Cheating in Markets: A Laboratory Experiment*

Alessandra Cassar†, Daniel Friedman‡ and Patricia Schneider§

August 2007

Abstract

We develop a two-market model under three conditions: autarky, frictionless free trade, and free trade with cheating. With cheating, buyers can underpay by $\pi\%$ in cross-market trades and sellers can deliver $\pi\%$ of full value. We solve for competitive equilibrium with cheating and obtain novel testable predictions on price, volume and surplus. We test these in a laboratory experiment using parameters intended to challenge the theory. The results are generally consistent with competitive equilibrium. We find evidence of price unification, market segmentation, a cross-market volume of trade lower under cheating than in frictionless free trade but a higher overall volume.

Keywords: Cheating, Missing Trade Puzzle, Frictions, Market Experiment

JEL Classification: C92, D85, F10, O10

*We are grateful to the National Science Foundation for funding under grant SES-0351801. We received helpful comments from Darren Acemoglu, James Rauch, Jason Shachat, Vernon Smith; participants at the International Economic Science Association Meeting in Amsterdam (June 2004); North American Meeting of the Economic Science Association in Tucson (November 2004); National Academy of Science Beckman Frontiers of Science Symposium in Irvine (December 2004); International Conference on Experiments in Economic Sciences in Okayama, Japan (December 2004); Annual Meeting of the American Economic Association in Philadelphia (January 2005); and department seminars at Brandeis University and at the University of San Francisco.

†Department of Economics, University of San Francisco - acassar@usfca.edu.

‡Department of Economics, University of California, Santa Cruz - dan@ucsc.edu.

§Department of Economics, Mount Holyoke College - pschneid@mtholyoke.edu.

1 Introduction

A central theoretical proposition in economics, bolstered by laboratory experiments since Smith (1962), is that frictionless markets perform at 100% efficiency. However, all actual markets have trading frictions to some degree. In particular, cheating is possible whenever quality is not costlessly observable and whenever buyer or seller can't simultaneously and instantaneously fulfill their obligations. The seller might ship an item of lower quality, delay delivery, or not deliver at all. The buyer might bounce a check, send partial or late payment, or not pay at all. Such "cheat frictions" loom large in major markets of the ancient and medieval world (e.g., Greif, 1993) and in most markets of countries with weak enforcement of contracts, e.g., in much of sub-Saharan Africa (Fafchamps, 2004) and in Russia in the 1990s (e.g., Klebnikov, 2000; Leijonhufvud and Craver, 2001).

Even in modern markets developed economies with sound legal institutions, the court system plays a secondary role in preventing cheating. People don't embark in costly legal actions when transactions are small, and even for large transactions a debtor may be "judgment proof." Bernstein (1992, 1996, 2001) shows that entire industries in the US, including diamonds, grain and cotton, have essentially opted out of the public legal system, and instead rely on private quasi-legal systems and reputation-based sanctions. According to some observers, eBay's main competitive advantage in Internet auctions is its reputation rankings, which reduce cheat frictions (e.g., Anderson et al., 2004; Resnick et al., 2006).

Cheat frictions are also an issue at the international level. National jurisdictions and existing international institutions leave many gaps. For example, about half of international sales of cotton are governed by the private Liverpool Cotton Association rather than by the official Convention on the International Sale of Goods or by national courts (Bernstein, 2001).

International trade economists for years have debated the "mystery of the missing trade." The observed volume of international trade is far smaller overall than predicted by traditional models, even when formal trade barriers are taken into account (Trefler, 1995; McCallum, 1995; Helliwell, 1998). A leading suspect is the lack of trust in the enforcement of contracts in international markets (e.g., Rauch, 2001; Anderson and Marcouiller, 2002). Hidden transaction costs in international trade can include extorted bribes and the risk of hijacking, as well as more subtle quality shortfalls or delays in payment. Rodrik (2000) argues that contract enforcement is in fact more difficult where multiple legal jurisdictions are involved, and Marcoullier and Young (1995) argue that informal enforcement mechanisms are also less effective for international transactions. Anderson and Young (2002) show that imperfect contract enforcement in the importer's country is equivalent to a tariff under risk neutrality.

The present paper studies the impact on trade when contracts are not perfectly enforceable among anonymous traders. Motivated in part by the "missing trade"puzzle, we use international trade terminology when it clarifies the exposition, but we do not develop a fully-fledged international trade model. Indeed, in order to focus sharply on the questions of present interest, our model neglects income effects and production, and so has a partial equilibrium flavor. By contrast, Noussair, Plott and Reizman (1995) and subsequent laboratory studies employ the full general equilibrium model to investigate a different set of issues, such as the impact of international trade on resource allocation and the dynamics of intermarket equilibration.

We develop a simple two-market model under three conditions: local trades only (autarky), local and distant trade with costless enforcement of contracts (frictionless free trade), and distant trade with partial enforcement (cheat friction in international trade). In the cheat condition, the buyer in distant trades has the option to pay only a given fraction $\pi < 1$ of the agreed price, and the seller has the option to deliver only π of the value. Contracts are fully enforced in local transactions. Thus buyers and sellers must trade off better trade opportunities in distant markets against the friction of imperfect contract enforcement.

The model can be solved explicitly to characterize competitive equilibrium with cheating for any value of $\pi \in [0, 1]$. At $\pi = 1.0$, of course, we have frictionless free trade and, not surprisingly, at $\pi = 0.0$ the model predicts a reversion to autarky. In between, the model yields novel testable predictions on price, volume and surplus. For example, agents with highest value and lowest cost are diverted to inefficient but "safe" domestic transactions, while agents closer to the margin trade only internationally and always cheat. The overall volume of trade is higher (!) than in frictionless free trade because extra-marginal agents have now profitable opportunities to trade in the distant market, but (consistent with the missing trade literature) international (cross-market) trade volume is lower and, of course, overall surplus extraction is lower. As π decreases from 1.0 to 0.0, domestic prices move non-linearly from autarky levels to the frictionless free trade level.

This competitive model is then tested in a new laboratory environment in which human subjects can trade in a home ("Local") market and also in a foreign ("Distant") market.

In the cheat treatment, contracts are not perfectly enforceable in the foreign market and traders remain anonymous in the foreign market so they cannot establish a reputation. By comparing market outcomes in this treatment to those in the autarky and frictionless free trade treatments, we can measure cleanly the impact of the cheat friction. The laboratory results thus evade a pervasive identification problem with field data (Fafchamps, 2007).

The theoretical model and the laboratory environment are not intended to replicate closely actual domestic and foreign trade. We can learn more in the lab about questions of general interest when we choose parameters to get sharp results, rather than parameters chosen to be representative of the outside world. In this spirit, we deliberately picked an extreme, unrealistic parameter set that gives insight into several classic issues.

First, what is the predictive power of the classic models of autarky and free trade? As explained below, our supply and demand configurations are simple but present a real challenge for the classic models. In particular, does frictionless free trade always produce unified prices, i.e., does the law of one price hold between the two markets? More generally, is convergence slowed or stopped by the many options of where to trade, with whom, and whether to cheat? Of particular interest, does the new theoretical model predict the outcomes well when cheating is allowed?

The results of the experiment are generally consistent with the competitive equilibrium predictions. We find strong evidence of price unification and of market segmentation. When contracts are not enforceable the overall volume of trade is indeed higher than in frictionless free trade (or in autarky). Consistent with the missing trade literature, the volume of international trade (excluding domestic trade) is lower than in frictionless free trade and, although not universal, cheating is indeed rampant.

The paper is organized as follows. Section 2 presents the experimental design. Section 3 summarizes the theoretical model. Section 4 presents the results followed by a discussion in Section 5. Mathematical details on the competitive model appear in Appendix A. Complete instructions to subjects are available at the first author's webpage and, for the convenience of referees, are included in the present draft as Appendix B. A subsequent paper, Cassar, Friedman and Schneider (2007), shows that reputation-based interpersonal networks can partially (but not completely) overcome the cheat friction.

2 Experimental Design

The experiment uses the well-known continuous double auction (CDA) market format. At any instant during a trading period, each buyer can post a public bid (offer to buy a unit at a given price or better) and each seller can post a public ask (offer to sell a a unit at a given price or better). Each trader also at any instant can accept another trader's offer and immediately transact at the posted price p. A buyer with unit value v earns the profit or surplus $v-p$ on the transaction, and a seller with cost c on the unit earns $p-c$, so the overall gains on the transaction are $v-c$.

Our computerized CDA has several distinctive features, illustrated in Figure 1. Two markets run simultaneously. Depending on the treatment, a trader may be able to trade only in her home market ("Local Market"), or in both markets ("Local Market" and "Distant Market"). Each trader can transact up to 4 units each period, and different units can have different cost or value. Each trader has a "nickname" that in the autarky and frictionless free trade can be used to identify her to potential transaction partners. In the cheating friction treatment, the nickname is suppressed and only "??" is seen in the distant market. Figure 1 shows the window active during the trading period. Between trading periods traders can view past transactions and profits by clicking the history tabs. All the screens seen by the subjects are shown in Appendix B.

Sixteen human subjects (recruited by email from a list of hundreds of volunteers, most UCSC undergraduates) participated in each laboratory session. Some sessions used only subjects with no prior experience with our laboratory market. Other sessions used only experienced subjects, who had participated in a prior session. Each subject was randomly assigned to one of four buyer roles or one of four seller roles in one of the two different "Local Markets" referred to below as the Red market and the Blue market.

Each session began by going through part A of the instructions, followed by a practice period. Next came the first block of 3 to 4 periods, and then later parts of the instructions and later blocks of periods using different treatments. Buyer values and seller costs were reshuffled once about half-way through the two-hour sessions with experienced subjects. Each trading period lasted 240 seconds with a 10 second break between periods. After the last period, subjects were paid a \$5 show-up fee plus earnings for all periods; most subjects earned between \$15 and \$35. Tables 2a and 2b report the treatments used in each block of each session.

Autarky Treatment. Sessions with inexperienced traders begin with 3 periods of autarky. Under autarky agents can buy and sell only in their "Local Market" and cannot cheat, i.e the buyer has to pay in full and the seller has to deliver a whole item. As shown in Figure 2 and Table 1, inverse supply and demand are higher in the Red market than in the Blue market.

