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MARSHALL AND WALRAS, DISEQUILIBRIUM TRADES AND THE DYNAMICS OF EQUILIBRATION IN THE CONTINUOUS DOUBLE AUCTION MARKET

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Prices and quantities converge to the theoretical competitive equilibria in continuous, double auction markets. Because the double auction is not a tatonnement mechanism, disequilibrium trades take place, which have the capacity to change the theoretical equilibrium. The absence of any influence of the disequilibrium trades on the equilibrium appears to be due to a property found in the Marshallian model of single market adjustments. The Marshallian model incorporates a principle of self-organizing, coordination that mysteriously determines the sequence in which specific pairs of agents trade in an environment in which market identities and agent preferences are not public. Disequilibrium trades along the Marshallian path of trades do not change the theoretical equilibrium. The substance of this paper is to demonstrate that the Marshallian principle captures a natural tendency of the adjustment in single, continuous, double auction markets and to suggest how it takes place. The Marshallian model of quantity adjustment and the Walrasian model of market price adjustment can be seen as companion theories that explain the allocation and price processes of a market. The Marshallian model explains the evolution of the allocation, who will meet and trade, and the Walrasian excess demand explains the evolution of prices when they do.

SECTION 1: INTRODUCTION

In this paper, we explore the possibility that an empirical regularity of the market convergence process removes the theoretical need to assume that markets are organized by the Walrasian tatonnement. Of course, the idea of tatonnement and the assumption that no trades take place at disequilibrium prices are deeply engrained in economic theory. Indeed, it is sometimes asserted that the theory works only if the market mechanism is the fictional Walrasian auctioneer. The results reported here suggest that, at least in the case of a single market, the almost universally employed abstraction of tatonnement is unnecessary. Substantial parts of market level behavior can be successfully modeled by an empirical assumption made by Marshall even though many questions about individual behavior remain unanswered.

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The use of the Walrasian auctioneer and tatonnement metaphors seems to have taken their modern form in a controversy between Walras and Edgeworth about the nature of market convergence. The controversy turned on the possibility that the equilibrium itself would shift in response to disequilibrium trades. Edgeworth maintained that there is no general dynamical theory determining the path of the economic system from any point assigned at random to a position of equilibrium. He looked to a theory of recontracting as the foundations of a dynamical theory.[1] Walras looked to the application of special instruments and market processes and from those discussions the metaphorical auctioneer took form. Interestingly, at about the same time, the 1890's, Marshall advanced a theory of dynamics that resolves the Walras-Edgeworth controversy (refer to appendix H of Marshall, 1961 eighth edition, p. 806) in the case of a single market. However, the Marshallian theory was not examined as part of the controversy and seems to have gone substantially unnoticed in the literature that followed. Marshall was not challenged to generalize to the simultaneous equilibrium of multiple markets, the primary concern of Walras and Edgeworth. The oversight might be due to the fact that the Marshallian theory rests on a very special behavioral assumption that the order in which traders make purchases and sales is dictated by the relative size of their demand and supply prices. On the surface, the behavioral property seems very implausible. However, the results reported here demonstrate that the Marshallian behavioral assumption is not only plausible, it can be observed operating in experimental, double auction markets.

Kaldor seems to have anticipated the evolution of theory in light of the controversy with the summary "While Edgeworth's analysis may be slightly obscure and Walras' assumption slightly ridiculous, the main idea stands clear: in so far as there is any initial 'haggling and bargaining' this should be done by playing with 'chips' and not with 'hard cash'." (See D. Walker, 1973, p.138.) The tatonnement model, in which no trades take place at disequilibrium prices and is widely applied to general equilibrium, suggests resolution of the issue in terms of current theory. (see Kenneth J. Arrow and F.H. Hahn, 1971, p.264- 270) Of course, special theoretical efforts exist to explore convergence through non-tatonnement; as examples see (Hahn and Negishi (1962), Fisher (1972), Levine (1996) and recontracting (Uzawa (1962), Green (1974)). However, theory notwithstanding, experimental work has largely proceeded through a study of the non-tatonnement, continuous double auction in which disequilibrium trades are made. Continuous double auction markets are observed converging to the competitive equilibrium with great reliability. However, the reason for the convergence is unknown and regarded as a pressing question, especially in the light of the Walras and Edgeworth discussions.

In order to appreciate the challenge to theory presented by the observed equilibration together with the perplexing nature of the equilibration process, some details of the continuous double auction trading mechanism are needed as background information. The continuous double

[1] Details of this controversy are found in Walker (1996). Discussions of Walras's ideas of tatonnement can be found in Walker (1987).

auction allows agents to publicly submit bids to buy and asks to sell in continuous time. Bids to buy are typically arranged from high to low in an order book and asks to sell are arranged from low to high. The identity of the agents and the preferences of agents are all private information. Trades occur when a buyer tenders a bid to buy that is above the lowest offer to sell that exists in the order book or when a seller tenders an ask to sell that is below the highest bid to buy that exists in the order book. Trade prices are public but the identities of the traders are known only in the form of abstract identification numbers if they are known at all. Of significance in this institutional setting is the general lack of information about trading partners that one might think necessary for coordination and for the development of trading strategies. Indeed, information required for the level of coordination assumed by the Marshallian theory would seem to be entirely absent. Continuous double auctions without the order book have been studied but will not be considered here.

