction cost treatment, where only one market side is active, this price concealment is the probable cause for its inefficient outcome.

This preference of traders for private offers seems at odds with the ongoing creation of industry consortia in which traders provide competitors (those that are part of the consortium) with information. Once consortia are built and functional, it will be more costly for traders to trade outside the consortium and conceal prices. Industry consortia may provide some compensation for the loss of privacy. Rivals might want to inform each other in order to attempt to collude, and hence commit themselves to incentives for providing price information. However, the effects of price communication on prices it not clearly established.

In our last treatment we test whether sellers have strict or weak preferences to conceal prices from competitors. Specifically, we ‘punish’ price concealment between rival sellers. A seller has to pay a (small) fine if he or she chooses to conceal a price quote from his or her rivals.[11] Buyers continue to have the same positive transaction costs as before, so that sellers remain the active market side. Furthermore if sellers do inform each other we can measure price communication on prices and efficiency.

The results show that the preference to conceal their price quotes from their rivals is strict. A large fraction of price offers is concealed from rivals, even if it is costly for sellers to do so. However, when rival sellers do inform each other, this price communication among competitors tends to increase prices significantly. Furthermore, we do not find an strong effect of price communication on price dispersion or on the speed of convergence.

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[11] This treatment is inspired by industry consortia, where commitment to a market place should make it more expensive for traders outside this market place, hiding their prices.

The next section describes the features of the experimental design common to all treatments. In section 3 we investigate whether traders form public or private exchanges in absence of any frictions. Section 4 contains the treatment with transaction costs, and section 5 has traders faced with penalties for concealing information. The concluding discussion can be found in section 6.

2. Experimental Design

Market Structure

Each experimental market session consisted of a sequence of one practice round and 18 trading rounds. Each trading round lasted three minutes. Markets were inhabited by 12 traders, 6 buyers and 6 sellers. Traders retained their roles throughout the session. In a trading round, each individual trader could trade at most one unit of a homogenous good at no trading costs. The private value of a trader (cost value or redemption value) changed from round to round. The set of values, however, remained the same, and this was common knowledge. Hence, the market environment (i.e., the induced aggregate demand and supply function) was constant across the practice round and the 18 rounds of the experiment. The cost and redemption values were given in points, and 1 point exchanged for 0.3 Dutch guilders (Hfl).[12]

The demand and supply functions induced by these values are illustrated in Figure 1. As can be seen, the competitive equilibrium was at a quantity of 4 units and a price in the interval [30,35]. Hence, for both buyers and sellers there were four infra- and two extra-marginal traders. The induced demand and supply schedule were, of course, to a large extent arbitrary. Our main consideration was to strike a balance between the probability of an extra-marginal trade occurring (a high probability requiring elastic schedules), and the efficiency loss associated with an extra-marginal trade (a large efficiency losses requiring inelastic schedules).

Besides values, traders were also assigned ID-letters: A, B, C, D, E, and F for buyers, and U, V, W, X, Y, and Z for sellers. These ID-letters were randomly (re)assigned to the traders at the beginning of each round. The assignment of ID-letters was neither related to the assignment of values nor to the "real" identity of the subjects. The subjects were informed about this.

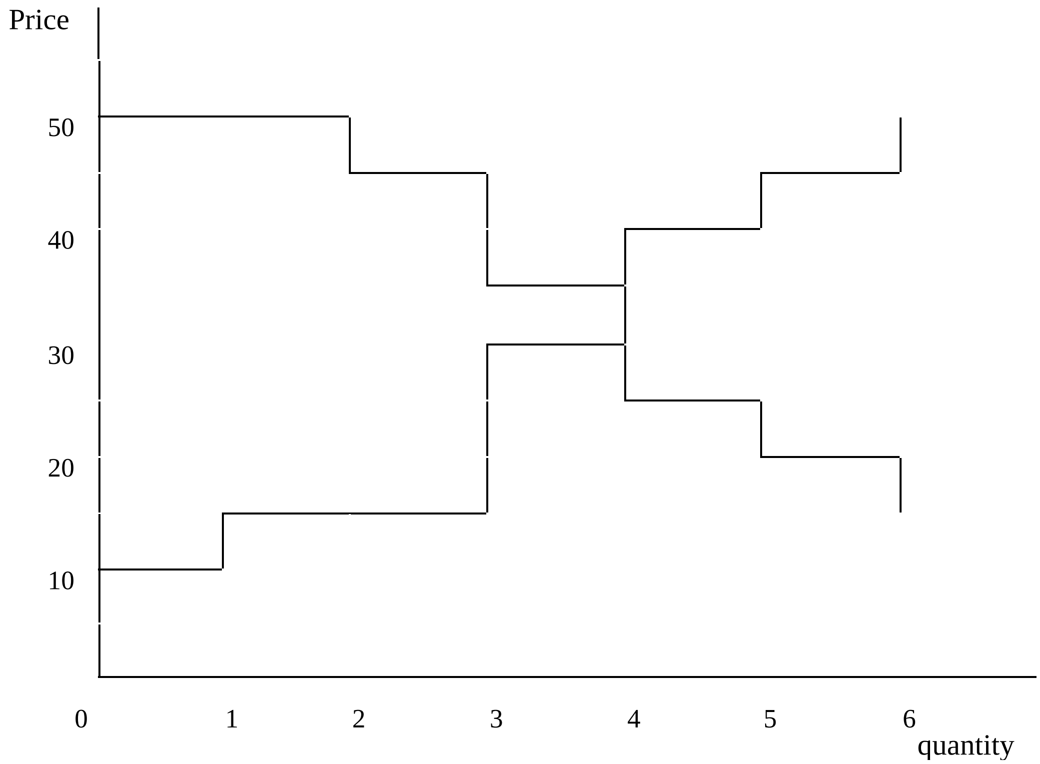


Figure 1: The induced demand and supply schedule

Information display

The trading process was handled by means of networked computers. At any time a trader's computer screen displayed the following information: the round number, the time left for trading, a trader's role (buyer or seller) and ID-letter, the cost or resale value, and a trader's total profits up to that round. In treatment with transaction costs, the costs a buyer had already incurred during the round at hand was also displayed on the screen.

In the middle of the display were the lists of ask- and bid prices, one above the other. These lists only contained those offers that the trader was informed about. Both ask- and bid prices were ordered from high to low, and for each offer also the ID-letter of the sender was indicated.

[12] At the time of the of the experiment 1 Hfl exchange for about $ 0.50.

Finally, at the bottom of the screen, there was a row with the prices of those accepted offers that the trader had been informed about. Only prices were revealed but not the IDs of the transacting parties.

Procedure

For each treatment,[13] four independent experimental sessions were run. Students at Tilburg University were recruited as subjects through announcement in the university bulletin and in classes. Participants were solicited for a two hour decision making experiment which would earn them money. Fifteen subjects were registered for each experimental session to allow for no-shows. In session DA1, however, only 10 subjects showed up. This sessions was run with 10 traders, using the design of Figure 1 with one buyer (redemption value 50) and one seller (cost value 15) excluded, leaving the range of equilibrium prices unchanged.