Frictionless Free Trade Treatment. Sessions with inexperienced traders continue with a block (3 or 4 periods)[1] of frictionless free trade. Here each trader can participate in both markets at the same time. Side-by-side color-coded copies of the main window allow each trader to post, observe and accept offers in the distant market as well as in the local market. The third panel of Figure 2 shows the total demand and supply when cross market trade is allowed. Note that in equilibrium, only Red buyers and Blue sellers transact, and all Red sellers and all Blue buyers are extramarginal. This treatment therefore provides a new stress test for competitive equilibrium theory.

Cheat Treatment. The next 4 period block in sessions with inexperienced traders, and the first block of 4 periods with experienced players, features the option to cheat a fixed exogenous degree $\pi = 0.5$ in trades in the distant market. Cheating is never allowed in local trades, e.g., in the Blue market between two Blue traders. The choices are sequential. First the trader accepting an offer chooses whether to cheat or not. That choice is observed by the trader who posted the offer, who then decides whether to cheat. Sellers cheat by delivering a good that costs πc instead of c and that provides value πv instead of v. Buyers cheat by paying only πp instead of p. (Instructions avoid the word "cheat,"and just talk about the choice of paying $100\pi\%$ or 100%, etc.)

For example, suppose that $\pi = 0.5$ and that a buyer posts bid price $p = 50$ on a unit he values at $v = 60$. If a seller from the distant market with cost $c = 40$ accepts and decides not to cheat but the buyer then decides to cheat, then the buyer surplus is $v - \pi p = 60 - 0.5 * 50 = 35$ and the seller surplus is $\pi p - c = 0.5 * 50 - 40 = -15$.

It should be emphasized that in this treatment, cross market transactions are anonymous. Traders' nicknames are shown in all-local market transactions, but are replaced by "??" when they post or accept bids and asks in distant markets. The idea is to obtain a clean

[1] As shown in Table 2a, the initial inexperienced sessions CHEAT05-07 have 3 period blocks, but we shifted to 4 period blocks for subsequent inexperienced sessions to reduce the cognitive load on our subjects.

estimate of cross-market trade in the absence of international reputation and first-degree price discrimination.

3 Theoretical Predictions

Computing the competitive equilibrium (CE) predictions is straightforward under autarky and free trade. An examination of Figure 2 will convince the reader that in Red market autarky, the CE price is $p^*_{RA} = 65$, and quantity is $q^*_{RA} = 8$. Since the price is set by the marginal sellers, buyer surplus of 100 is larger than seller surplus of 60, resulting in total Red market surplus of 160. The autarky CE in the Blue market has the same quantity and surplus but at CE price $p^*_{BA} = 25$. Overall surplus in autarky is $S_A = S_{RA} + S_{BA} = 320$, as indicated in the first row of Table 3.

The supply and demand curves in frictionless free trade are the (horizontal) sum of supply and demand in Red and Blue markets, as depicted in the third panel of Figure 2. The CE is seen to have $p^*_{FT} = 45$, quantity $q^*_{FT} = 16$, and a resulting surplus $S_{FT} = 640$. In the second row of Table 3, these predictions are entered in the cross-market column because in the frictionless free trade CE, Blue sellers will "export" and sell units to Red buyers. See Appendix A for details of the CE computations.

Note that CE trade volume in frictionless free trade remains the same as in autarky, but the CE surplus doubles to 640, of which 360 is Blue seller surplus and 280 is Red buyer surplus. The environment is a challenge for theory, especially because CE surplus falls to 0 for Blue buyers and for Red sellers. This extreme redistribution may retard convergence to CE and may encourage violations of the law of one price.

Competitive equilibrium with cheating is not covered in textbooks and so deserves a longer explanation. The option to cheat means that there are additional markets. Besides domestic transactions in Red and Blue markets where no cheating is allowed, there are international transactions in each market that may or may not involve cheating. At first glance, then, it might seem that there are four additional markets. However, in equilibrium these collapse to just one additional market: international transactions where both parties cheat. The full explanation appears in Appendix A. In brief, the idea is (a) cheating is the (iterated dominant) equilibrium strategy in international transactions so the non-cheating international markets disappear, and (b) arbitrage eliminates price differences in international trade, so international trades (all involving cheating) should take place at the same price in both Red and Blue markets.

The upshot is that there are three distinct markets in equilibrium, denoted R (Red domestic), B (Blue domestic) and C (cheat or cross). In any competitive equilibrium, traders take as given a vector of prices and choose quantities so as to maximize profit. The resulting supply and demand schedules then must clear at the given prices. A CE with cheating $\pi \in (0, 1)$ thus is a price vector $p^* = (p^*_R, p^*_B, p^*_C)$, together with the associated trades, such that

- Every Blue trader transacts each unit in market B or C or holds the unit, whichever is more profitable. Given π and p^*, this condition yields the quantity supplied and demanded in market B, and Blue traders' portion of supply and demand in market C.
- Every Red trader transacts each unit in market R or C or holds the unit, whichever is more profitable. Given π and p^*, this condition yields the quantity supplied and demanded in market R, and Red traders' portion of supply and demand in market C.
- Supply equals demand in each of the three markets, given π and p^*.

Using a close linear approximation of the laboratory parameters, Appendix A derives closed form expressions for an essentially unique CE for arbitrary $\pi \in [0, 1]$. The expressions coincide with the autarky CE for $\pi = 0$ and coincide with the frictionless free trade CE for $\pi = 1$. In between, the CE varies smoothly but non-linearly between the two extremes. It allows some traders that are extramarginal in autarky and frictionless free trade to be able to earn profits.

The last row in Table 3 summarizes the CE outcomes for $\pi = 0.5$. Because of the discrete supply and demand, one of the price predictions is no longer unique but still lies in a narrow interval. CE prices are: 45 in the cross-market, $32.5 - 35$ in the Blue market, and 60 in the Red market. CE trading volume increases from 16 to 22 units: 10 units trade across markets and involve cheating by both buyer and seller, while 6 units trade domestically in each home market.

Despite the higher overall trading volume, the CE surplus decreases to 425. An intuitive explanation is that relative to frictionless trade, actual cheating cuts the surplus in half in each transaction in C. Moreover, the threat of cheating in C causes high-surplus traders to retreat to their home markets where they transact with low surplus – but guaranteed honest – traders (high cost sellers in R and low value buyers in B). Transactions involving these low surplus traders are inefficient, so the mere threat of cheating also reduces the surplus while reducing the volume of cross-market trade.

Besides the specific predictions in Table 3 we shall test three more general hypotheses based on the competitive equilibrium analysis.

H1. Price unification. Under frictionless free trade, mean transaction price is the same in the Red market as in the Blue market. The natural alternative to this null hypothesis is that inertia allows Blue prices to remain lower than Red. Under cheating, price unification doesn't hold anymore and prices are expected to be highest for Red market transactions, lowest for Blue market transactions and in between for international transactions.

H2. Market segmentation. When cheating is allowed, traders with highest value and lowest cost trade exclusively in the domestic market, and traders closer to the margin trade only in the cross-market (and cheat). The null hypothesis is that value and cost are unrelated to choice of domestic vs cross-market.

H3. Trade volume. Overall trade volume is higher when cheating is allowed than under either frictionless free trade or autarky. The reason is that 6 units that are extra-marginal under frictionless free trade are traded domestically when cheating is allowed. On the other hand, consistent with some intuitions on the missing trade puzzle, cross-market trade volume is lower under cheating than under frictionless free trade. The null hypothesis is that trading volume is independent of treatment.

4 Results

We ran ten sessions with inexperienced traders and seven sessions with experienced traders, with treatments described in Tables 2a and 2b. We begin by summarizing the outcomes under the three treatments, and then examine tests of the main hypotheses.

Autarky. Figure 3 shows the real-time sequence of transactions in all Autarky periods. With inexperienced traders, actual prices converge towards CE from above in the low price Blue market, and converge from below in the high price Red market. Table 4 shows that the standard deviation of prices declines in both markets; the only exception is due to a few outliers in the Red market for period four. By the final period, this measure of price dispersion is down to 3.0 for the Blue market and 5.1 for the Red, while the average price is within 0.3 of the CE predictions. Over all periods, average price in each market differs from the CE prediction by less than one-fourth of a standard deviation. Thus price convergence is quite sharp in both high and low price markets.

Average trading volume is within 0.6 unit of the CE prediction in every period in both markets, and the overall average volume of 8.1-8.3 is very close to the 8.0 prediction. Average gains from trade are 286.4, about 89.5% of the CE prediction 320.0.

Frictionless Free Trade. Table 5 and Figures 4 and 5 show behavior in Frictionless Free Trade. As predicted, domestic trade volume shrivels, averaging 1.3 unit or less each period in both Red and Blue markets. Average volume in the cross market reaches 15.4 in the fourth period and averages 15.2 overall, quite close to the CE prediction of 16.0. Average prices in the cross market (and overall) are within 0.3 of the CE prediction 45. Price dispersion declines dramatically in the cross market; the standard deviation falls from 11.6 to 3.6. A key prediction is that CE surplus doubles to 640. The average realized surplus also rises sharply. It is 599 or above in all periods, and efficiency reaches 619.3/640=96.8% in the last period, and 606.3/640=94.8% overall.

We conclude that actual behavior tracks the extreme CE predictions surprisingly well in the first two treatments.

Trade with Cheating Frictions. Tables 6ab and 7ab and Figures 6-9 show behavior when cheating is allowed in cross-market trade. With inexperienced subjects who have just finished the frictionless free trade treatment, the actual average number of cross-market trades with no cheating falls from 15.2 to 1.7, compared to the CE predicted fall from 16.0 to 0. Meanwhile, the average number of cross-market trades with cheating rises to 13.2, beyond the CE forecast of 10.0. With experienced traders, the average number of cross-market trades with no cheating falls to 2.3, and the average number with cheating rises to 9.0. Thus cheating is indeed rampant in cross-market trade (89% of trades for inexperienced and 80% for experienced traders), and deviations from the CE quantity predictions diminish with time for inexperienced traders. (The trend for experienced traders is less clear, a point we shall return to later.)

The predicted price is 45 for cross market trades, and average prices are 45.9 for inexperienced and 48.2 for experienced traders. The standard deviation declines over time, and averages about 6 for inexperienced and less than 5 for experienced traders. Thus there is approximate price convergence to CE, in some respects even tighter than in the frictionless free trade treatment.

The CE model overpredicts trade volume in the two domestic markets. Actual volume in both local markets averages about slightly less than a third of the predicted 6.0 for inexperienced subjects and around half the predicted value with experienced subjects. The trend is upward but slow. Slow convergence is also seen in domestic prices which remain less extreme than predicted and fairly dispersed, even if they average significantly higher in the domestic Red market than in the Blue market as predicted. Average price stays about 5 points above the predicted band in the Blue market and 3.5 below in the Red market with inexperienced traders, while with experienced traders the prices are a bit closer to the predicted values in both markets.