A modern representation[2] of the two classical theories, Marshall and Walras, are illustrated in Figure 1. Walras is found in almost any current textbook. Market demand and supply are displayed in the usual sense. If the price is P*, the excess demand is $D(P^*) - S(P^*)$ as shown. The Walrasian tatonnement adjustment process holds that dP is a function of excess demand, $dP = f(D(P) - S(P))$. Equilibrium in the model is a P** such that $D(P^{**}) - S(P^{**}) = 0$. It is important to notice that the model has no facility for identifying trading partners. Individuals appear in no particular order in this construction since both $D(P^*)$ and $S(P^*)$ depend only on the quantity individuals demand at P* (the sums) and not in some particular order dictated by preference or personal indicator. There is no theory about who trades with whom or the order in which trades occur. If trades do take place at prices other than the equilibrium, the presumption is that the functions will change form and the equilibrium itself will change.

Marshall has a different approach.[3] While the Marshallian theory appears to be just the inverse of the Walrasian theory, in fact, it is much more. Marshall places his theory on quantity adjustment – volume. Volume will increase if demand price is greater than supply price. In Figure 1, let Q* be the existing quantity. The demand price is $P_d(Q^*)$ and the supply price is $P_s(Q^*)$. The Marshallian market adjustment model holds that dQ depends on the difference between the demand price and the supply price. If $P_d(Q^*) - P_s(Q^*) > 0$ then quantity increases and equilibrium in the model is the Q** such that $P_d(Q^{**}) - P_s(Q^{**}) = 0$. Marshall makes no assumptions about price, other than the trade price is between the demand price and the supply price. Unlike the Walrasian model, the Marshallian model does not assume that all trades take

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[2] Both Marshall and Walras produced detailed variations of their theories as well as the types of institutions that might support the processes that they imagined. See Walker(1996).

[3] His theory is most clearly seen when he discusses the conditions for stability. See Marshall appendix H, eighth edition, p. 806 where he gives his multiple equilibrium stability graph. Our interpretations of the Marshallian market model are focused only on the market level aggregation of individual demand and supply curves as opposed to how the market aggregations might be derived from or related to individual incentives, bidding strategies or market instruments. Similarly, when interpreting the Marshallian dynamics theory, we are only considering market level adjustments as opposed to how individual decisions might make them come about. Different discussions at the individual level of analysis can be found at Svensson (1984), Vroey (1999), and Zaratiegui (2002).

place at the same price so multiple prices can emerge. However, the Marshallian model by construction incorporates the implicit assumption that the trades occur between specific traders and that the trading pairs trade in a specific order. The buyer with the highest demand price remaining in the market trades with the seller with the lowest supply price remaining in the market. Clearly, the Marshallian theory is not simply the inverse of the Walrasian theory. It adds a very strong assumption about trading patterns that has been called the "Marshallian path".

By contrast, it is relevant to notice that the Walrasian model assumes that there is a single price P in the market while in the continuous double auction there is no single price. In the double auction, prices change with each trade. Furthermore, within the Walrasian model, due to the fact that the market demands and supply curves are a sum of the (inverse) individual demands and supplies, the curves can shift with each trade depending on who happens to trade. Nevertheless the observed dynamics of the continuous double auction markets support elements of the Walrasian tatonnement model in the sense that the equilibrium of the dynamic model, $0 = dP = f(D(P^{**}) - S(P^{**})) = f(0)$, is observed even though the shapes of the functions themselves can be shifting as a result of trades. In the context of the Walrasian model, a paradox of non-tatonnement adjustment becomes apparent. How can the theory have predictive power when the theory itself says that it should not apply?

The experiments reported here test for the existence of the Marshallian path in the continuous double auction. The data analysis is sequential in which questions are posed based on the answers to previous questions. The results demonstrate (Section 5) that the Marshallian path exists in the data. Having established the existence of the Marshallian path in the data then the analysis becomes focused on ideas about how and why it emerges. Since, the obvious sources of coordinating information are absent due to the limited public information in the experimental double auction, it is only natural to ask how such self-organizing behavior can take place. Three theories present themselves for analysis. One theory holds that the highest demander and the lowest supplier have the greatest latitude for trade and that competitively placed bids and asks as guided by the continuous double auction have them more likely meeting in the market. A second theory holds that chance plays an important role, and that randomly placed bids and asks consistent with not losing money produces the correlation between gains from trade and sequence. A third theory holds that the internal motivation for trade presented by the utility of potential gains has those with the greatest potential gains finding their way to the front of the line. Our results suggest that it is the first of these three theories best accounts for the data.

Before continuing to discuss the experiments, it is useful to observe how the Marshallian theory and the Walrasian theory fit to create a more coherent picture of market dynamics than does either separately. If trades follow the Marshallian path then the demand and supply functions do not shift with each trade. Excess demand at various prices is not changed by the trading so the Walrasian model captures a measured force on the price changes. Thus, the Marshallian path adds a degree of coherence to the Walrasian theory of price dynamics. The Marshallian path also suggests that market adjustment follow the path of most rapid wealth creation. Wealth creation is through realized gains from trade and the Marshallian path has those that represent the greatest gains trading first. However, we hasten to add that how the theory might work in multiple markets and multiple unit trades is yet to be investigated.