Upon arrival in the lab, subjects drew an envelope with a seat number. If more than 12 subjects showed up, one to three empty envelopes were added to the stack of seat numbers. The subjects drawing an empty envelope received 10 Hfl for showing up and left the room. Once the remaining subjects were seated, the instructions for the experiment were distributed and read aloud by the experimenter. Then the subjects were given some minutes to study the instructions at their own pace, and to privately ask questions. After the practice round, the 18 rounds which determined subjects' earnings were run. After round 18 the subjects privately received their total earnings and left the room. Sessions lasted about one and a half hours. Earnings were on average about Hfl 49, and ranged between Hfl 21 and Hfl 65.

3. Private or Public Exchange

To investigate whether traders prefer public or private exchanges we have three different markets.

[13] The treatments will be described below.

Trading institutions

(a) Treatment 1: Endogenous Market (EM)

Buyers could try to buy by making bids, and sellers could try to sell by making asks. When making an offer (an ask or a bid), a trader had to enter a price at which she was prepared to trade. She also had to enter the IDs of those traders she wanted to inform about the offer. A trader was forced to enter the ID of at least one trader from the other market side, i.e. the ID of at least one potential trading partner. This constraint was imposed to prevent traders from sending 'fake' offers to only their own market side, i.e. to only their competitors. Furthermore, offers that could lead to negative profits were not permitted.

Offers could be adjusted at any moment by simply submitting a new offer. Then the old offer became invalid. Hence, each trader had at most one outstanding offer. Since everyone could trade at most one unit, a trader who had already made a transaction could no longer make offers.

As long as a trader had not traded in that round, she was allowed to accept any offer of a potential trading partner about which she was informed. Again we enforced the restriction that an offer could only be accepted if it led to a non-negative profit. We did, however, not enforce the rule that a trader always had to accept the best price offered. When an offer was accepted, it was withdrawn from the market, and those traders who had been informed about the offer were also informed that a transaction had occurred at that price.

(b) Treatment 2: Double Auction (DA)

In the DA treatment, traders did not have to enter any trader ID-letters when submitting an offer. All offers were automatically sent to all other traders, i.e. to all potential trading partners as well as to all competitors. All traders were also informed when and at what price a trade occurred. This treatment boiled down to the standard continuous double-auction market, with the exception that trader IDs were added and that traders were not restricted to accept the best offer available.

(c) Treatment 3: Decentralized Bargaining Market (DBM)

In the DBM treatment, traders had to enter one and only one ID-letter of a potential trading partner when they entered an offer. Furthermore, when a transaction occurred, only the two parties involved were informed.

Expected Results

To describe the (expected) results it is useful to introduce the following two variables. D_{client} refers to the 'dissemination of an offer among clients', and is defined as the fraction of potential trading partners informed about an offer. D_{comp} refers to the 'dissemination of an offer among competitors', and is defined as the fraction of competitors (i.e., other traders on the same side of the market) informed about an offer. These two variables capture the defining features of the different trading mechanisms. For example, in a DA we have $D_{client} = 1$ and $D_{comp} = 1$ for all offers. All traders are informed about all asks and bids. In a DBM we have $D_{client} = 1/6$ and $D_{comp} = 0$ for all offers. An offer is sent to one trader on the other market side, and no other trader is informed about it. In the endogenous market treatment the two variables were endogenous and determined by the traders themselves.

For reasons of symmetry, we did not expect to find any difference between the demand and the supply side of the market in the EM treatment. That is, we expected that the numbers of asks and bids were the same, and that D_{client}(asks) = D_{client}(bids) and D_{comp}(ask) = D_{comp}(bids). Moreover, there did not seem to be a compelling reason for traders to send an offer to only a subset of the potential trading partners. Sending an offer to all potential trading partners could only increase the probability of acceptance. Furthermore, offers that were not yet accepted could always be adjusted in any direction. Since each trader could trade at most one unit in our design, arguments for price discrimination do not apply. Hence, we expected subjects to transmit their offers to every potential trading partner: $D_{client} = 1$. However, it was not *a priori* clear what to expect regarding the information to competitors. On the one hand, traders may want to conceal an offer from competitors ($D_{comp}= 0$) in order to prevent or delay being overbid (respectively undercut) by competitors. In that case the resulting institution would be characterized by offers which apply to all potential trading partners ($D_{client}= 1$) but which are kept secret from competitors ($D_{comp}= 0$). Such an institution could be referred to as a ‘double sided private exchange’. On the other hand, traders may want to inform rivals about their prices in an attempt at collusion. When competitors know each others’ offers, secret rebates are excluded. The incentive to outbid or undercut may be reduced when rivals can perfectly observe and follow them. After all, “the policing of a price agreement involves an audit of the transaction prices” (Stigler, 1964, p. 47). If competitors decide to inform each other about offers ($D_{comp} = 1$), in combination with $D_{client} = 1$, the resulting institution would then be equivalent to a DA.

What did we expect regarding prices and efficiency? As in numerous other DA experiments, we expected prices and quantities in our DA treatment to converge quickly to the market clearing level, and outcomes close to full efficiency. For the DBM treatment, on the other hand, we expected a slower convergence of prices and quantities, connected with lower efficiency levels.

For the EM treatment, we expected the outcomes to be conditional on the results regarding D_{comp}. If the endogenous market gave rise to an institution that was equivalent to a double auction, we expected prices, efficiency, and convergence to be in line with the DA treatment. If, on the other hand, it gave rise to a double sided private exchange then it is more difficult to predict its outcomes. Such a market has never been investigated before. Nevertheless, some clear hints are provided by several bounded rationality models which are developed to explain convergence of prices and quantities in double auctions (Easley and Ledyard 1993, Friedman 1991, Gode and Sunder 1997, and Gjerstad and Dickhaut 1995). In these models traders respond adaptively to observations of offers of competitors and potential trading partners and realized transactions prices. Furthermore, in these models the speed of convergence depends positively on (the number of) these observations. In a double sided private exchange traders would typically observe only half of the offers and realized prices, whereas these data are public information in the DA. Hence, if a double sided private exchange would emerge in the EM treatment, then a reasonable expectation would be that convergence of prices and quantities to the market clearing level is slower than in the DA treatment, but faster than in the DBM treatment.

Results

First we examine which market institution actually emerged in the endogenous market treatment (Result 1). Then we compare prices (Result 2) and efficiency levels (Result 3) across the three different treatments (EM, DA and DBM).

Result 1. The endogenous market is a double sided private exchange

The market institution emerging in the EM treatment is best described as a double sided private exchange. Offers were typically sent to every potential trading partner but to no competitor.