Total surplus is quite variable in this treatment: 385.6 ± 56.8 with inexperienced traders and 428.7 ± 81.7 with experienced, versus the CE prediction of 425. The no-cheat cross-market trades, i.e. honest cross-market transactions among anonymous agents, increase surplus beyond the CE prediction, but the other departures from CE more than offset.

The cheating rates summarized in Table 8 help us understand the departures from CE predictions. The rates tend to increase with inexperienced subjects, who initiate cheating in 63.6% of period 1 transactions and in 72.2% of period 4 transactions. When the initiator of a transaction is honest, the counterparty chooses her dominant strategy of cheating in only 53.3% of cases in the first period, rising to 68.8% in the last one. Of course, when the initiator cheated, the counterparty responds by cheating most of the time, over 95% by the last period. Experienced counterparties cheat on cheating initiators even more often, but they are less inclined to cheat on honest initiators; that rate is less than 60% overall and shows no clear trend. Perhaps as a result, experienced initiators cheat less often than their inexperienced counterparts. We offer an interpretation of this behavior in the next section.

To summarize, the CE predictions for this treatment again are rather extreme, and again behavior moves strongly in the predicted direction. We have less than complete convergence, however, and in particular the domestic trade volume does not recover to the predicted level.

Table 9 reports the test statistics for the three general hypotheses.

H1. Price unification. The average price for the 373 trades executed in the Red market (including both domestic and cross market transactions) in frictionless free trade was 45.5, versus 45.1 for the 268 Blue market trades. According to both the two sample t-test statistic and the non-parametric Mann-Whitney test for equality of these averages we cannot reject the null hypothesis of price unification and we conclude that prices are quickly unified under frictionless free trade. By contrast, we predict prices not to be unified when cheating is allowed, and the same tests now strongly reject that hypothesis. Under cheating, the average transaction price in the Red market is indeed significantly higher than in the Blue market.

H2. Market segmentation. When cheating is allowed in inexperienced sessions, Red buyers acquire units domestically in the Red market with average value 76.4 versus average value 60.3 for units they acquire in the cross-market. In experienced sessions the value averages are 75.4 for the domestic market and 64.9 for the cross market. The results of both the t-test and the Mann-Whitney shown in Table 9 allow us to reject the null of independence of values from market choice. Segmentation is therefore quite significant and in the predicted direction for Red buyers.

For inexperienced sellers, units sold domestically in the Blue market have average cost 21.9 versus 28.9 for units sold by Blue sellers in the cross market. For experienced subjects, the averages are 18.8 in the domestic Blue versus 27.2 in the cross-market. Once again, the tests allow us to conclude that the segmentation hypothesis prevails also for Blue sellers.

H3. Trade volume. The last section of Table 9 displays the overall and cross-market volume averages under all three treatments. As predicted, the total volume of trade is significantly higher when cheating is allowed than in either frictionless free trade or autarky. Restricting the comparison to cross-market transactions, we found that international trade volume is significantly higher under frictionless free trade than when cheating is allowed. Thus the data support this distinctive implication of the theoretical model.

5 Discussion

In this paper we extend the competitive equilibrium (CE) model to predict the impact of an important friction, weaker contract enforcement in international trade. We then subject the basic and extended CE model to a laboratory stress test. The laboratory parameters are chosen to deliver violent dislocations in CE prices, trading partners, transaction volume and total surplus as we change treatments from autarky to frictionless free trade to trade with enforcement frictions. The laboratory data nevertheless follow the CE predictions rather closely. In particular,

1. In autarky, both Red and Blue markets converge rapidly to the CE price and trading volume. Efficiency, i.e., surplus extraction as a fraction of the maximum possible, averages 89.5%, somewhat lower than in typical double auction markets (which usually run for more than 4 periods).

2. In frictionless free trade, convergence to CE prices and quantities is surprisingly rapid given the choice of extreme parameters that sideline all Blue buyers and all Red sellers. Surplus extraction is quite good, and average efficiency rises to 94.8%.

3. Price unification is essentially complete in frictionless free trade.

4. Outcomes when traders can cheat in international transactions are predicted well by a new extension of the competitive equilibrium model. Overall trading volume indeed increases significantly when cheating is allowed. At the same time, as predicted by our model and as suggested by the "missing trade" literature, the international (cross-market) volume is significantly lower. Cheating predominates in international trade, and higher valued buyers and lower cost sellers retreat to their domestic markets. The precise quantitative predictions of the model are quite accurate for average prices in all markets, quantities in the cross market, and overall surplus. The model overpredicts the level of domestic trade although sessions with experienced subjects move in the right direction.

Although the CE model does a remarkably good job overall of explaining the data, there is an interesting discrepancy in the cheat treatment. Besides the overprediction just noted in domestic trade volume, the CE model underpredicts honest international trade volume. Both experienced and inexperienced traders completed an average of 2.8 units of honest transactions in the first period without full contract enforcement. In later periods with inexperienced traders, that number declined steadily to 1.1 by the fourth and last period, seemingly headed to the CE prediction of 0.0. But with experienced traders, such honesty decayed more slowly, and increased back to 2.3 in the last period. Although it is not a large fraction of the cross market transactions (8.6% for inexperienced subjects, 21.6% for experienced subjects), it does seem persistent.

What might encourage some traders to substitute out of inefficient domestic transactions and into efficient (but not individually rational) international transactions? A variety of non-market experiments (e.g., the trust game Berg, et al., 1995, and subsequent studies) demonstrate that some individuals are willing to trust anonymous counterparties, who in turn often reward their trust. Such behavior may also have a minor role in our market setting (cf. Fehr et al., 1993).

Readers familiar with the international trade literature may perceive another anomaly. Empirical work suggests that it is the highest surplus transactors who are most likely to trade in international markets, and some theoretical models have been constructed that support this conclusion (e.g., Yeaple, 2005). By contrast, the highest surplus transactors in our model (and data) tend to retreat to domestic markets when international markets have cheat frictions. Although our cheat friction (1-π) can be interpreted as *ad valorem* transport or transaction cost, our model does not include fixed transactions costs and differs in many other respects from those in the literature. One caveat, therefore, is that previous and current theoretical results may be sensitive to fixed transaction costs and other seemingly minor modeling choices. A second caveat is that the empirical finding is observed in a world that includes not only *ad valorem* transaction costs but also fixed costs and institutions that mitigate transaction costs.

Our results demonstrate cleanly that a trade friction leads to a major deterioration in market performance, in a simple laboratory environment as well as in the CE model. What market (or interpersonal) institutions might evolve to mitigate such frictions? We hope to explore that question, and in particular the role of interpersonal networks, in subsequent work.

6 Appendix A: Theoretical Derivation

First we derive competitive equilibrium (CE) predictions, focusing on the case of linear demand and supply that closely approximate the parameters used in the experiment. Then we derive the predictions for the actual step functions used in the experiment.

6.1 Linear Demand and Supply

Autarky

The Red market inverse demand function is

$$p_{RA}^{D} = \begin{cases} 85 - \frac{5}{2}q, & q \in [0,16]; \\ 0, & q > 16, \end{cases} \tag{1}$$

and the inverse supply function is

$$p_{RA}^{S} = \begin{cases} 45 + \frac{5}{2}q, & q \in [0,16]; \\ \infty, & q > 16. \end{cases} \tag{2}$$

Autarky CE in the Red market (p_{RA}^*, q_{RA}^*) is characterized by the supply = demand condition $p_{RA}^S(q) = p_{RA}^D(q)$. The unique solution for the functions (1) and (2) is $q_{RA}^* = 8$, so $p_{RA}^* = p_{RA}^S(8) = 65$. The associated buyer surplus is $\int_0^{q^*}(p^D(q) - p^*)dq = 80$, while seller surplus is $\int_0^{q^*}(p^* - p^S(q))dq = 80$ and so CE surplus in the Red market is $S_{RA} = 160$.

Similarly in the Blue market, the autarky inverse demand is $p_{BA}^D = 45 - \frac{5}{2}q$ for $q \in [0,16]$ and is 0 for larger q, while inverse supply is $p_{BA}^S = 5 + \frac{5}{2}q$ for $q \in [0,16]$ and is unbounded for larger q. The associated CE price is $p_{BA}^* = 25$ with CE quantity $q_{BA}^* = 8$. Again buyer surplus and seller surplus both are 80, so $S_{BA} = 160$. Overall CE autarky surplus is $S_A = S_{RA} + S_{BA} = 320$.

Free Trade

Summing the direct demand functions obtained from the inverse demand functions given above, one can verify that the total inverse demand function is $p_{FT}^D = 85 - \frac{5}{2}q$ for $q \in [0,32]$, and is 0 for larger q. Likewise, the total inverse supply function is $p_{FT}^S = 5 + \frac{5}{2}q$ for $q \in [0,32]$ and is unbounded for larger q. Frictionless free trade CE is the unique solution to total supply = total demand, namely price $p_{FT}^* = 45$ and quantity $q_{FT}^* = 16$. Now buyer surplus is 320, and by (1), it all goes to Red buyers. Likewise, seller surplus is also 320, all of which goes to Blue sellers. Overall CE surplus in frictionless free trade is $S_{FT} = S_{RFT} + S_{BFT} = 640$.

Cheating Frictions

The analysis of cross-market trade with frictions is less familiar and more complex, so we proceed in small steps. Recall that cheating is an option for each party in a cross market transaction, but is not an option for either party in a domestic transaction. Recall also that cross-market transactions are anonymous. The basic competitive assumption (often called price taking) is that an individual's decisions do not affect her subsequent terms of trade. Given anonymity, it is reasonable to extend this assumption to the decision on whether to cheat. Under this extended competitive assumption, rationality dictates maximizing profit separately on each transaction.

In the main protocol in the experiment, the trader posting the accepted price observes the acceptor's decision on whether or not to cheat before making her own decision. Cheating is a dominant strategy for her. For example, suppose she is a seller with cost c who posted ask price p, and the buyer cheated. Then she will receive revenue πp whether or not she cheats. She will incur cost πc if she cheats, or cost c if she doesn't. For any $\pi < 1$ she maximizes profit by cheating. If the buyer didn't cheat the revenue is higher but the argument is the same. The argument is similar if she is a buyer with value v who posted bid price p: her revenue is fixed (at πp if the seller cheated or at p if not) but cheating always reduces her cost and increases her profit. Since the party posting the price has a dominant strategy, there is a unique (iterated dominance) equilibrium, and in it the party accepting the price also cheats. Some early pilot experiments used a simultaneous decision protocol, equivalent to the classic prisoner's dilemma. Here cheating is a dominant strategy for both parties.