SECTION 2: BACKGROUND EXPERIMENTAL WORK

Experimental markets converge to the static equilibrium predicted by the model.[4] While there is no detailed theory of the equilibration process (Easley and Ledyard (1992) being an obvious exception), important features of the Walrasian dynamics are found in experimental markets (Plott (2000), Anderson, et al. (2003), Crockett, et al. (forthcoming), Hirota, et al. (2005). In addition, evidence does exist in support of the Marshallian path (Cason and Friedman (1996)) but for the case of externality driven instabilities, the Marshallian dynamics is supported as opposed to the Walrasian dynamics (Plott and George, 1992) There is also evidence that a Marshallian path can result from purely random behavior (Gode and Sunder (1993)), Chapter 3 in Schredelseker and Hauser (2008) or randomness with slight biases toward the prices of past trades (Brewer (2008)) and simulations Zhan et al. (2002a, 2002b), Posada et al. (2007, 2008). Additional suggestions of the Marshallian paths are found in finance for both the CAPM (Bossaerts, et al. (2001)), and in information aggregation in finance experiments (Barner, et al. (2005)). While patterns are very suggestive that disequilibria are resolved through the Marshallian path of trades, the experiments reported here are designed to directly test that possibility.

SECTION 3: THE EXPERIMENTAL DESIGN CHALLENGE

Testing for the elements of the Marshallian path is complicated due to the many variables that must be controlled for a meaningful measurement. The experimental design reflects the following considerations.

1. All agents should place value on a single unit. If agents had multiple units and those units had different values there would be an issue about which unit was considered traded first and which unit should count for the trader to have traded before some other.

2. The experiment should permit the measurement of behavior of agents who are placed at different positions on the market demand and supply curves.

3. The experiment should control for individual differences in the sense that the parameters should place different individuals in the same situation for measurement and observation.

[4] Several good accounts of this phenomenon are summarized in Plott and Smith: *Handbook of Experimental Economics Results* (2008).

4. The experiment should control for different levels of internal motivation in the sense of the underlying potential rewards as measured in dollars. [5]

5. The demands and supplies should be symmetric to control for known directions of convergence reflecting asymmetries in consumer and produce surplus.

6. Price expectation should be controlled by having different demands, supplies and resulting equilibrium price each period and having no obvious pattern. Market quantity should be the same so market quantity provides no hint of underlying parameters.

7. The market institution should be well tested and computerized so issues of subtle market details and leaking information are controlled.

In order to deal with issues 2, 3, and 4, induced preferences are structured as different "types" and individuals are assigned a "type" which are rotated among subjects in different periods in order to implement the appropriate experimental controls. The types are differentiated along two characteristics. The first characteristic, called the "franc type" determines the place a subject is found on the demand or supply curve. The second characteristic, called the "incentive type" is determined by the translation of francs into U.S. dollars. Trading takes place in francs but the strength of incentives is founded in dollars. After explaining the details of the types we will explain how they are rotated to exercise the needed controls.

The first characteristic, the "franc type", is the magnitude of the demand and supply prices measured in terms of francs, the experimental currency. For the demand side and the supply side, six basic franc types are used. The demanders (suppliers) with the largest (smallest) redemption value (cost) are indexed as H and agents on both sides of the markets with just slightly less advantageous values are labeled as h. For analysis purposes, the data from these two franc types will be pooled and called H_p. Agents with franc incentive types near the middle of the market demand and supply curves are labeled as M and m. The agents with the least advantageous incentives are labeled as L and l. The pooled variables will be designated as M_p and L_p, respectively.

Subject were partitioned into two "incentive types", R and r, that designated the translation of francs into U.S. currency. Three of the six demand side subjects and three of the six supply side subjects were given "high exchange rates" (.65 cents per franc) indicated as R, and the others were given "low exchange rates" (.02 cents per franc), indicated as r. These initial assignments were in place for six periods and then the exchange rates were switched in the sense that those that previously had low exchange rates were given high and vice versa. The experiment continued six more periods after the switch.

[5] Subject transactions are in the form of an experimental currency called francs. The exchange rate between francs and dollars was a treatment variable.

The six buyer franc types and six seller franc types are contained in Figure 2 and displayed in a manner that demonstrates the relationship with the equilibrium price. Issue 5 is addressed by the fact that the consumer and producer surplus are equal. Thus, the direction of convergence to the equilibrium is controlled for a known influence by virtue of the symmetry.

Issue six is addressed in two ways. First, the franc types are rotated among the six demand (supply) subjects such that each of the six types is assigned exactly once in the first six periods and exactly once the second six periods. The slight difference between the H and h, M and m, L and l allowed the same subject to be essentially the same type twice without the subject being alerted. Secondly, each round a constant (positive or negative) was added to the francs of all types each period so the demand and supplies shifted up or down in a manner that created the same constant change in the equilibrium price. Thus, the equilibrium shifted each period while the individual types rotated making it very difficult, if not impossible, for a subject to detect the nature of the shifts.

Subjects were informed of their incentives, franc values, and exchange rates, at the beginning of each period. The information was delivered electronically through the experimental market software of Marketscape. Subjects were not informed of the exchange rate of any other subject, the franc values of other subjects or even the fact that the franc values of others were changing.