In order to present the evidence for Result 1 we calculated for each offer the value of D_{client}, that is, the number of potential trading partners to whom the offer was sent, divided by the maximum number to whom it could have been sent (i.e. divided by 6).[14] Notice that D_{client} ranged between 1/6 and 1 since each offer had to be sent to at least one potential trading partner. Similarly, we computed D_{comp} for each offer, that is, the number of competitors who were informed about the offer divided by the maximum number who could have been informed (i.e. divided by 5). Of course, D_{comp} ranged between 0 and 1.

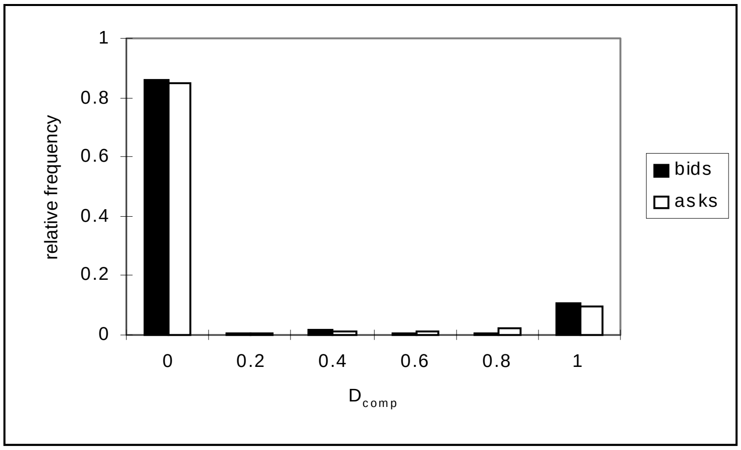
Table 1. Dissemination of offers among clients (D_{client}) and competitors (D_{comp})

Session	average D_{client}	median D_{client}	% offers with D_{client}=1	average D_{comp}	median D_{comp}	% offers with D_{comp}=0
EM1	0.69	1	55	0.05	0	93
EM2	0.92	1	87	0.09	0	89
EM3	0.94	1	88	0.10	0	87
EM4	0.87	1	82	0.24	0	74
all sessions	0.85	1	77	0.12	0	85

Table 1 presents mean and median values for both D_{client} and D_{comp} for each of the four EM sessions separately and averaged over all rounds. Also the percentage of offers with D_{client} = 1 and D_{comp}= 0 is indicated. The table shows that an offer was sent to 85% of the potential trading partners on average, with 100% being the median value. Furthermore, 77% of all offers were sent to every potential trading partner (D_{client} = 1). A look at the session data indicates that this pattern was representative also for the individual sessions. Even in EM1, where average D_{client} was lowest, an offer applied to all potential trading partners in more than half of the cases.

The dissemination of offers among competitors provided a completely different pattern. On average, only 12% of the competitors were informed about an offer, and the median value is zero. In 85% of all cases not one competitor was informed. It is evident that subjects were very reluctant to share information about their offers with their competitors.

[14] Note that this measure underestimates the actual the dissemination of an offer among potential clients,



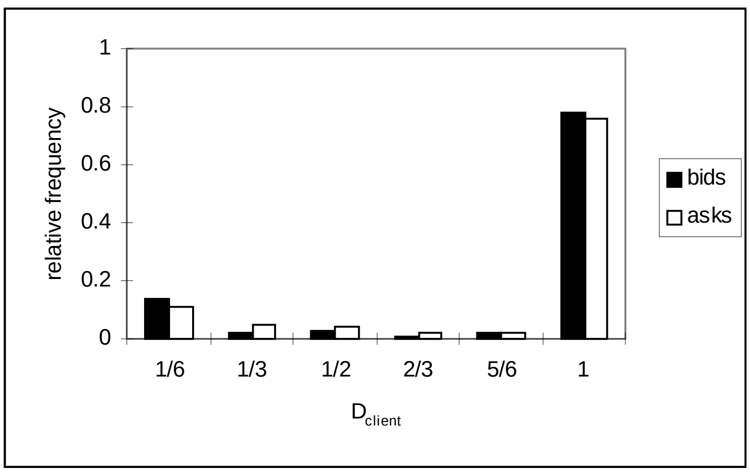


Figure 2: Relative frequencies of dissemination of bids and asks among potential trading partners (D_{client}) and competitors (D_{comp}) in the EM treatment

A similar picture arises if one looks at the dissemination of asks and bids separately. Figure 2 shows the relative frequencies of the different levels of D_{client} and D_{comp}. In most cases an ask applied to all buyers and no other seller was informed about the ask, whereas a bid typically applied to all sellers while no other buyer was informed about it.

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since sometimes traders knew that some potential trading partners had already left the market.

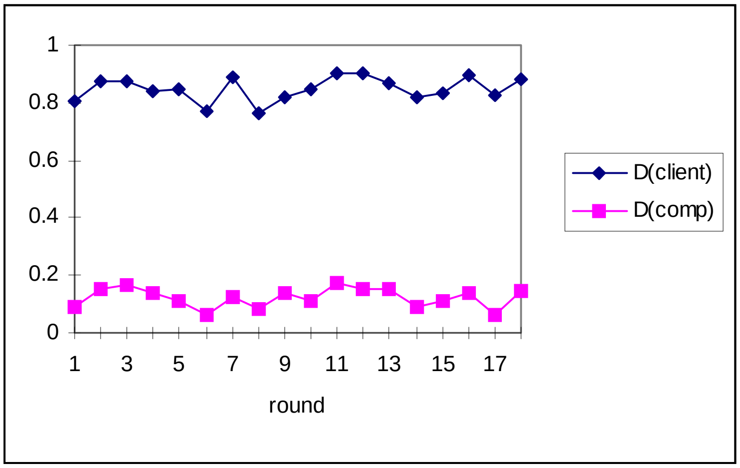

Figure 3: Development of average D_{client} and D_{comp} in the EM treatment

This pattern was stable over the time, as can be seen in Figure 3 which displays the development of average D_{client} and D_{comp} over the 18 rounds. From the very beginning of a session, subjects typically made offers to all potential trading partners and did not inform competitors, and this behavior did not change much over time. We also checked for the development of D_{client} and D_{comp} within the rounds. We found no distinctive differences between the beginning and the end of a round.

Result 2. Prices

Prices in the endogenous market treatments (EM) were as close to the equilibrium price as those in the DA-treatment and closer to the equilibrium price than those in the DBM-treatment.

Table 2. Average absolute difference between actual prices and equilibrium price range

Session#	DA	EM	DBM
1	0.57	0.54	2.04
2	1.72	0.88	1.26
3	1.49	0.67	1.76
4	0.61	1.08	1.31
All sessions	1.1	0.79	1.59

Remember that in our design the equilibrium price was set-valued (see Figure 1). Therefore, we looked at the average absolute difference between actual prices and the equilibrium price range [30,35]. The endogenous market treatment has an average distance to the equilibrium price that is not significantly different from the double auction, (p=*68%*).[15] On the other hand, the distance to the equilibrium price was larger in the DBM-treatment (1.59) than in the EM-treatment. Furthermore, as can be seen in Table 2, even prices in session EM4 (the EM-session with the largest distance between actual and equilibrium prices) were closer to equilibrium than prices in DBM2 (the DBM-session with the lowest distance to equilibrium). Hence, the difference between EM and DBM was highly significant ($p = 2.8\%$).