Hence in any equilibrium, cheating is universal in cross-market transactions. One convenient consequence is that there is only one cross-market in equilibrium. If cross-market transaction prices were higher in the Blue market, for example, then more sellers and fewer buyers would go there. Such shifts in cross-market supply and demand (casually referred to in Section 3 as "arbitrage") would equalize prices and thus unify the cross-market.

Another convenient consequence is that profit (or surplus) is easy to characterize. In a domestic transaction at price p between a buyer with value v and a seller with cost c, the buyer's surplus is $v - p$ and the seller's surplus is $p - c$, since cheating is not an option. By contrast, in a cross-market transaction with cheating, the buyer's surplus is $\pi v - \pi p = \pi(v - p)$ and the seller's surplus is $\pi(p - c)$.

Now we can characterize supply and demand. Fix $\pi \in (0, 1)$, and suppose traders take as given the price vector (p_R, p_B, p_C). Then a Red Buyer with value $v = v^*$ is indifferent between a domestic and cross market transaction, where v^* satisfies the equal profit condition

$$\pi(v - p_C) = v - p_R \tag{3}$$

The left hand side of (3) increases more slowly in v than the right hand side. Hence for $v > v^*$ a domestic transaction is more profitable, while for $v < v^*$ a cross-market transaction is more profitable. Thus in equilibrium the inverse demand curve in the Red market is truncated below at $p_R^D = v^*$, and inverse demand in the cross-market is truncated above at the same point.

Likewise, a Blue seller's indifference condition is

$$\pi(p_C - c^\star) = p_B - c^\star. \tag{4}$$

Sellers with higher cost prefer the foreign market C and sellers with lower cost prefer the domestic market B. The Blue inverse supply curve thus is truncated above at $p_B^S = c^*$, and inverse supply in the cross-market is truncated below at the same point.

Equilibrium with Cheating Frictions

We seek a price vector (p_R, p_B, p_C) such that supply = demand simultaneously in the three interdependent markets. Assuming (to be checked later) that the truncation binds in the Red market, equate Red supply at p_R to Red demand at v^* to obtain $p_R = 45 + \frac{5}{2}q = 45 + \frac{5}{2}[\frac{2}{5}(85 - v^*)] = 130 - v^*$. Solve (3) to obtain $v^\star = \frac{1}{1-\pi}p_R - \frac{\pi}{1-\pi}p_C$. Insert this into the previous expression for p_R and simplify to obtain

$$(2 - \pi)p_R = \pi p_C + (1 - \pi)130. \tag{5}$$

Likewise, assume that the truncation binds in the Blue market, equate Blue demand at p_B to Blue supply at c^* to obtain $p_B = 45 - \frac{5}{2}q = 45 - \frac{5}{2}[\frac{2}{5}(c^* - 5)] = 50 - c^*$. Solve (4) to obtain $c^\star = \frac{1}{1-\pi}p_B - \frac{\pi}{1-\pi}p_C$. Insert into the previous expression for p_C and simplify to obtain

$$(2 - \pi)p_B = \pi p_C + (1 - \pi)50. \tag{6}$$

Finally, consider direct supply and demand in the cross market. Supply is the residual from the Blue market, $S_C(p_C) = S_B(p_C) - S_B(c^*) = \frac{2}{5}(p_C - c^*)$. Demand is the residual from the Red market, $D_C(p_C) = D_R(p_C) - D_R(v^*) = \frac{2}{5}(v^* - p_C)$. Equate the two expressions and simplify to obtain $p_C = \frac{1}{2}(c^* + v^*)$. Insert the expressions for v^* and c^* obtained earlier and simplify to obtain

$$p_C = \frac{p_R + p_B}{2}. \tag{7}$$

We now have a full characterization of the equilibrium. To obtain explicit expressions, insert (7) into (5) and (6) and solve to get, for all $\pi \in [0, 1]$

$$\begin{aligned}
p_C &= 45, && (8)\\
p_R &= \frac{130 - 85\pi}{2 - \pi}, && (9)\\
p_B &= \frac{50 - 5\pi}{2 - \pi}, && (10)\\
v^* &= \frac{130 - 45\pi}{2 - \pi}, \texttt{and} && (11)\\
c^* &= \frac{50 - 45\pi}{2 - \pi} && (12)
\end{aligned}$$

It is straightforward to check that the truncations bind at $v^\star$ and $c^\star$ when $\pi \in (0, 1)$. For $\pi = 1$ the expressions reduce to the frictionless free trade CE, $p_R = p_B = p_C = 45$. For $\pi = 0$ we obtain the autarky CE, $p_R = 65$ and $p_B = 25$; since also $v^\star = 65$ and $c^\star = 25$ the units that trade in autarky all trade domestically. Of course, with $\pi = 0$, nobody can earn a positive equilibrium profit in the cross market anyway.

The transition between autarky and frictionless free trade is non-linear as π varies in $(0, 1)$. For instance, $\frac{dp_R}{d\pi} = \frac{-40}{(2-\pi)^2} < 0$, and $\frac{d^2 p_R}{d\pi^2} = \frac{80}{(2-\pi)^3} > 0$, so p_R is a decreasing convex function of π. Likewise, p_B is increasing and concave in π.

6.2 Step Functions

With the actual step functions used in the experiment, it is routine to compute competitive equilibrium (CE) under autarky and frictionless free trade. One simply draws the usual supply and demand curves as in Figure 2 (and Table 1) and analyzes them as in the text.

Equilibrium with Cheating Frictions

The previous section introduced all the ideas necessary to compute CE in the cheating treatment, but obtaining exact results with step functions requires some extra work. The work is simplified by noting:

- Demand and supply in market B depend on p_C but not on p_R, and likewise demand and supply in market R depend on p_C but not on p_B. This follows from the earlier observation that in equilibrium all cross market transactions involve cheating.

- The only possible equilibrium price in Market C is $p_C = 45$. This result arose from symmetry in the linear case, and it is true *a fortiori* in the step function case because there is an extra-wide step in the demand function (four units) at that price.

Due to those simplifications, in computing CE it suffices to compute supply and demand (or excess demand) in the domestic markets as functions only of own price, and the resulting spillovers of demand and supply into market C, under the maintained assumption that $p_C = 45$. Such computations are reported in the following two tables.

Blue market	# Blue units offered in			# Blue units demanded
p_B	Cross-market $\Pi_C > \Pi_B$	Indifferent $\Pi_C = \Pi_B$	Domestic (Blue) $\Pi_C < \Pi_B$	Domestically up to
< 27.5	16	0	0	8 if $(20, 27.5)$
27.5	14	2	0	8
$(27.5, 30)$	14	0	2	8
30	12	2	2	8
$(30, 32.5)$	12	0	4	6
32.5	10	2	4	6
$(32.5, 35)$	10	0	6	6
35	6	4	6	6
$(35, 37.5)$	6	0	10	4
37.5	4	2	10	4
$(37.5, 40)$	4	0	12	4
40	2	2	12	4
$(40, 42.5)$	2	0	14	2
42.5	0	2	14	2
> 42.5	0	0	16	2 if $(42.5, 45]$ 0 if > 45

Red market	# Red units demanded			# Red units offered
p_R	Cross-market $\Pi_C > \Pi_R$	Indifferent $\Pi_C = \Pi_R$	Domestic (Red) $\Pi_C < \Pi_R$	Domestically (up to)
< 45	0	0	16	0
45	0	2	14	0
$(45, 47.5)$	2	0	14	0
47.5	2	2	12	0
$(47.5, 50)$	4	0	12	0
50	4	2	10	2
$(50, 52.5)$	6	0	10	2
52.5	6	2	8	2
$(52.5, 57.5)$	8	0	8	2 if $(52.5, 55)$ 4 if $[55, 57.5)$
57.5	8	2	6	4
$(57.5, 60)$	10	0	6	4
60	10	2	4	6
$(60, 62.5)$	12	0	4	6
62.5	12	2	2	6
$(62.5, 65)$	14	0	2	6
65	14	2	0	10
> 65	16	0	0	10 if $(65, 70)$ 12 if $[70, 75)$ 14 if $[75, 80)$ 16 if ≥ 80

Inspection of the tables, row by row, discloses that there is excess demand in the Red market at prices below $p_R = 60$ and excess supply at higher prices, so the only candidate for equilibrium is $p_R = 60$. In the Blue market there is excess demand at prices below $p_B = 32.5$ and excess supply at prices above $p_B = 35$. Hence the only candidate CE price vectors are $p_C = 45$, $p_R = 60$, $p_B \in [32.5, 35]$. The corresponding supply and demand quantities balance at $q_C = 10$, $q_R = 6$, and $q_B = 6$. These result in surpluses $S_C = 125$, $S_R = 150$, and $S_B = 150$.

References

[1] Anderson, S., Friedman, D., Milam, G., Singh, N., 2004. Seller strategies on eBay. Working Paper Series 1024, Department of Economics, UC Santa Cruz.

[2] Anderson, J., Marcoullier, D., 2002. Insecurity and the pattern of trade: an empirical investigation. The Review of Economics and Statistics 84, 342–352.

[3] Anderson, J., Young, L., 2002. Imperfect contract enforcement. NBER WP No. 8847. Revised as Trade and Contract Enforcement.

[4] Andreoni J. 2005. Trust, reciprocity, and contract enforcement: experiments on satisfaction guaranteed. Working Paper.

[5] Berg, J., Dickhaut, J., McCabe K., 1995. Trust, reciprocity, and social history. Games and Economic Behavior 10, 122–142.

[6] Bernstein, L., 1992. Opting Out of the Legal System: Extralegal Contractual Relations in the Diamond Industry. Journal of Legal Studies, XXI:115-157.

[7] Bernstein, L., 1996. Merchant Law in a Merchant Court: Rethinking the Code's Search for Immanent Business Norms. University of Pennsylvania Law Review, 144(5):1765-1821.

[8] Bernstein, L., 2001. Private Commercial Law in the Cotton Industry: Creating Cooperation Through Rules, Norms, and Institutions. Mich. L. Rev., 99:1724.

[9] Cassar, A., Friedman, D., and Schneider P., 2007. A Laboratory Investigation of Networked Markets. Working Paper.