SECTION 4: EXPERIMENTAL DESIGN AND PROCEDURES

A total of four experiments were conducted. Each experiment consisted of 12 subjects and 12 periods plus one practice period. Each subject had the capacity to trade only one unit during each period of the experiment and no one was allowed to buy and resell units. Redemption values and costs were stated in an experimental currency called francs. Francs could be transformed into U.S. dollars at a specified exchange rate. The two characteristics, the "franc" type and the "incentive" type allow us to study the impact of each of these on the timing of trade decisions and actions by the traders. This rotating feature was described in Section 3. The exact parameters are discussed in Section 4.1.Trading was conducted through a computerized double auction system, Marketscape, which operates through an open book and is described in section 3.2. Section 3.3 discusses the experimental procedures. Subjects were recruited from the subject data base for the Caltech Laboratory for Experimental Economics and Political Science. They were paid a show-up fee of 10 U.S. dollars plus whatever they earned in the experiment.

4.1 Parameters

For all periods of all experiments, there were six buyers and six sellers, each allowed to trade at most once. The currency was denominated in francs.

Parameters were keyed to a "base" demand and supply. This base shifted up and down across periods by large constants so the shapes of the market demand and supply were the same across periods except for the price intercept, which changed from period to period. Since the constant amounted to an equal shift upward or downward in both the demand and supply curves, the equilibrium across the periods differed only by the same constant. As is explained later, individual incentives were rotated so each period an individual faced different incentives but those incentives were the same as the incentives faced by some other subject in a different period. Figure 2 illustrates the nature of the base demand and supply.

The redemption values and costs for the subjects for all periods are detailed in Table 1. Indeed, the exact parameters used in all periods and across all subjects are shown in Table 1(a) and (b). Notice that if trades take place at equilibrium then given the type, the profits in francs were the franc values: 400, 390, 150, 140, 25 and -15 for types H, h, M, m, L, l respectively.

Before proceeding to the market organization, let us summarize notations which will be used throughout for the possible types of traders. As mentioned above, for purposes of statistical analysis, some of the groups are pooled. Denote the pooled sets of franc/redemption value types by H_p (high), M_p (middle) and L_p (low) where H_p includes both the H and h types, M_p includes both the M and m types, and L_p includes L and l types[6]. Denote the exchange rate type as either R (high/ 2 cents) or r (low/ .65 cent). Then denote a trader type as ij, where i denotes the redemption value type and j denotes the exchange rate type. For example, a trader type H_pr has a high redemption value and a low exchange rate.

4.2 Market Organization

All the experiments were done at the Caltech Laboratory for Experimental Economics and Political Science (EEPS)[7]. Each experiment used 12 Caltech undergraduate/graduate students who were randomly assigned ID numbers. Each subject was located at a laboratory computer and was logged in to the appropriate URL. Instructions consisted of a simple, written overview given in the appendix followed by a supervised practice period in which subjects bought and sold to each other without monetary payoffs. The detail of instructions were computerized . The trading technology was conducted on a virtual machine [8]. An interactive program allowing practice with the trading technology is available at http://eeps.caltech.edu/expt.html. Apart from public questions posed to the experimenter, the communication between subjects was prohibited. Each

[6] Since the difference in the (francs) profits between H and h is small, we have grouped them together for the purpose of statistical analysis. Thus, both H and h are pooled together into the H_p group. Similar reason holds for the M_p group. Note however, that l has a negative (franc) profit if trade takes place at the equilibrium price while L has a positive profit. Still we group them together as they are very close to each other in terms of profits in francs.
[7] The exact dates being 27 Feb 2010, 10 Mar 2010, 15 Mar 2010 and 22 Mar 2010.
[8] See http://marketscape.caltech.edu/wiki. It also has resources on related experiments, including detailed demonstrations.

subject operated in two markets: one was a *public market*, where public orders to buy from (or sell to) other subjects were placed and the other was a *private market* in which the subject traded with the experimenter (these served as the redemption values and costs of classical experimental economics). In the private market, orders could only be seen by the subject herself and only one unit could be exchanged. Orders sent to the public market were placed in an open book, where they remained until accepted by someone or cancelled by the subject placing the order.

4.3. Experimental Procedures

Subjects were given an information sheet for maintaining records. Subjects logged in and were randomly assigned to be either a buyer or seller. Then the experimenter announced the location of the web instructions, and explained the use of private and public market. The experimenter also led a demonstration on submitting orders, canceling orders, trading, and computing profits. Following the instructions, a five minute-practice period started. The subjects' computations were checked for mistakes during the practice period. The software required subjects to collect redemption values by sale to the experimenter in their private markets and to do this before the period ended. Thus, thirty seconds before each period ended, the experimenter asked the subjects to pay attention and clear their inventories if they had not done so.

Before each period started, the subjects were asked to write down their exchange rate that was sent to them privately through Marketscape. The first period was a practice period. After this practice period, subjects were told that they were making decisions for actual money, and this continued for 12 periods with each period being 4 minutes in length (240 seconds). No subject knew that the experiment would last only 12 periods until the last period was completed, at which time they were told to compute the total profits. Subjects recorded the difference between their final franc value and their initial franc value to determine their final profit in francs. Subjects calculated their profit in dollar values, submitted the information sheet and were paid in dollars.