One purpose of market institutions is the provision of a matching and information structure that allows the traders to reap the gains of trade. Hence, we investigate to what extent the endogenous institution serves that purpose. We investigated the gains of trade not reaped by the traders, i.e. we looked to what the extent the sum of consumer and producer surplus fell short of its maximum level. A natural measure of inefficiency is the foregone surplus as percentage of the maximum possible surplus. Another measure is the number of inefficient rounds, i.e. the number of rounds where the forgone surplus was larger than zero. Using either of these two measures we find:

[15] Throughout we employed two-tailed Mann-Whitney tests with session averages as observations.

Result 3. Efficiency

a) The forgone surplus in the EM treatment was as low as in the DA treatment.

b) The forgone surplus was highest in the DBM treatment, and significantly so.

Table 3a. Foregone surplus (in % of total surplus)

Session #	DA	EM	DBM
1	1.48	1.77	6.31
2	0.25	0	7.83
3	1.26	1.26	9.34
4	1.77	0.76	5.30
All sessions	1.19	0.95	7.20

Table 3b. Number of inefficient rounds

Session#	DA	EM	DBM
1	3	3	13
2	1	0	11
3	3	4	11
4	4	2	6
All sessions	11	9	41

For each of the three treatments, Table 3a presents the average levels of foregone surplus and the number of inefficient rounds. The average inefficiency level in the EM and the DA sessions were about 1% and in the DBM sessions it was about 7%.[16] Contrary to our expectations the double sided private exchange that endogenously emerged in the EM treatment was about as efficient as the DA. The efficiency levels of the individual sessions of the two treatments overlapped and the difference between the treatments was not significant (p = 68%). This shows

[16] The impact of a trade of an extramarginal trader as well as that of a non-trade of an intramarginal trader on efficiency depends of course on the supply and demand conditions. Hence, not the absolute values of forgone surplus but the differences in efficiency between the treatments are important.

that an endogenous market institution can be as efficient as the DA. The least efficient institution was the DBM. Even the most efficient DBM session (DBM4) was less efficient than the least efficient EM session (EM1). Again, the difference between the EM and the DBM treatment was highly significant (p = 2.8%).

Qualitatively the same results appeared when we looked at the number of inefficient rounds (Table 3b). In the EM (DA) treatment only 9 (11) of 72 periods were inefficient. In the DBM in more than half of the rounds not all gains of trade where reaped (41 inefficient rounds out of 72). Again the difference between EM and DBM was significant (p = 2.8%), whereas the difference between DA and EM was not (p > 50%).

For a further examination of the efficiency properties one can distinguish between two different types of inefficiencies. A round is inefficient whenever an extramarginal buyer or seller trades. Such inefficient trades can only occur at out-of-equilibrium prices. But even in the absence of inefficient trades, a round may be inefficient if not all intramarginal traders strike a deal. Such an inefficient non-trade can occur if potential trading partners do not find each other or if they cannot agree on the price. It turned out that the inefficiencies during the early rounds of a session were due to inefficient trades as well as inefficient non-trades. If a later round was inefficient, however, this was almost always due to inefficient non-trades. This pattern emerged in all three treatments. Both types of inefficiencies, however, were much more frequent in the DBM- than in the EM and the DA treatment.

4. Transaction Costs

In the previous section we studied the market that emerges when each trader is given the technology to costlessly broadcast offers to any subset of traders. We now introduce one-sided transaction costs to study whether the decisions of traders to whom to broadcast their offers are influenced by and adapt in a meaningful way to transaction costs.

Treatment 4: Transaction Costs (TC)

The market technology is as in the endogenous market treatment: Whenever traders make an offer they have to decide to which potential trading partners and which competitors the offer should be revealed. Traders can only make offers which apply to at least one potential trading partner. Sellers could conceal or reveal asks from their competitors at no cost. When submitting an ask to the market, they could simply decide not to inform any of their competitors, just as they could decide to inform all of them or just a subset of them. However submitting bids to the market was costly for the buyers. In particular for each submitted bid, a buyer incurred a cost of 0.25 points for each trader (buyer or seller) whom he wanted to inform of the offer.

In this treatment we expected buyers to be less active by making both less bids and possibly also broadcasting those bids less widely. Therefore the emerging market should be rather one sided with sellers doing most of the active offering and buyers to rely mainly on waiting and accepting offers (which is costless to them). Given that traders chose not inform competitors in the endogenous market, we may expect that sellers still choose to make private offers.[17] Together these choices imply that there would be very little information to the active market side, the sellers. This may lead to inefficiencies. There exists, however, an institution that is as efficient as the double auction, and entails no transaction costs: the offer auction (Walker and Williams 1988). In an offer auction only sellers make asks. These asks apply to all buyers and every trader is informed about all asks and all transaction prices. To achieve this institution, sellers would have to inform each other about the offers they make, hence communicate their prices.

Results for the endogenous market with transaction costs (TC)

Result 4. The market structure with transaction costs

The market institution is best described as a one sided private exchange. Most of the offers were made by sellers and were typically sent to every buyer, but not to any competitor.

[17] Buyers now have to incur a cost for informing each other of any bid, this should therefore not lead them to inform their competitors more often.

The numbers of asks and bids in the TC treatment provide first evidence for Result 4. Whereas the introduction of the one-sided transaction costs left the average number of asks per round unchanged, it decreased the average number of bids from 15.7 to 8.6 (see Table 4).

Table 4. Average number of offers per round

Offer	Session	EM	TC
Bids	1	14.4	11.2
	2	15.1	5.6
	3	13.0	9.7
	4	20.3	8.1
	average	15.7	8.6
Asks	1	20.6	21.6
	2	16.4	15.2
	3	11.8	20.4
	4	17.3	13.7
	average	16.5	17.7

The effect of transaction costs on the dissemination of bids among sellers was even more dramatic than the effect on the number of bids. While in the EM treatment the average D_{client} of bids was 0.858, it dropped in the TC treatment to a level of 0.384 (see Table 5).

On the other hand, the dissemination of asks did not change with the introduction of the transaction costs. Average D_{client} in the TC treatment was 0.853, whereas in the EM it was 0.865 - typically asks applied to essentially all buyers (see Table 5). When we combined the effect of the decrease in the number of bids with the effect of the lower dissemination of bids, we found that the average number of bids a seller received per round dropped from 13.4 in the EM to 3.3 in the TC treatment. On the other hand, the average number of asks a buyer receives per round did not change (14.3 in the EM, 15.1 in TC treatment), and it was about 5 times as large as the number of bids a seller received in the TC treatment. Hence, we can conclude that the introduction of one-sided transaction costs induced the emergence of an institution where offers were made by the sellers, but not by the buyers. The behavior of traders was stable across periods. Only the average number of bids in the TC treatment declined slightly further during the course of the experiment. Hence, in the transaction cost treatment, the more experienced the buyers the less they were willing to make bids.