[10] Fafchamps, M., 2004. Market Institutions in Sub-Saharan Africa. Cambridge: MIT Press.

[11] Fafchamps, M., 2006. Spontaneous Markets, Networks, and Social Capital: Lessons from Africa. In The Microeconomics of Institutions, Tim Besley and Raji Jayaraman (eds.), MIT Press (forthcoming).

[12] Fafchamps, M., 2007. Development and Social Capital. Journal of Development Studies.

[13] Fehr, E., Kiersteiger, G., Riedl A., 1993. Does Fairness Prevent Market Clearing? An Experimental Investigation. Quarterly Journal of Economics 108, 437-460.

[14] Greif, A. 1993. Contract enforceability and economic institutions in early trade: the Maghribi traders' coalition. American Economic Review, 83, No.1.

[15] Helliwell, J.F., 1998. How Much Do National Borders Matter? Washington, D.C.: Brookings Institution.

[16] Klebnikov, P., 2000. Godfather of the Kremlin: Boris Berezovsky and the Looting of Russia. New York: WW Norton & Co.

[17] Leijonhufvud, A., Craver, E., 2001. Reform and the fate of Russia. Documents de Travail de l'OFCE 2001-03, Observatoire Francais des Conjonctures Economiques (OFCE).

[18] Marcouiller, D., Young, L., 1995. The black hole of graft: the predatory state and the informal economy. American Economic Review 85:3, 630–646.

[19] McCallum, J., 1995. National borders matter: Canada-US regional trade patterns. American Economic Review, 85:3, 615–623.

[20] Neugebauer, T., 2004. Intermediaries as contractual enforcers or making deals with Peppe. Working Paper.

[21] Noussair, C., Plott, C., Reizman, R., 1995. An experimental investigation of the patterns of international trade. American Economic Review, 462–491.

[22] Rauch, J.E., 2001. Business and social networks in international trade. Journal of Economic Literature, XXXIX, 1177–1203.

[23] Resnick, P., Zeckhauser, R., Swanson, J., Lockwood, K., 2006. The Value of Reputation on eBay: A Controlled Experiment. Experimental Economics. V. 9, iss. 2, pp. 79-101.

[24] Rodrik, D., 2000. How far will international economic integration go? The Journal of Economic Perspectives 14:1, 177–186.

[25] Smith, V., 1962. An experimental study of competitive market behavior. Journal of Political Economy, 70:2, 111–137.

[26] Trefler, D., 1995. The case of the missing trade and other mysteries. American Economic Review 85:5.

[27] Yeaple, S., 2005. A Simple model of Firm Heterogeneity, International Trade, and Wages. Journal of International Economics.

Table 1. Parameters

Market BLUE					Market **RED**				
Buyers' Values					Buyers' Values				
Buyer ID	Unit 1	Unit 2	Unit 3	Unit 4	**Buyer ID**	Unit 1	Unit 2	Unit 3	Unit 4
B1	45	45	20	20	**B1***	85	85	80	80
B2	40	40	15	15	**B2***	60	60	55	55
B3	35	35	10	10	**B3***	75	75	50	50
B4	30	30	5	5	**B4***	70	70	45	45
Sellers' Costs					Sellers' Costs				
Seller ID	Unit 1	Unit 2	Unit 3	Unit 4	**Seller ID**	Unit 1	Unit 2	Unit 3	Unit 4
S1	10	10	15	15	**S1***	50	50	65	65
S2	25	25	30	30	**S2***	55	55	70	70
S3	20	20	35	35	**S3***	60	60	75	75
S4	25	25	40	40	**S4***	65	65	80	80

Table 2a. Experimental Design - Inexperienced Subjects

Session	Periods	Treatment	Session	Periods	Treatment
CHEAT05	1-3	A	NETCHEAT04	1-4	A
(Jan16, 2004)	4-6	FT	(Mar03, 2005)	5-8	FT
	7-9	C		9-12	C
	10-15	N		13-16	N
CHEAT06	1-3	A	NETCHEAT06	1-4	A
(Feb06, 2004)	4-6	FT	(Mar10, 2005)	5-8	FT
	7-10	C		9-12	C
	11-14	N		13-16	N
CHEAT07	1-3	A	NETCHEAT08	1-4	A
(Feb13, 2004)	4-6	FT	(Mar31, 2005)	5-8	FT
	7-10	C		9-12	C
	11-15	N		13-16	N
NETCHEAT01	1-4	A	NETCHEAT09	1-4	A
(Feb10, 2005)	5-8	FT	(Apr07, 2005)	5-8	FT
	9-12	C		9-12	C
	13-16	N		13-16	N
NETCHEAT02	1-4	A	NETCHEAT11	1-4	A
(Feb24, 2005)	5-8	FT	(May05 2005)	5-8	FT
	9-12	C		9-12	C
	13-16	N		13-16	N

Legend:

A=Autarky; FT=Frictionless Free Trade; C=Cheat Friction with Anonymity;

N= Network treatment not analyzed here.

Table 2b. Experimental Design - Experienced Subjects

Session	Periods	Treatment	Session	Periods	Treatment
CHEAT08	1-4*	C	NETCHEAT10	1-4	C
(Feb20, 2004)	5-16	N	(Apr07, 2005)	5-16	N
	17-20	C**		17-28	N**
	21-28	N	NETCHEAT12	1-4	N
CHEAT09	1-4	C	(May11, 2005)	5-8	C
(Feb27, 2004)	5-16	N		9-16	N
	17-28	N**		17-20	C**
NETCHEAT05	1-4	C		21-32	N
(Mar10, 2005)	5-16	N	NETCHEAT13	1-12	N
NETCHEAT07	1-4	C	(May18, 2005)	13-16	C
(Mar31, 2005)	5-16	N		17-28	N**
	17-28	N**			

Legend:

A=Autarky; FT=Frictionless Free Trade; C=Cheat Friction-Anonymity;

N=Network treatment not analyzed here.

* These four periods were discarded because of a software problem.

** Buyer values and seller costs were reshuffled just before period 17.

Table 3. Testable Predictions

	Red Market			Blue Market			Cross-market					
							No Cheating			Cheating		
	p_R	q_R	S_R	p_B	q_B	S_B	p_{NC}	q_{NC}	S_{NC}	p_C	q_C	S_C
Autarky	65	8	160	25	8	160	N/A	N/A	N/A	N/A	N/A	N/A
Free Trade	-	0	0	-	0	0	45	16	640	N/A	N/A	N/A
Cheat Friction	60	6	150	32.5-35	6	150	-	0	0	45	10	125

Table 4. Autarky Results

	Blue Market			Red Market		
	P_B	q_B	S_B	P_R	q_R	S_R
Predicted	**25**	**8**	**160**	**65**	**8**	**160**
Period 1	27.3	8.1	142.0	63.8	8.1	130.0
Std. Dev.	4.4	0.7	15.3	7.9	1.2	17.8
Obs.	81	10	10	81	10	10
Period 2	25.5	8.0	146.0	64.4	7.8	152.0
Std. Dev.	4.0	0.9	15.6	3.7	0.6	8.6
Obs.	80	10	10	78	10	10
Period 3	25.1	8.5	141.5	64.9	8.1	146.5
Std. Dev.	3.2	0.5	23.9	3.5	1.0	17.0
Obs.	85	10	10	81	10	10
Period 4	25.1	8.6	154.3	65.3	8.3	133.6
Std. Dev.	3.0	0.5	6.1	5.1	1.1	27.7
Obs.	60	7	7	58	7	7
Total per Market	25.8	8.3	145.3	64.6	8.1	141.1
Std. Dev.	3.8	0.7	17.1	5.4	1.0	19.6
Obs.	306	37	37	298	37	37

Table 5. Frictionless Free Trade Results

	Blue Market			Red Market			Cross Market			Combined		
	P_B	q_B	S_B	P_R	q_R	S_R	P_C	q_C	S_C	P	q	S
Predicted	**--**	**0**	**0**	**--**	**0**	**0**	**45**	**16**	**640**	**45**	**16**	**640**
Period 1	34.2	1.0	13.5	57.8	1.2	24.0	45.0	15.9	573.5	45.3	18.1	611.0
Std. Dev.	11.1	1.3	17.3	7.9	0.8	24.8	11.6	1.8	87.8	12.0	1.9	73.7
Obs.	10	10	10	12	10	10	159	10	10	181	10	10
Period 2	41.9	1.3	17.0	61.0	1.0	13.0	44.5	14.5	569.0	45.3	16.8	599.0
Std. Dev.	8.0	1.0	13.4	8.1	0.8	16.4	6.6	1.3	36.2	7.9	1.0	25.6
Obs.	13	10	10	10	10	10	145	10	10	168	10	10
Period 3	43.2	1.3	23.0	61.4	1.0	11.5	45.2	15.2	567.5	45.9	17.5	602.0
Std. Dev.	6.4	0.8	18.0	11.2	1.1	13.8	6.1	1.2	33.9	7.5	1.3	26.4
Obs.	13	10	10	10	10	10	152	10	10	175	10	10
Period 4	41.0	0.6	13.6	63.2	0.7	13.6	43.9	15.4	592.1	44.6	16.7	619.3
Std. Dev.	2.2	0.5	13.5	13.6	0.8	18.4	3.6	0.8	39.5	5.8	0.8	19.5
Obs.	4	7	7	5	7	7	108	7	7	117	7	7
Total per Market	40.3	1.1	17.0	60.4	1.0	15.7	44.7	15.2	574.2	45.3	17.3	606.9
Std. Dev.	8.6	1.0	15.7	9.5	0.9	18.8	7.8	1.4	53.7	8.9	1.4	42.6
Obs.	40	37	37	37	37	37	564	37	37	641	37	37

Table 6a. Cheat Friction: Price Results (Inexperienced Subjects)

	Blue Market	Red Market	Cross Market		Combined
			Cheat	No Cheat	
	P_B	P_R	P_C	P_{NC}	P
Predicted	**32.5-35**	**60**	**45**	**-**	**46**
Period 1	43.1	55.8	47.0	46.2	47.2
Std. Dev.	7.7	6.7	7.7	7.1	7.9
Obs.	16	13	137	28	194
Period 2	39.1	54.4	44.6	45.9	45.1
Std. Dev.	3.3	7.6	6.0	4.7	6.6
Obs.	13	15	139	17	184
Period 3	39.7	58.1	46.1	45.6	46.7
Std. Dev.	2.9	8.4	5.6	6.3	7.3
Obs.	18	20	132	12	182
Period 4	39.5	56.7	46.0	47.8	47.0
Std. Dev.	4.5	5.6	4.5	6.3	6.7
Obs.	20	25	105	10	160
Total per Market	40.3	56.5	45.9	46.3	46.5
Std. Dev.	5.1	7.0	6.2	6.2	7.2
Obs.	67	73	513	67	720