SECTION 5: RESULTS AND OBSERVATIONS

This section discusses the results and is divided into five sub-sections. Section 5.1 analyzes the convergence of market prices. Results on the effect of difference in the position on the demand and supply curve and incentives on the timing of trades are given in Section 5.2 and Section 5.3 presents the corresponding results for all acts, defined as a bid to buy, an ask to sell, a take-bid, a take-ask, or a cancellation in the market. Section 5.4 discusses the results on the profitability of the market versus limit orders differentiated by the trader types and proportion of limit to market orders submitted by different trader types. We also analyze the effect of experience of subjects on the above results and provide some observations in Section 5.5.

5.1. Convergence of Market Prices

Figure 3 describes the behavior of equilibrium prices across periods. Note the shift every period. It also plots the mean and median trade prices (pooled across the four experiments) for each period. Notice that that the mean/median prices shift each period and track the shifting equilibrium quite well. This tracking property is captured by the first result that convergence to the competitive equilibrium occurs across periods even with the parameters shifting.

Result 1. Trade prices tend to move towards the competitive equilibrium across periods.

Support: Table 2 contains the results of the estimation of the Ashenfelter/El-Gamal[9] (AEIG) model of market convergence, which allows different experiments to be idiosyncratically off-equilibrium in early periods but assumes that they all converge to the same point by their final period.

$$P_{it} - P_{it}^{eq} = \sum_i D_i B_{1i}\left(\frac{1}{t}\right) + B_2\left(1 - \frac{1}{t}\right) + u_{it}$$

where i is the experiment, t is the period, and the Bs are the coefficients to be estimated. P_{it} is the average price of a trade in period t of the experiment i. D_i takes value 1 if the experiment is i and zero otherwise. P_{it}^{eq} is the equilibrium price predicted by the competitive model in period t of the experiment i.

The model is designed to deal with both the facts of multiple periods and multiple experiments with possible different rates of convergence. The dependent variable is the divergence from the equilibrium price. The measured variables B_{1i} measure the starting point of prices for experiment i that is relied upon less and less as t grows and in the limit receives no weight at all. The fact that each experiment has its own B_{1i} variable reflects the need for the measurement to acknowledge the fact that experiments start differently. During later periods, as t grows, the weight shifts from experiment-specific measurements to the common measurement B_2. If the data are normalized so the equilibrium price is zero, then if the dependent variable converges to the equilibrium price the value of B_2 should be zero if the data are near the competitive price during the later periods. The coefficient B_2 is an estimate of the asymptotic behavior of the time series that is to be compared with the equilibrium prediction of the competitive model.

The regression results are displayed in Table 2. B_2 is estimated to be -6.75 francs. The large p-value corresponding to the B_2 coefficient suggests that we cannot reject the hypothesis that $B_2 = 0$ even at high levels of significance. Thus we can conclude that convergence to the competitive equilibrium occurs across periods even with parameters shifting[10].

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[9] This model was first used in Noussair et al. (1995) and subsequently in Jamison and Plott (1997).
[10] Cason and Friedman (1996) and Jamison and Plott (1997) also find that convergence to competitive equilibrium occurs across periods with shifting parameters. Thus, this first result can be viewed as a replication of those experiments.

A comparison of the data in the initial periods, the B1i terms, further supports the conclusion of convergence. These terms estimate the initial starting points of the contract prices during the first period of the experiment. These values are far away from the equilibrium prediction of zero so system movement towards zero is evidence of an equilibration dynamic[11].

5.2. Trades

Since there were four experiments conducted and each experiment has 12 periods, there are in total observations on 48 periods. However, due to a lack of close monitoring, in 12 of those periods there were more than one trade done by at least one of the traders. Below we use only those 36 periods in which each trader transacted at most once. The results reported in this section are based on the pooling of data for each period across time. Grouping subjects into two distinct categories of exchange rate allows us to analyze the effect of higher potential profits (in francs)[12] among traders on the timing of the trades separately for the high and low exchange rate population. After discussing the effect of different potential profits in francs on the timing of trades, we end this section with a discussion of the effect of different exchange rates on timing of trades after controlling for the potential profits in francs among traders. We start with the following result.

Result 2. Traders with higher potential profits in francs (profits relative to the equilibrium) trade earlier relative to other traders.

Support: The average trading times from market open until trade for the H_p type, M_p type and L_p type are 74.67, 122.99 and 167.62 seconds respectively. This suggests that the traders with high redemption value trades earlier compared to the other types, the medium type traders trade earlier when compared with the traders with low redemption value. Table 3 gives the average trading time for each of these types subdivided by exchange rate type. For the high exchange rate the elapsed time before trade is 77.9 seconds for the H_p type and 110.43 and 175.09 for the M_p and L_p respectively. The low exchange rate reflects the same tendencies across the H_p, M_p and L_p. Figure 4 shows the number of traders of each type H_p, M_p or L_p involved in trades occurring in each of the time-intervals mentioned. Clearly, most of the H_p type traders are involved in a trade occurring during the initial intervals, followed by the M_p types. Note that the traders of type L_p are trading more towards the end of the period. To provide statistical support for this phenomenon, we do two tests, the details of which we discuss below.