Table 5. Average values of D_{client} and D_{comp}

Offer	Session	D_{client} EM	D_{client} TC	D_{comp} EM	D_{comp} TC
Bids	1	0.782	0.337	0.099	0.009
	2	0.875	0.411	0.080	0.039
	3	0.955	0.423	0.091	0.016
	4	0.820	0.366	0.203	0.004
	average	0.858	0.384	0.118	0.017
Asks	1	0.627	0.838	0.023	0.117
	2	0.965	0.810	0.101	0.042
	3	0.923	0.880	0.090	0.074
	4	0.945	0.884	0.288	0.122
	average	0.865	0.853	0.125	0.089

Like in the EM treatment, the dissemination of offers among competitors (D_{comp}) was very low in the TC treatment (see Table 5). Hence, in both treatments offers were kept secret from the competitors.

Result 4 is hence quite favorable to the idea that transaction costs are capable of shaping the behavior of market participants and hence the resulting market institutions. The introduction of one-sided transaction costs led to a sharp decrease of costly bids, and the few remaining bids were much less disseminated.

What is the information structure of the resulting one sided private exchange? In a 'pure' one sided private exchange, when only asks are made and competitors are never informed, every seller knows only his own asks and only his own realized trades. The seller would have even less information than in the DBM, where he observes sometimes offers of buyers. Of course, in the TC sessions the emerging one sided private exchange was 'impure', i.e. some bids were made and some asks were transmitted to other sellers. In the TC treatment an average seller was informed about 19.8% of the offers made by others, and about 10.8 % of the acceptance of offers made by others - on average a seller is only informed about every fifth offer and only about every tenth acceptance of an offer (other than his own offers). In comparison, in the EM treatment an average seller was informed about 51.5 % of the offers made by others, and about 50.2% of the acceptance of offers made by others. Of course, in the DBM treatment these numbers are about 9% and 0%, and in the DA both numbers are 100 %. If we look at the evolution of the institution in the transaction cost treatment over time, we observe no trend towards an institution providing more information. On the contrary, the percentage of offers a seller is informed about decreases slightly as buyer learn to avoid transaction costs ad make less offers.

Next we investigate efficiency properties.[18] We have already seen that buyers do incur some transaction costs. We now investigate the efficiency of transactions only, not taking into account the wasteful transaction costs.

Result 5: Efficiency of the market with transaction costs

The foregone surplus was significantly higher in the TC treatment that in the endogenous market treatment (EM) and the double auction (DA). However, the foregone surplus was significantly lower than in the decentralized bargaining market (DBM).

[18] There were no significant differences between the TC and the DBM and EM respectively with respect to the difference between actual prices and the equilibrium price range.

Table 6a. Foregone surplus (in % of total surplus)

Session #	DA	EM	TC	DBM
1	1.48	1.77	3.54	6.31
2	0.25	0	2.02	7.83
3	1.26	1.26	3.79	9.34
4	1.77	0.76	2.02	5.30
All sessions	1.19	0.95	2.84	7.20

The average inefficiency level was about 3% in the TC treatment as compared to 1% in the double auction (DA) and the endogenous market (EM) treatments and 7% in the DBM treatment. Even the most efficient TC sessions (TC2 and TC4) were less efficient than the least efficient EM (EM1) and DA (DA4) session. The difference between the TC and these two other treatments was highly significant (p=2.8). However, the least efficient TC session (TC3) was more efficient than the most efficient DBM session (DBM 4), and efficiency differences were significant at (p=2.8%).

Table 6b. Number of inefficient rounds

Session#	DA	EM	TC	DBM
1	3	3	5	13
2	1	0	5	11
3	3	4	7	11
4	4	2	5	6
All sessions	11	9	22	41

A similar results hold when we consider the number of inefficient rounds (Table 6b). These inefficiencies can be caused by inefficient trades (at out of equilibrium prices) or by inefficient non-trades. Both types occur in early rounds, whereas in later rounds inefficiencies are mostly caused by inefficient non-trades.

5. The Effects of Price Communication

So far the emerging markets in our experiments share the feature that traders conceal offers from their competitors. When, as in the emerging market treatment, both market sides were active, the resulting institution lead nevertheless to high levels of efficiency. However, when only one market side was active (while the other had to bear transaction costs), the resulting institution was inefficient. Furthermore, the efficiency of offer auctions suggests that this preference of traders to conceal offers is the culprit for the observed inefficiency. We therefore find strong evidence that even in a homogenous good environment in which traders were not able to form relationships, traders do not opt for public market institutions. The emerging markets can be characterized as private exchanges, which are only efficient if both market sides are active.

This preference for private offers may seem at odds with the ongoing creation of industry consortia in which traders commit themselves to provide their competitors (those that are partners in the consortium) with information. There seem to be two (non exclusive) possible reasons for the formation of industry consortia. The first is that they may increase efficiency. If we are in a world like the transaction cost treatment, where mostly one market side is active, then information transmission among sellers would have increased efficiency. Higher levels of efficiency may increase profits for both market sides, sellers and buyers. A second reason is that price communication among competitors may allow and facilitate collusion. The hypothesis is that if sellers in the transaction cost treatment would inform each other, they may be able to coordinate on higher prices. While this increases profits for sellers, it is bound to reduce profits for buyers (who therefore may not have incentives to join such markets).

In our last treatment we provide traders with explicit incentives to communicate prices to their competitors. Specifically traders have to incur (small) costs if they want to conceal offers from their rivals.[19] This will show whether traders (sellers) have a weak or indeed a strong preference for not informing their competitors. Furthermore, if sellers chose to inform each other, we can study the effect of price communication on prices and efficiency.

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[19] These costs can be thought of as higher costs a seller has to face when she wants to strike a private deal

Treatment 5: Price Communication (PC)

Treatment 5 is as the transaction cost treatment 4 in that buyers have to bear transaction costs of 0.25 points for each trader (buyer or seller) they inform of the offer. Furthermore a seller incurs a fixed cost of 0.02 points for each competitor from which she withholds a price quote. The options to conceal or reveal price quotes are identical to those in treatment 4, only the direct costs of doing so are different. For example, a price quote can be concealed from all five competitors at zero costs in treatment 4, the transaction cost treatment, whereas doing so entails a cost of 0.1 points (5 x 0.02) in Treatment 5.

The transaction cost treatment now serves as a baseline treatment to measure the preferences of sellers to conceal offers and, in case those preferences are not strict, to study the effects of price communication.

Expected Results for the effect of price communication.

The results of the subsidized price communication treatment will show whether traders (sellers) have a weak or indeed a strong preference for not informing their competitors. What are the possible gains of sellers when they choose to inform each other?