Table 6b. Cheat Friction: Quantity and Surplus Results (Inexperienced Subjects)

	Blue Market		Red Market		Cross Market				Combined	
					Cheat		No Cheat			
	q_B	S_B	q_R	S_R	q_C	S_C	q_{NC}	S_{NC}	q	S
Predicted	**6**	**150**	**6**	**150**	**10**	**125**	**0**	**0**	**22**	**425**
Period 1	1.6	28.5	1.3	29.5	13.7	204.7	2.8	132.5	19.4	395.2
Std. Dev.	0.7	22.4	1.3	34.9	3.4	85.4	3.0	140.6	1.5	77.8
Obs.	10	10	10	10	10	10	10	10	10	10
Period 2	1.3	26.0	1.5	29.0	13.9	272.1	1.7	61.5	18.4	388.6
Std. Dev.	1.3	28.8	1.7	32.9	2.4	54.4	1.3	42.1	1.7	45.6
Obs.	10	10	10	10	10	10	10	10.0	10	10
Period 3	1.8	34.0	2.0	44.5	13.2	246.2	1.2	57.0	18.2	381.7
Std. Dev.	1.5	37.0	1.6	40.6	2.2	65.3	1.5	71.1	1.9	55.3
Obs.	10	10.0	10	10.0	10	10	10	10	10	10
Period 4	2.2	46.7	2.8	64.4	11.7	220.4	1.1	44.4	17.8	376.0
Std. Dev.	1.9	45.9	1.4	39.5	1.6	70.3	1.3	53.4	1.8	49.9
Obs.	9	9	9	9	9	9	9	9	9	9
Total per Market	1.7	33.5	1.9	41.28	13.2	236.3	1.7	74.62	18.5	385.6
Std. Dev.	1.4	33.8	1.5	38.33	2.5	71.9	2.0	90.14	1.8	56.8
Obs.	39	39	39	39	39	39	39	39	39	39

Table 7a. Cheat Friction: Price Results (Experienced Subjects)

	Blue Market	Red Market	Cross Market		Combined
			Cheat	No Cheat	
	P_B	P_R	P_C	P_{NC}	P
Predicted	**32.5-35**	**60**	**45**	**-**	**46**
Period 1	37.0	56.8	48.2	46.9	47.2
Std. Dev.	3.9	4.7	5.0	5.6	7.3
Obs.	22	16	71	22	131
Period 2	37.3	56.9	47.7	44.6	46.5
Std. Dev.	4.4	3.4	5.1	6.1	7.6
Obs.	28	21	73	20	142
Period 3	36.2	56.3	48.4	46.3	46.8
Std. Dev.	3.4	2.4	4.9	5.3	7.5
Obs.	29	20	78	12	139
Period 4	35.3	57.0	48.8	45.2	46.7
Std. Dev.	3.7	3.1	3.5	3.7	7.9
Obs.	31	23	65	18	137
Total per Market	36.4	56.8	48.2	45.7	46.8
Std. Dev.	3.9	3.4	4.7	5.3	7.6
Obs.	110	80	287	72	549

Table 7b. Cheat Friction: Quantity and Surplus Results (Experienced Subjects)

	Blue Market		Red Market		Cross Market				Combined	
					Cheat		No Cheat			
	q_B	S_B	q_R	S_R	q_C	S_C	q_{NC}	S_{NC}	q	S
Predicted	**6**	**150**	**6**	**150**	**10**	**125**	**0**	**0**	**22**	**425**
Period 1	2.8	65.6	2.0	43.8	8.9	194.5	2.8	115.0	16.4	418.9
Std. Dev.	1.9	49.9	1.3	41.6	3.6	87.6	2.9	130.8	2.8	91.4
Obs.	8	8	8	8	8	8	8	8	8	8
Period 2	3.5	78.8	2.6	65.6	9.1	191.6	2.5	103.1	17.8	439.1
Std. Dev.	1.2	39.9	1.3	37.3	3.1	72.5	2.7	113.7	1.0	85.6
Obs.	8	8	8	8	8	8	8	8.0	8	8
Period 3	3.6	81.3	2.5	55.0	9.8	205.6	1.5	68.1	17.4	410.0
Std. Dev.	0.9	33.9	0.9	31.1	2.7	56.4	1.9	91.4	2.3	73.8
Obs.	8	8.0	8	8.0	8	8	8	8	8	8
Period 4	3.9	91.9	2.9	66.3	8.1	190.5	2.3	98.1	17.1	446.8
Std. Dev.	1.3	42.8	1.7	45.6	4.2	125.6	3.2	124.8	1.8	86.3
Obs.	8	8	8	8	8	8	8	8	8	8
Total per Market	3.4	79.4	2.5	57.66	9.0	195.6	2.3	96.09	17.2	428.7
Std. Dev.	1.4	41.1	1.3	38.44	3.3	85.1	2.6	111.79	2.0	81.7
Obs.	32	32	32	32	32	32	32	32	32	32

Table 8. Cheating Rates in Cross Market Transactions

	Initiator Cheat Rate (%)		Non-Initiator Cheat Rate (%) given Initiator			
Inexperienced Subjects						
			Didn't Cheat		Cheated	
Period 1	63.6	(105/165)*	53.3	(32/60)	85.7	(90/105)
Period 2	59.6	(93/156)	73.0	(46/63)	92.5	(86/93)
Period 3	72.9	(105/144)	69.2	(27/39)	93.3	(98/105)
Period 4	72.2	(83/115)	68.8	(22/32)	96.4	(80/83)
Total**	66.6	(386/580)	65.5	(127/194)	91.7	(354/386)
Experienced Subjects						
	Initiator Cheat Rate (%)		Non-Initiator Cheat Rate (%) given Initiator			
			Didn't Cheat		Cheated	
Period 1	47.3	(44/93)	55.1	(27/49)	86.4	(38/44)
Period 2	52.7	(49/93)	54.5	(24/44)	98.0	(48/49)
Period 3	61.1	(55/90)	65.7	(23/35)	96.4	(53/55)
Period 4	51.8	(43/83)	55.0	(22/40)	93.0	(40/43)
Total**	53.2	(191/359)	57.1	(96/168)	93.7	(168/191)

* Number of observations reported in parentheses.

** Cross market transactions only.

Table 9. Hypotheses Tests

Price Unification

	H_0: $p_{B,FT}$ - $p_{R,FT}$ = 0	H_0: $p_{B,C}$ - $p_{R,C}$ = 0
	Total*	Total*
Mean (Blue, Red)	45.1, 45.5	44.0, 49.0
T-Test (two-tailed)	-0.50 (0.62)	-13.1 (0.00)
MW Test (two-tailed)	-0.14 (0.89)	-13.4 (0.00)
Nobs	268, 373	607, 622

Market Segmentation

	Red Market (Buyers' Values) H_0: $v_{R,C}$ - $v_{RC,C}$ = 0		Blue Market (Sellers' Costs) H_0: $c_{B,C}$ - $c_{BC,C}$ = 0	
	Inexperienced	Experienced	Inexperienced	Experienced
Mean (Domestic, Cross)	76.4, 60.3	75.4, 64.9	21.9, 28.9	18.8, 27.2
T-Test (one-tailed)	8.30 (0.00)	6.42 (0.00)	-3.94 (0.00)	-7.23 (0.00)
MW Test (one-tailed)	8.12 (0.00)	6.16 (0.00)	-3.68 (0.00)	-7.43 (0.00)
Nobs	73, 580	80, 359	67, 580	110, 359

Trade Volume

	H_0: Q_C - Q_{FT} = 0			H_0: Q_C - Q_A = 0
	Total*	Cross-Market**		Total*
Mean (C, FT)	17.9, 17.3	13.2, 15.2	Mean (C, A)	17.9, 16.3
T-Test (one-tailed)	1.50 (0.07)	-4.08 (0.00)	T-Test (one-tailed)	4.38 (0.00)
MW Test (one-tailed)	2.35 (0.00)	-3.87 (0.00)	MW Test (one-tailed)	4.93 (0.00)
Nobs	71, 37	71, 37	Nobs	71, 37

*Refers to all transactions listed in Tables 2a and 2b (experienced and inexperienced sessions)

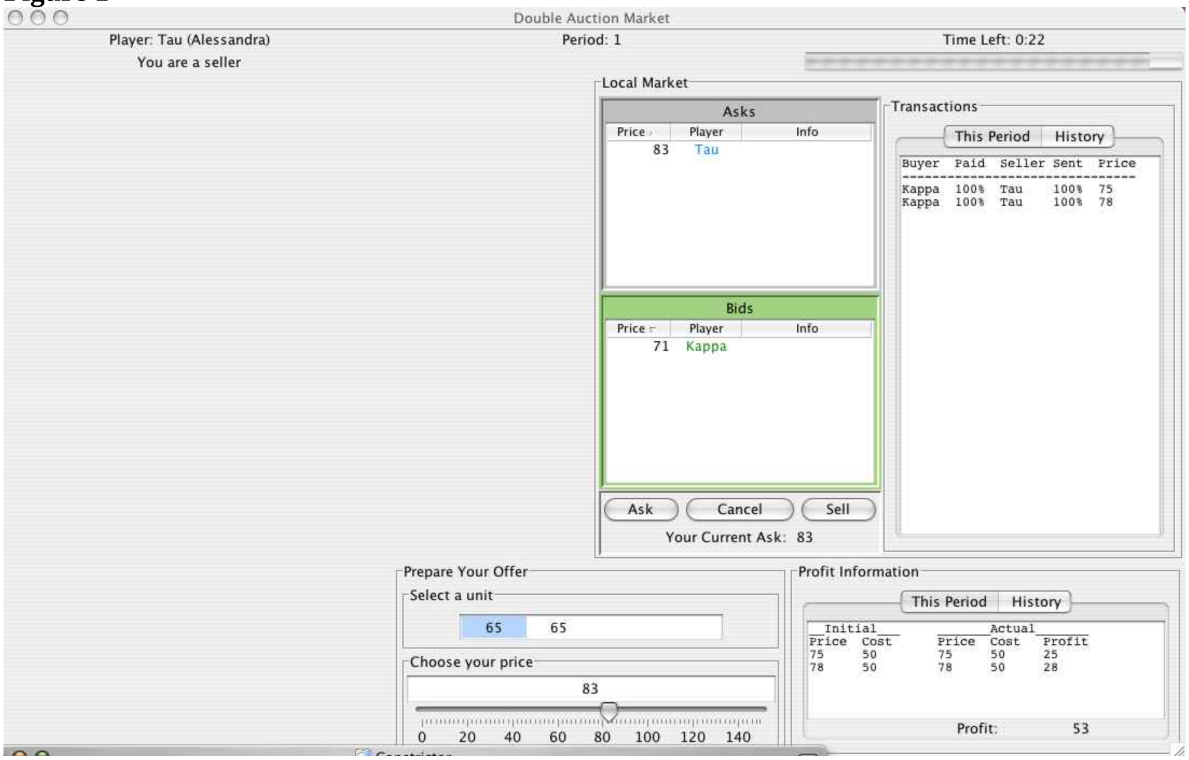
**Refers only to cross-market (non-domestic) transactions listed in Tables 2a and 2b (experienced and inexperienced sessions)

A=Autarky; FT=Frictionless Free Trade; C= Cheat Friction with Anonymity

MW refers to the two-sample Wilcoxon rank-sum (Mann-Whitney) test

P-values reported in parentheses

Figure 1



Autarky trading screen is shown for a seller (ID code Tau, actual name Alessandra) in her "Local Market". She can post an offer by either typing the desidered price or by dragging the slider to the desired value in the "Prepare Your Offer" box and then clicking the Ask button.