We start by comparing the type H_pR traders to the M_pR types and use this case to illustrate in detail the specifics of the methodology used for all cases. This means that we are comparing the high redemption value traders with the middle valuation traders among the high exchange rate

[11] The evidence is that for most of the periods but not all (note that there are a total of 48 periods) trade prices tend to move towards the competitive equilibrium price during a particular period.
[12] Potential profits in francs/redemption value/valuation would be interchangeably used throughout this paper.

population. Figure 5 depicts the proportion of type H_pR traders ($p(H_pR)$ in the Figure) and the proportion of M_pR traders ($p(M_pR)$ in the Figure) involved in the trades till the t^{th} second (both as a proportion of $H_pR + M_pR$ traders). Thus, we always have $p(H_pR) + p(M_pR) = 1$. For example, if there are 10 traders of type ($H_pR + M_pR$) who are involved in the trades until say 5^{th} second out of which only 3 are of H_pR type, then $p(H_pR)$ till 5^{th} second is 0.3 and $p(M_pR)$ until 5th second is 0.7.

A high $p(H_pR)$ (considerably higher than $p(M_pR)$) implies that more H_pR traders are trading when compared to the M_pR traders[13]. And a high $p(H_pR)$ in the initial seconds followed by a decline in the subsequent seconds till the closing of the market shows that the H_pR traders are more active in the earlier seconds and become less and less active thereafter. Thus, from the Figure 5, one can readily infer that the H_pR traders trade earlier when compared to the M_pR traders.

For further understanding, we model the proportion pHpR over time using the following model:

$$\log(p(H_pR)/1-p(H_pR)) = B_i*(1/t) + B_f*(1-1/t) + u_{it}$$
$$u_{it} = \rho u_{it-1} + e_{it}$$
$$e_{it} \sim N(0,\sigma)$$

where, t denotes the time in seconds. B_i and B_f are the coefficients that are to be estimated[14]. B_i can be interpreted as the initial value (at the opening of the market) of the logarithm of the ratio of proportion of type H_pR traders involved in trades to proportion of types M_pR traders involved in trades and B_f can be thought of as the final value (towards the closing of the market) of the logarithm of ratio of the same proportions.

We can use the difference in the coefficients B_i and B_f to test whether the H_pR type traders are active during the initial seconds and become less active thereafter or whether they are active throughout. We test the null hypothesis that the final proportion is higher than or equal to the initial proportion:

Null hypothesis: $B_f - B_i \geq 0$
Alternate hypothesis: $B_f - B_i < 0$

We obtain a p-value of 0.00. Thus, we reject the null that the final is greater than or equal to the initial coefficient, and conclude that the proportion of traders of type H_pR (having higher potential profits when compared to M_pR traders) in the trades towards the beginning of a period

[13] Also note that there are only two H_pR traders for every two M_pR traders. We have an equal number of traders for each of the types in each of the experiments.
[14] We model the logarithm of the ratio of proportions instead of the proportion itself for the obvious reason that we might get impossible predictions for proportions higher than one and also non-normal errors.

is significantly higher than the proportion of the same type of traders involved in total trades towards the end of the period. This result demonstrates that the individuals who have higher potential profits are more active towards the beginning when compared to the end of a period. This is a qualitative conclusion because it does not test for the proposition that $p(H_pR) > p(M_pR)$ during the initial seconds. To test for this more refined hypothesis, we run a series of binomial tests for different time intervals. See the first row of Table 4 for the p-values of the following test for different time intervals:

H_0: $p(H_pR) \leq p(M_pR)$ or $p(H_pR) \leq 0.5$
H_1: $p(H_pR) > p(M_pR)$ or $p(H_pR) > 0.5$

The p-value is 0.003 for the first time interval 1-25 seconds. This implies that one can reject the null hypothesis that $p(H_pR) \leq p(M_pR)$ even at 1% level of significance. Note that as we move to the later periods, it becomes difficult to reject the null hypothesis. This clearly suggests that during the initial time intervals, more H_pR traders are trading when compared to the M_pR traders whereas more M_pR traders are involved in trades towards the later time intervals when compared to the H_pR traders. Thus, the above two tests help us to conclude that the H_pR traders trade earlier than the M_pR traders.

Doing the similar analysis for the other binary comparisons, namely, H_pR versus L_pR, M_pR versus L_pR, H_pr versus M_pr, H_pr versus L_pr, and M_pr versus L_pr (see Table 5 and Table 4 for details on the different comparisons and the relevant p-values), we can conclude that the traders with relatively higher type trade earlier relative to the lower types except for one single case. In the case of M_pr versus L_pr, there is no indication of the higher types (M_pr) trading earlier.

Additional support for Result 2 is provided by the time path of wealth creation from market activities. The For the Walrasian stable case, the Marshallian path of transactions implies that the wealth created will form a quasi-concave function of time.[15] Since the wealth created by trade is the gains from exchange and the gains are measured in francs, the proposition can be tested. Figure 6 contains the accumulation of gains from exchange in francs each second from the beginning of an experimental period. The data are fitted to a second degree polynomial function. As can be seen, the quadratic is almost a perfect fit with R^2 of .998. This is an exceptionally strong test since the theoretical proposition holds if time is measured in terms of

[15] Near unstable equilibria markets follow the dynamic predictions of the Walrasian model (See Plott, 2000) unless the instability is produced by an externality (Plott and George, 1992). In the absence of an externality, an equilibrium that is stable according to Marshall but unstable according to Walras will find transactions moving away from the equilibrium towards the nearest stable Walrasian equilibrium even if the stable Walrasian equilibrium is less efficient. Thus, the market will follow a wealth decreasing path. This pattern of dynamics is consistent across several different types of experimental markets.

number of trades as opposed to clock time. In clock time, there will always be periods when no trade takes place thus causing “bumps” (small non concavities) in the data.[16]
Having established that position on the inverse demand function is related to speed of transactions, the analysis now turns to the exchange rates. Is the speed of transactions related to “intrinsic motivations”?