First, sellers would avoid the costs for concealing offers from competitors.

Second, we have seen that the TC treatment led to inefficiencies, presumably because the active market side (the sellers) did not receive enough information. If sellers would choose to always inform each other, then the resulting institution would resemble an offer auction. In an offer auction only sellers make asks. These asks apply to all buyers and every trader is informed about all asks and about every acceptance of an ask. From a previous study (Walker and Williams 1988) we know that an offer auction exhibits the same properties as the DA. Therefore price communication among competitors might indeed lead to higher efficiencies and sellers may be able to claim part of this surplus.

Third, price communication may raise prices. Remember that in our market (Figure 1) the competitive quantity is 4 and the equilibrium price range is [30,35]. At a market price of 35, the

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outside the exchange set up by this sellers' consortium.

joint profit of sellers is 70 (and buyers' profits are 40) which is a considerable improvement over the joint profits of 50 which they attain at a price of 30 (where buyers' profits will be 60). Therefore more information among competitors might lead to a higher average transaction price than the one achieved in the transaction cost treatment (TC), which is 31.5.

Results for the Price Communication Treatment

Result 6: Communication

Most sellers strictly prefer to conceal their offers from rivals.

In a majority of the cases (59.6% averaged across sessions) sellers do not inform any competitor even if this secrecy is costly. In the remaining cases at least one rival is informed about the offer. In those cases, typically *all* rivals are informed (averaged across sessions we have D_{comp}=1 for 38.4% of the asks). The average dissemination of offers is higher in the price communication treatment 5 than in the transaction cost treatment 4, but at D_{comp}=0.377 it is still far below unity. Many sellers are willing to pay for secrecy. There is no tendency for D_{comp} to change much over time.

Table 7. Dissemination of ask prices among sellers

Session #	average value of D_{comp}		% offers with D_{comp}=0	
	TC	PC	TC	PC
1	0.117	0.394	85.4	58.0
2	0.042	0.016	95.2	97.8
3	0.074	0.466	89.5	47.4
4	0.122	0.632	85.8	35.3
average	0.089	0.377	89.0	59.6

Note: Averages and percentages are taken first over the offers within a round and then over the rounds.

As can be seen in Table 7, there is quite some heterogeneity across sessions. Whereas in session 2 almost all sellers opted to conceal prices, in PC4 sellers quite often chose to inform each other.

Result 7: The effects of price communication

Price communication between sellers has a small positive effect on transaction prices.

Table 8 presents average transaction prices for the different sessions and treatments. It appears that average prices are higher in treatment 5, the Price Communication treatment, (32.6) than in treatment 4 (31.5). The difference is small and marginally significant at p=0.11 with a two-tailed Mann-Whitney test and the 8 session averages as observations. This is in line with the hypothesis that increased price communication between sellers has an upward effect on transaction prices.[20]

Table 8. Mean and standard deviation of transaction prices in the Price Communication treatment (PC) and the Transaction Cost treatment (TC).

	mean price		standard deviation	
Session #	TC	PC	TC	PC
1	32.6	33.4	2.30	3.43
2	31.8	31.4	2.87	3.58
3	31.1	32.8	4.99	3.70
4	30.3	33.0	4.26	2.56
Average	31.5	32.6	3.60	3.32

Notes: Means and standard deviations of prices are taken first over the offers within a round and then averaged over the rounds.

Since there is a lot of heterogeneity on the amount of price communication across sessions, we analyze the relation between sellers communication and transaction prices in the PC

[20] This effect rests mainly on the early rounds of the experiment. Until round 12, average prices in treatment 4 (TC) are persistently below those in treatment 5 (PC). In the later rounds, however, their is no difference between the treatments.

treatment at a more disaggregated level. For each round we calculate the average level of D_{comp} across all asks (that is, for accepted as well as unaccepted asks). This gives us a measure for the general level of sellers' price communication in a round. We compare this to the corresponding average value of the transaction prices in the round. Across all rounds and sessions, the Pearson correlation between these two values is significantly positive: $r_P = 0.44$ (n=72, $p<0.01$).

The impact of price communication may arise from the fact that offers which were concealed from rivals ($D_{comp}=0$) were significantly lower ($p=0.066$) than offers that were revealed to at least one other seller ($D_{comp}>0$).[21]

In sum, we find that increased price communication between sellers increases transaction prices. The effect is statistically significant but moderate in absolute terms. In particular, average prices typically stay within the range defined by the competitive equilibrium.

We have seen that sellers display a preference to conceal price quotes (Result 6). Furthermore, Result 7 indicates that sellers benefit collectively from revealing price quotes. The next result shows that revealing price quotes has a public goods characteristic.

Result 8

It is individually rational to conceal price offers from competitors.

For each session in the PC treatment, Table 9 reports the average price of accepted asks. A distinction is made between accepted asks concealed from rivals ($D_{comp} = 0$) and accepted asks revealed to at least one rival ($D_{comp} > 0$). We find the accepted asks with $D_{comp} = 0$ have an average price of 33.7 and those with $D_{comp} > 0$ have an average price of 33.3.[22] Although the difference is small, it is statistically significant ($p = 0.08$, n=3). Furthermore, a price difference of 0.4 is sufficient to warrant the fine of concealment (0.1 = 5 rivals x 0.02) if no more than four

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[21] The average price of offers with $D_{comp} > 0$ was 42.2, compared to 38.3 for $D_{comp} > 0$.

[22] Of all accepted asks in the TC treatment, those with $D_{comp} > 0$ have an average price of 30.9 and those with $D_{comp} = 0$ an average price of 32.1. There are however only 9 accepted asks with $D_{comp} > 0$ versus 180 with $D_{comp} = 0$. Therefore, the table focuses on the sessions of the PC treatment.

price quotes are made before acceptance (the average number of quotes per seller per round is 1.6).

Table 9. Average price for concealed and revealed accepted offers

Session #	D_{comp}=0	D_{comp}>0
1	34.8	33.0
2	32.4	--
3	33.6	33.5
4	34.2	33.3
average	33.7	33.3

Notes. $p = 0.08$ Wilcoxon matched-pairs signed-ranks test (n = 3)

These data suggest that concealing price quotes from rivals is indeed the individually rational thing to do. Even though sellers benefit collectively from price sharing, an individual seller has little interest to reveal its prices to competitors. By revealing price quotes to competitors, a seller is more prone to being undercut by a rival seller. Concealed offers can carry a higher price than revealed offers.

We now explore the effects of price communication on efficiency.[23]

Result 9

Low levels of price communication did not significantly improve market efficiency, compared to the transaction cost treatment.