The "Select a unit" part of the "Prepare Your Offer" box shows Tau's costs for the current unit (highlighted, 65) and the remaining ones (here another one at 65).

Similar to "Asks", "Bids" appear in the green coloured box of her "Local Market" (here there is only one bid at 71 from buyer Kappa).

The "Transactions" box shows the current period transactions in her local market; by clicking on the History tab the previous periods transactions are shown. Under autarky, all prices and trader ID's are shown.

A seller can transacts a single unit in two ways: Either by clicking on an existing bid and then clicking on the Sell button (and the buyer confirms it), or by waiting until some buyer clicks on the seller's ask (and she confirms it).

The "Profit Information" box at the bottom right of the screen shows Tau's previous transactions and profit. The History tab details trading profits and transactions in all earlier periods (always accessible to players).

Buyers' trading screens are similar, with Bid and Buy buttons in the center box, values instead of costs in the "Prepare Your Offer" box, etc.

Figure 2.

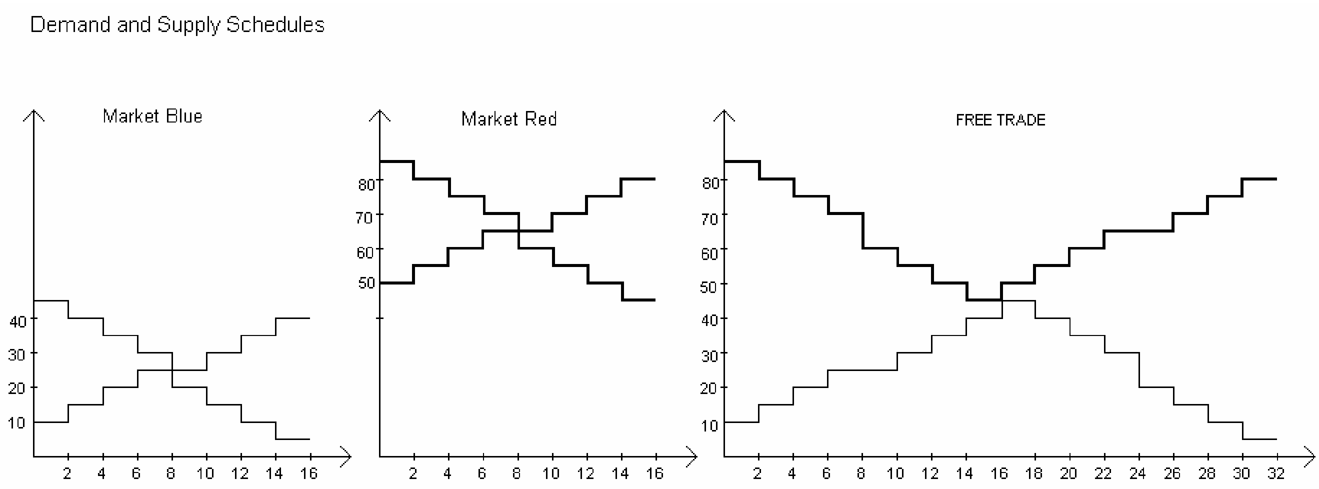


Figure 3.

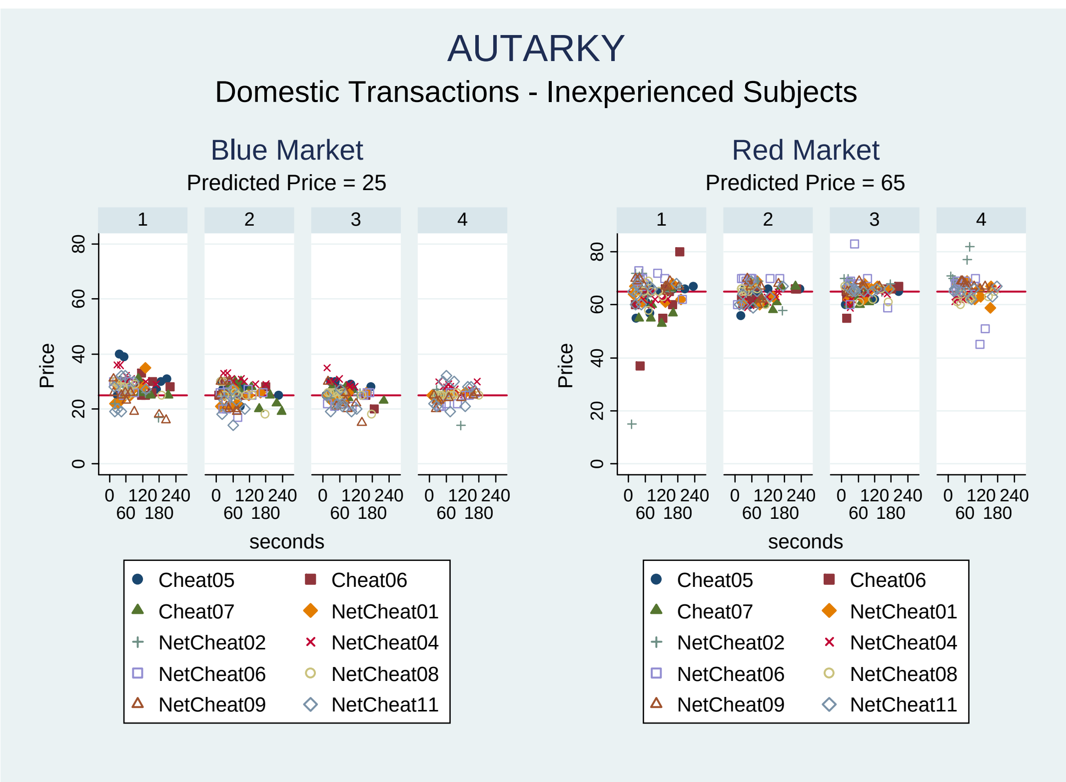


Figure 4.

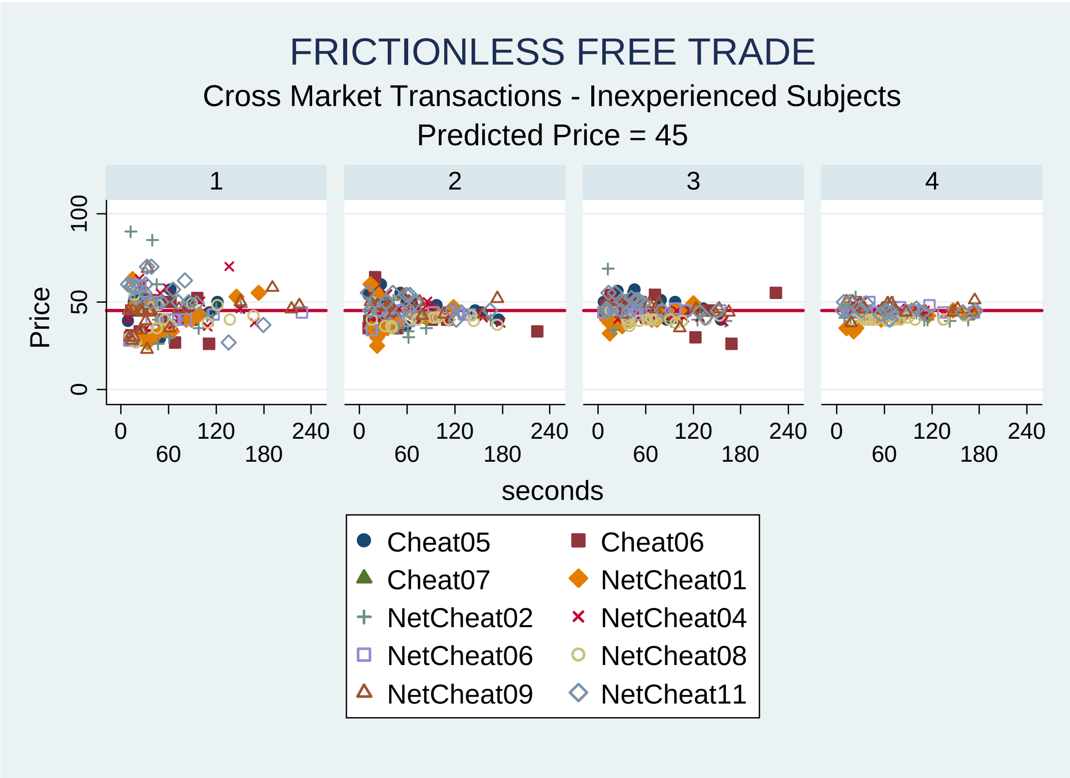


Figure 5.