Result 3. Traders with higher exchange rate do not trade earlier relative to the low exchange rate traders. Exchange rate has no systematic effect on the timing of the trades.

Support: The average trading times for the traders with high exchange rate (R) and low exchange rate (r) are 109.24 and 116.1 seconds respectively. This suggests that there is not much of an effect of difference in exchange rate on the timing of trades. Table 3 gives the average trading time for each of these types subdivided by redemption value type. The traders with high exchange rate trade later on an average (compared to the low exchange rate traders) among the high and low redemption value subgroups, whereas they trade earlier among the middle redemption value subgroup.

Figure 7 shows the number of traders of each type R or r involved in trades occurring in each of the time-intervals mentioned. Again, it is clear from the figure that the traders with high exchange rate are not trading earlier in comparison to the low exchange rate traders.

Before we advance to the next section, few points are worth noting. The binary comparisons also allow us to analyze the cases where both the redemption values and exchange rates of the traders are varied. These cases are given in the last six rows of Table 4 and are also contained in Table 5. It can be seen that the H_pR type traders trade earlier when compared to either M_pr or L_pr clearly indicating that the traders with highest potential profits (H_pR traders have the highest redemption value as well as high exchange rate) finish trading much earlier when compared to any of the other types, except the H_pr types. Also, the H_pr types trade earlier when compared to the M_pR and L_pR types. The comparisons M_pR versus L_pr and M_pr versus L_pR are indeterminate in the sense that we cannot conclude anything about the relative sequence of trades among these types.

5.3. All Acts: Bids, Asks and Cancellations

A key issue is whether position on the inverse demand curve influences the attempt to trade or the ability to trade. Do the traders with the highest gains from trade do so early because they are “at the market place” early or is it that they find it easier to be successful once they are there and thus trade earlier? Traders bid, ask, and cancel orders with the sole aim of a trade. Since in the experiment each trader had only one unit to trade, a trader exits the market once she has bought a

[16] For the model “gains from trade at tth trade in theory = a + b[gains from trade in data] + e”, we find that the 95% confidence interval contains a=0, b=1.

unit or sold a unit. The next result demonstrates that it is the relative fact that those with higher market potential exert earlier and greater effort that leads to the Marshallian path and not because the greater ability alone. Thus, we have the following results.

Result 4. Traders with higher potential profits in francs (profits relative to the equilibrium) act (bid/ask/take-bid/take-ask/cancel) earlier in a period relative to other traders.

Support: The average act times for the H_p, M_p and L_p types are 66.60, 85.40, and 109.52 seconds respectively, suggesting that the traders with higher potential gains from trade act earlier on an average compared to the lower value types. Table 6 gives the average act time for each of these types subdivided by exchange rate type. Figure 8 shows the number of acts done by each of the three type traders, H_p, M_p and L_p. It is clear that the H_p types are more active in the starting intervals when compared to the later intervals. This is true for the M_p types also. Also, note that the M_p types dominate the H_p types when it comes to being active towards the latter half of the trading period. However, notice from Figure 8 that the low types are active throughout and certainly more active relative to the H_p and M_p traders for the latter half of the time intervals.

Figures 4 and 8 summarize the above results on trades and acts. When the market opens, the traders not knowing the valuations or costs of other traders start bidding/asking but most of the trades are done among the high valuation buyers and low cost sellers (these traders have the highest gains from exchange) followed by the middle type traders. See the bulk of the trades for the H_p type traders are towards the beginning of the period in Figure 4. In some sense, the traders having higher gains from exchange are positioning themselves best in the market. This phenomenon removes more of these traders as compared to the other types. The low valuation buyers and high cost sellers keep on bidding and asking but being limited by their incentives they can't compete with the high and middle type traders. Thus, most of the trades for these low types are towards the end of the period.

Result 5: Traders with high exchange rate do not act (bid/ask/take-bid/take-ask/cancel) earlier relative to the low exchange rate. Exchange rate doesn't make a difference.

Support: The average act times for the traders with high exchange rate (R) and low exchange rate (r) are 91.57 and 88.50 seconds respectively. Thus, there is no support for the theory that traders with high exchange rate act faster when compared to the traders with low exchange rates. Also see Table 6 for the details on the average time for an act.

5.4. Market Versus Limit Orders

We now turn to a secondary question about whether there is a relationship between limit and market orders and the position on the market demand and supply curve occupied by the agents involved in the transaction. A limit order provides a free option to counter-parties who can exercise the option by tendering a “market order”. The option conveys information about the willingness to transact that trading parties might not wish to reveal. To facilitate the analysis, we introduce the concept of *ratio*, which we define as the profit a subject actually earned divided by the profit she would earn at the equilibrium. In a sense, this measures a subject’s efficiency in making profit in the market. Since the l type traders are not supposed to trade under the competitive equilibrium theory, we drop these types from analysis whenever there is a discussion of the ratio. We have two results in this section, first concerning the profitability of market and limit orders among different trader types and second focusing on the portion of the market and limit orders for different trader types.