[23] Recall that prices in the transaction cost treatment were quite close to equilibrium prices, neither significantly farther than in the endogenous market treatment, nor significantly closer than in the decentralized bargaining market. Therefore, we are not surprised to find that price communication has no

Table 10. Foregone surplus (in % of total surplus)

Session #	EM	PC	TC
1	1.77	2.8	3.54
2	0	2	2.02
3	1.26	3	3.79
4	0.76	0.3	2.02
All sessions	0.95	2.02	2.84

Table 10 indicates that the average level of efficiency is higher in the price communication treatment (PC) than in the transaction cost treatment (TC), though not as high as in the emerging market treatment (EM). None of the differences are statistically significant, however. In PC 1-3, the sessions with low levels of price communication, the efficiency was as low as in the transaction cost treatment. Only session 4, in which sellers informed each other of around 65% of the offers, showed high levels of efficiency, comparable to the ones of the endogenous market treatment.

The results of the price communication treatment suggests that many traders have not just weak, but strong preferences to conceal information from their competitors. If traders would manage to provide incentives to disclose information to competitors, they would, collectively, benefit, to the detriments of the buyers. Price communication among competitors is characterized by public good features. Even though sellers would collectively benefit, each seller has incentives to keep her own ask secret.

5. Discussion and Conclusion

To investigate the driving forces that shape emerging market institutions we conduct experiments in which we endogenized the information and matching procedure. In our experiments the resulting institutions can be best characterized as private exchanges. When

effect on price dispersion or convergence.

traders had the opportunity, they chose to conceal offers from their competitors. These institutions provided less information than the double auction (where traders learned about all offers and all transaction prices), which can be thought of as a representative for public exchanges. Nevertheless the double sided private exchange mimicked the double auction in terms of efficiency and convergence to market clearing prices. In contrast, in a Decentralized Bargaining Market, where each trader is only allowed to communicate with one potential trading partner at a time, prices converged more slowly and efficiency was lower. These results imply that explanations for the efficiency of the double auction, which mostly heavily rely on information traders receive about their competitors, cannot capture our results, and hence may not capture the essential features that make the double auction so efficient.

When imposing one sided transaction costs on the buyers only the sellers made offers. This shows that even small transaction costs can shape the matching and information structure of markets. The preference of sellers to conceal their offers resulted the market to be a one sided private exchange which led to inefficient trading outcomes.

Even when sellers had to bear small costs, such that it becomes costly to hide information from the competitors, many sellers are willing to pay these costs. Providing information to competitors has features of a public good. Collectively the sellers would profit, by maintaining higher prices, though individually each seller has an incentive to keep her prices secret.

With the technology of the internet, it was presumed that traders would abandon private offers and conduct their trades publicly on public exchanges. However, many of the public exchanges failed. Our experiments support the hypothesis that this failure of public markets was not just due to a lack of the relevant technology, but due to traders' preferences for hiding information from competitors.

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Appendix: This appendix contains the instructions for the TC treatment. For the treatments DA, DBM, EM and PC we adapted the instructions accordingly.

Instructions:

Today we are going to set up a market in which some of you will be buyers and others will be sellers. Those of you who have drawn a "B" are buyers, those of you with a "S" are sellers. During the experiment you will have to make trading decisions and these decisions will determine your earnings. During the experiment your earnings will be denoted in points. For each point you earn you will get 30 cents for your participation. Your earnings will be paid to you privately and in cash after the experiment.

First, we will go through the instructions together. After that you will get the opportunity to study the instructions in your own pace and to ask questions. Also we will have a practice round before we start the experiment. If you want to make notes you can use the empty sheet that is on your table. Please, do not write on the instructions, and do not touch the keyboard until we are done with the instructions.

The experiment will consist of 18 trading rounds. In each trading round each buyer may buy at most one unit. Each seller may sell at most one unit. Trades are made in accordance with certain rules that will be explained below. If a buyer buys a unit in a round, her gross-earnings are equal to the *resale-value* of the unit to her minus the price she pays for the unit. If a buyer does not buy a unit, her gross-earnings for that round are zero. If a seller sells a unit in a round, his gross-earnings are equal to the price he receives for the unit minus the *cost-value* of the unit to the seller. If a seller does not sell a unit, his gross-earnings for that round are zero.

Resale-values as well as cost-values are strictly private information, no other participant than the concerning buyer or seller, respectively, will learn about it. Hence, every participant knows only his own gross-earnings from a trade. Your net-earnings in a round are equal to your gross-earnings minus the cost you made by sending offers to other traders. How these latter costs are determined will be explained below. Finally, your total earnings for the experiment are equal to the sum of your net-earnings in each of the 18 rounds.

Computer screen

The trading of units will take place by means of the computer. All relevant information will be available on your computer screen. You can now see what the screen will look like during the experiment.

In the top left of the screen you can see how many points you have earned up to that moment. Also the number of the present round is indicated. Below that you see how much time is left for trading in that round. For each of the 18 rounds the total time for trading is 3 minutes.

In the middle of the screen you will see a list of the relevant ask and bid-prices. An ask-price indicates the price at which a seller is prepared to sell, and a bid-price indicates the price at which a buyer is prepared to buy. Ask- and bid-prices will be explained in more detail below.

On the right-hand side of the screen your value is indicated. If you are a buyer, the *resale-value* of a unit in that round is indicated. If you are a seller, the *cost-value* of a unit in that round is indicated. Resale-values may be different for different buyers, and cost-values may be different for different sellers. Also your value may change from round to round. But every buyer gets the same resale-values the same number of rounds, and every seller gets the same cost-values the same number of rounds. Also you can see where your gross-earnings will be indicated, and that your net-earnings for the round will be equal to your gross-earnings minus the cost you have made in sending offers (as will be explained below).

In the middle left of the screen you see whether you are a buyer or a seller. Here also your ID-letter is indicated. The IDs for the buyers are A, B, C, D, E and F. The IDs for the sellers are U, V, W, X, Y and Z. Your ID will randomly change from round to round. Furthermore, IDs are not related to the cost- or resale-values. Hence, the IDs are for registration purposes only and do not convey information about the identity of participants or about their values.

In the bottom right of the screen you see a box called last action. This box mentions the last action that is relevant to you.

Finally, at the bottom of the screen you see a long flat row. In this row you are informed about all accepted asks and bids that were in your column of ask- and bid-prices.

Now we will first go through the specific instructions for buyers, and then through the specific instructions for sellers. On your hand-out you will only find the specific instructions that concern your role in the market.

Specific instructions for buyers

After the determination of the values and the IDs, the market opens for trading. If you want to buy a unit, and you have not yet bought a unit in that round, then you can do two things:

(1) You can press B to make a *bid* and to enter a price at which you are prepared to buy a unit. After you press B you are requested to enter a bid-price. This bid-price must be above or equal to zero and below or equal to your resale-value. After you have entered your bid-price, you must decide to which sellers you want to send your bid and which of the other buyers you want to inform about your bid. *You may send your bid to any number of sellers, but at least to one seller. You may inform any of the other buyers about your*

bid, but you are not obliged to do so. Therefore, after you entered your bid-price, you are also requested to enter the ID(s) of at least one seller to whom you want to send this bid and of any of the other buyers you want to inform. Hence, you may enter as many of the seller ID-letters (U, V, W, X, Y, Z) and buyer ID-letters (A, B, C, D, E, F) as you want, but you should at least enter one seller ID-letter. Recall that the IDs change from round to round. After you have entered the ID(s), your bid-price will appear in the lower middle of your screen in the column "bids" and it is marked with an asterix (*). Now your bid-price is transmitted to the sellers and buyers you have entered, and will appear in their columns of bid-prices together with your ID.