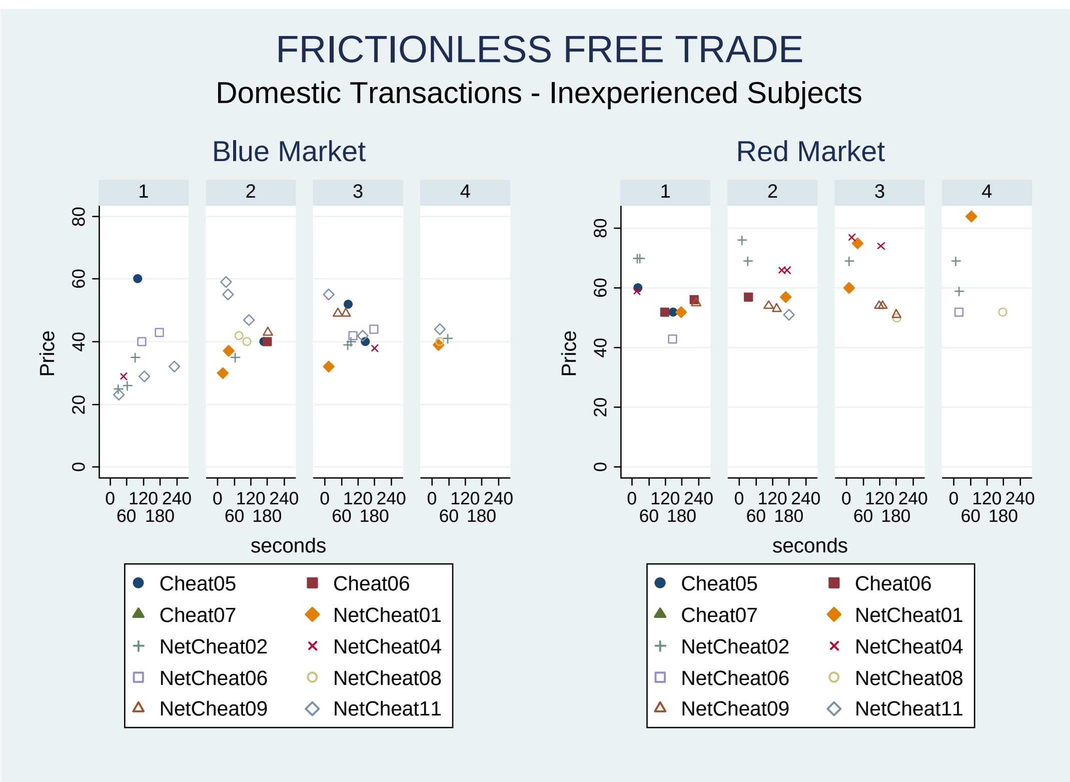


Figure 6.

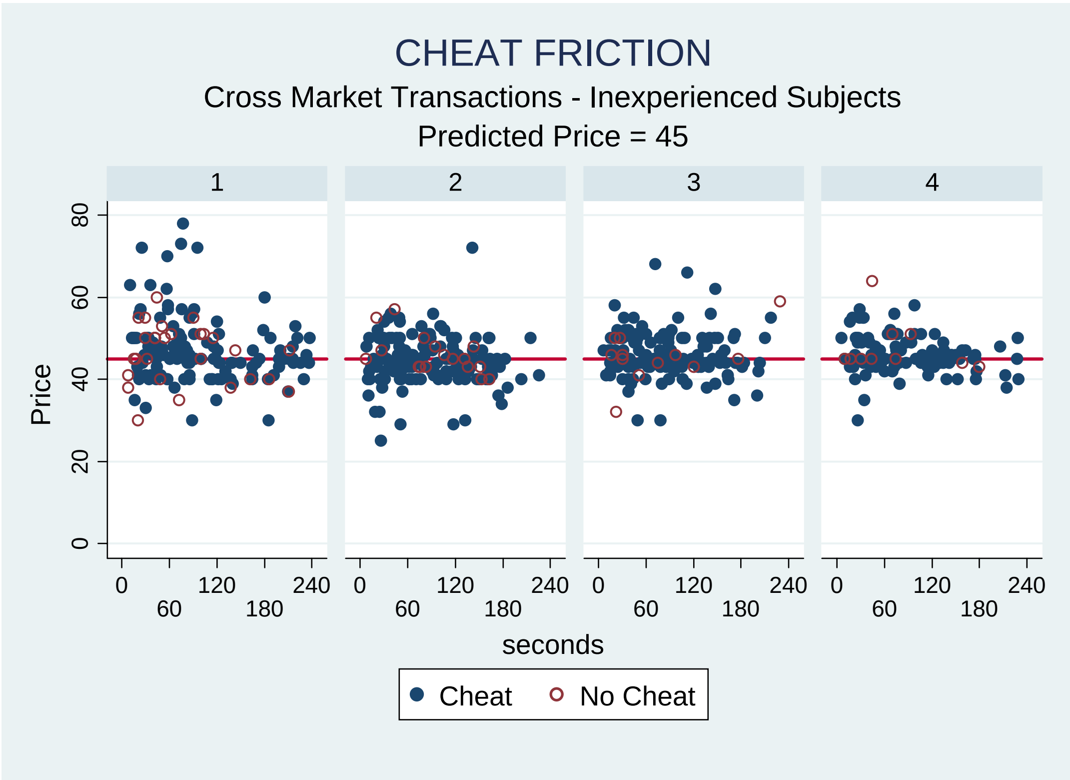


Figure 7.

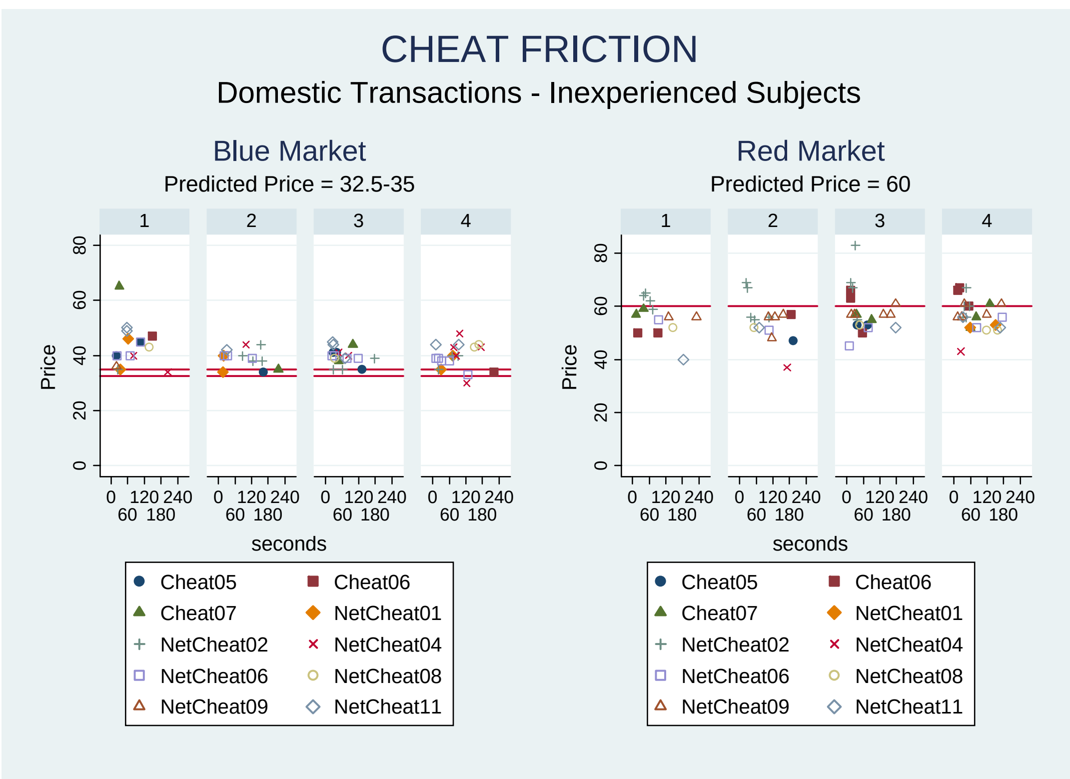


Figure 8.

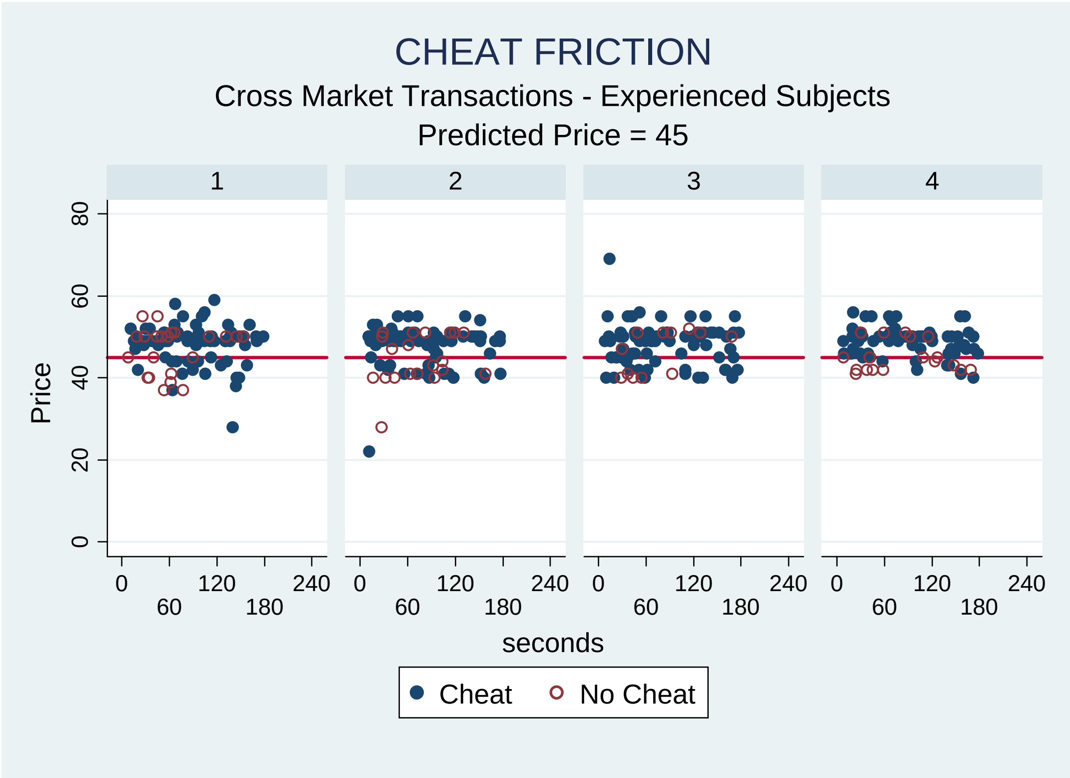


Figure 9.