By sending your bid to a seller or another buyer you incur a cost. To be precise, for each of the other traders (seller or buyer) that you decide to inform about your bid, you incur a fixed cost of 0.25 points. The total cost you incur by sending bids to other traders will be subtracted from your gross-earnings to determine your net-earnings for the round.

A seller who receives your bid may accept it or not. The buyers you selected can of course not accept your bid - they are only informed about it. As soon as one of the sellers accepts your bid, you will get a message in the lower-right corner of your screen under "last action", and the corresponding earnings will be calculated and indicated on your screen under "value". Also all other sellers and buyers you have chosen to send your bid to will learn that your bid is accepted. Your bid-price will vanish from their column "bids" and will appear in the row at the bottom of their screens.

If your bid is not accepted by a seller, you will not get a message. Notice that it is possible that you send a bid to a seller who has already sold a unit to another buyer. Hence, receiving no message may mean that the sellers you selected to send your bid to have not yet decided about your bid, that they reject it, or that they already sold a unit.

As long as you have not bought a unit in the trading round you may always revise your bid by just pressing "B", entering a (possibly new) price, and entering (possibly new) sellers' and buyers' IDs. If you enter a new bid, your old bid will disappear. By making a new bid you again incur a fixed cost for each of the other traders that you decide to inform about your new bid. However, you are not forced to make any (new) bid. Like buyers can make bids, sellers can make *asks*. This brings us to the second thing you can do to buy a unit.

(2) You can press on K. In that case you can buy one unit at one of the ask-prices that is indicated in the column "asks" in the upper-middle of your screen. Of course, you cannot use this option if this column is empty. If an ask-price is indicated in this column, then one of the sellers (indicated by his ID-letter) is prepared to sell a unit to you at the indicated price. If you decide to accept this ask-price you simply press K.

Since there may be more than one ask-price in the column, you also need to enter the seller-ID of the ask you wish to accept. Then the trade is conducted, your earnings are registered, and all buyers and sellers who were informed about this ask can see at the bottom of their screen that a trade has occurred at this price.

Specific instructions for sellers

After the determination of the values and the IDs, the market opens for trading. If you want to sell a unit and you have not yet sold a unit in that round, you can do two things:

(1) You can press P to make an *ask* and to enter a price at which you are prepared to sell a unit. After you press P you are requested to enter an ask-price. This ask-price must be below or equal to 100 and above or equal to your cost-value. After you have entered your ask-price, you must decide to which buyers you want to send the ask and which of the other sellers you want to inform about your ask. *You may send your ask to any number of buyers, but at least to one buyer. You may inform any of the other sellers about your offer, but you are not obliged to do so*. Therefore, after you entered your ask-price, you are also requested to enter the ID(s) of at least one buyer to whom you want to send this ask, and of any of the other sellers that you want to inform. Hence, you may enter as many of the buyer ID-letters (A, B, C, D, E, F) and seller ID-letters (U, V, W, X, Y, Z) as you want, but you should at least enter one buyer ID-letter. Recall that the IDs change from round to round. After you have entered the ID(s), your ask-price will appear in the upper middle of your screen in the column "asks" and it is marked with an asterix (*). Now your ask-price is transmitted to the buyers and sellers you have entered, and will appear in their columns of ask-prices together with your ID.

For each of the other traders (buyer or seller) that you decide to inform about your ask, you incur a fixed cost of zero - by sending your ask to a buyer or another seller you does not incur any cost. Hence if you make a trade in a round, your net-earnings for that round are equal to your gross-earnings.

A buyer who receives your ask may accept it or not. The sellers you selected can of course not accept your ask - they are only informed about it. As soon as one of the buyers accepts your ask, you will get a message in the lower-right corner of your screen under "last action", and the corresponding earnings will be calculated and indicated on your screen under "value". Also all other buyers and sellers you have selected to send your ask to will learn that your ask is accepted. Your ask-price will vanish from their column "asks" and appear in a row at the bottom of their screens.

If your ask is not accepted by a buyer, you will not get a message. Notice that it is possible that you send an ask to a buyer who has already bought a unit from another seller. Hence, receiving no message may mean that the buyers you selected to send your ask to have not yet decided about your ask, that they reject it, or that they have already bought a unit.

As long as you have not sold a unit in the trading round you may always revise you ask by just pressing "P", entering a (possibly new) price, and entering (possibly new) buyers' and sellers' IDs. If you enter a new ask, your old ask will disappear. However, you are not forced to enter any (new) ask. Like sellers can send asks, buyers can make *bids*. This brings us to the second thing you can do to sell a unit.

(2) You can press on V. In that case you can sell a unit at one of the bid-prices that is indicated in the column "bids" in the lower middle of your screen. Of course, you cannot use this option if this column is empty. If a bid-price is indicated in this column, then one of the buyers (indicated by her ID-letter) is prepared to buy a unit from you at the indicated price. If you decide to accept this bid-price you simply press V. Since there may be more than one bid-price in the column, you also need to enter the buyer-ID of the bid you wish to accept. Then the trade is conducted, your earnings are registered, and all sellers and buyers who were informed about this bid-price can see at the bottom of the screen that a trade has occurred at this price.

Summary

The experiment consists of 18 trading rounds, and each round lasts 3 minutes. You are either a buyer or a seller. In a round each buyer may try to buy one unit and each seller may try to sell one unit. For a buyer, gross-earnings will be equal to the resale-value of the unit minus the price paid. For a seller, gross-earnings will be equal to the price received minus the cost-value of the unit. Values are different for different traders, and they change from round to round. Buyers can try to buy by making bids or by accepting asks. Sellers can try to sell by making asks or accepting bids. Buyers' net-earnings in a round are equal to their gross-earnings minus the cost they made in sending bids to other traders. Each time a buyer makes a bid she incurs a cost of 0.25 points for *every* seller or buyer she decides to inform about this bid. Sellers costs from sending asks to other traders are zero. Therefore, their net-earnings are equal their gross earning.

During the experiment all earnings are denoted in points. After the experiment, your earnings in cash will be determined at a rate of *1 point = 30 cents*. You will receive your earnings privately, immediately after the experiment. Your earnings are your own business, you do not have to discuss them with anyone.

Final remarks

During the experiment, it is not allowed to talk or communicate with other participants in any way (other then through the trading). If you have a question, please raise your hand and the experimenter will come to your table. If anything strange appears on your screen, or if you think the computer is not doing what you think it should, please notify the experimenter so he can try to fix the problem.