Result 6. There is no significant difference in the profitability of market orders and limit orders.

Support: Figure 9 plots the average value of the *ratio* for market orders and limit orders across all the different types. Clearly, this ratio is almost the same among the market orders and the limit orders for the H and h traders. The ratio for these traders is close to 1 implying that these traders earn on an average what they should earn given their position on the demand curve and the equilibrium price. Market orders are slightly more profitable on average than limit orders among the M traders while opposite is true among the m traders. But for the L traders, market orders are highly profitable compared to limit orders.

Result 7. Traders with high (middle) redemption value tend to prefer market (limit) orders. However, among those traders with low (or no) gains from exchange, there is no clear preference between market and limit orders.

Support: Table 7 gives the total number of orders submitted by each of the trader types (by redemption value) subdivided into the number of market and limit orders. For the L_p type, the proportion of market to limit orders is around 1 implying that there is no trend for these traders to be on one side of the order. However, this proportion is 1.2 for the H_p types and 0.82 for the M_p types suggesting that H_p traders tend to prefer market orders while the M_p traders prefer limit orders.

The above two results combined suggests that even though there is no significant difference in the profitability of market order and limit order, on an average, H_p traders tend to be on the take-side whereas M_p traders tend to be on the taken-side.

5.5. Effect of Experience

In this section, we provide a few observations related to the experience of the subjects.[17] Although the experiments were not designed to test the effect of experience on the various aspects of the market, the fact that few subjects participated in more than one experiment allowed us to make the following observations.

Observation 1. The average time to trade for experienced subjects was lower than the inexperienced subjects. Experienced traders traded earlier on an average when compared with the inexperienced ones. This trend is true among all types, by franc values and also by exchange rates, except for the type L traders. See Table 8 for the average time for a subject to trade across different experience levels and types.

Observation 2. Experienced subjects picked market orders earlier on average than the inexperienced ones, except among the l types. However, no such pattern was observed for limit orders. The last two columns of Table 8 gives the average time taken to submit a limit order and to pick a market order for each of the trader types and also for different experience levels.

Observation 3. Average market order to limit order ratio is marginally higher among experienced traders when compared to the inexperienced ones, except for the type m traders. See Table 8 for the values of the ratio among market and limit orders differentiated by types. See the last column in Table 9 for the values of the average *ratio* by different types and experience levels.

SECTION 6: SUMMARY OF CONCLUSIONS

That markets converge to the equilibrium predicted by classical competitive demand and supply is well known but exactly how that happens is not well known. The Walrasian model holds that market equilibration works through price adjustments with the size of price changes dictated by the magnitude of excess demand and the allocations determined by those who acted to change price. The first theorem of welfare economics tells us that the resulting competitive equilibrium allocations are efficient. By contrast, Marshall has market equilibration working through volume adjustment with the adjustment dictated by the inverse excess demand through an efficiency seeking path. That is, the Marshall model is that the path of market development follows the maximum gains from trade. The intuition of the Marshallian model can be associated with the second theorem of welfare economics. Markets converge to an efficient allocation, gains from trade are exhausted, and the efficient allocation becomes supported by prices as a competitive equilibrium.

[17] We define experience as being present in more than one experiment out of the four conducted. Thus, if a subject participated in only one of the experiments, he is considered inexperienced.

Both Marshall and Walras hold a principle of equilibrium and focus on the dynamics of equilibration but both are incomplete. Walrasian model sees price adjustments as the organizing principle with the mechanisms for price change left to a fictional auctioneer. We can now see that bids and asks in the continuous double auction carry part of the burden of the auctioneer. The Marshallian model focuses on the rate of exchange and trades as the driving force of market convergence but provided no explanation of the coordination that brought together the particular sequence of trades. We can now see that the bids and asks of the continuous double auction contribute to the coordination and the relative aggressiveness of agents in tendering bids and asks serves as the vehicle for transactions speed.

Experimental evidence suggests that phenomenon exists to support both theories of market adjustment in the context of the continuous double auction. That the magnitude of excess demand influences price changes is supported by studies of stability and thus give life to the Walrasian model. The results reported here demonstrate that Marshall also has a role to play by determining who will trade. Thus, the two theories are complements, each bringing a different and independent principle to the theory of market adjustments. The two theories are not simply inverses of each other but explain different features of the adjustment process. Marshall tells us who will trade and the speed at which trades will take place and that trades will take place along the most efficient, wealth creating path. Walras tells us how prices will evolve when they do trade and that the ultimate prices will support equilibrium volumes and efficiency. Those theoretical principles are reflected in the data.

Paradoxes and challenges remain. The results reported here demonstrate that the adjustment within the market is Marshallian but analysis of stability demonstrates that in the absence of an externality the dynamic principle of price adjustment is Walrasian. This suggests that the two together are still incomplete, inviting theories of expectations and the role of small price adjustments. The adjustments of multiple markets, which was the primary concern of Edgeworth and Walras remains to be studied as are the implications of multiple unit preferences and trades. Similarly, the many modes of market organization are yet to be examined to determine what vestiges of the Marshallian adjustment model might be present or exactly what institutional features might facilitate its presence in the continuous double auction with a book.

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Figure 1: Marshallian versus Walrasian dynamics.

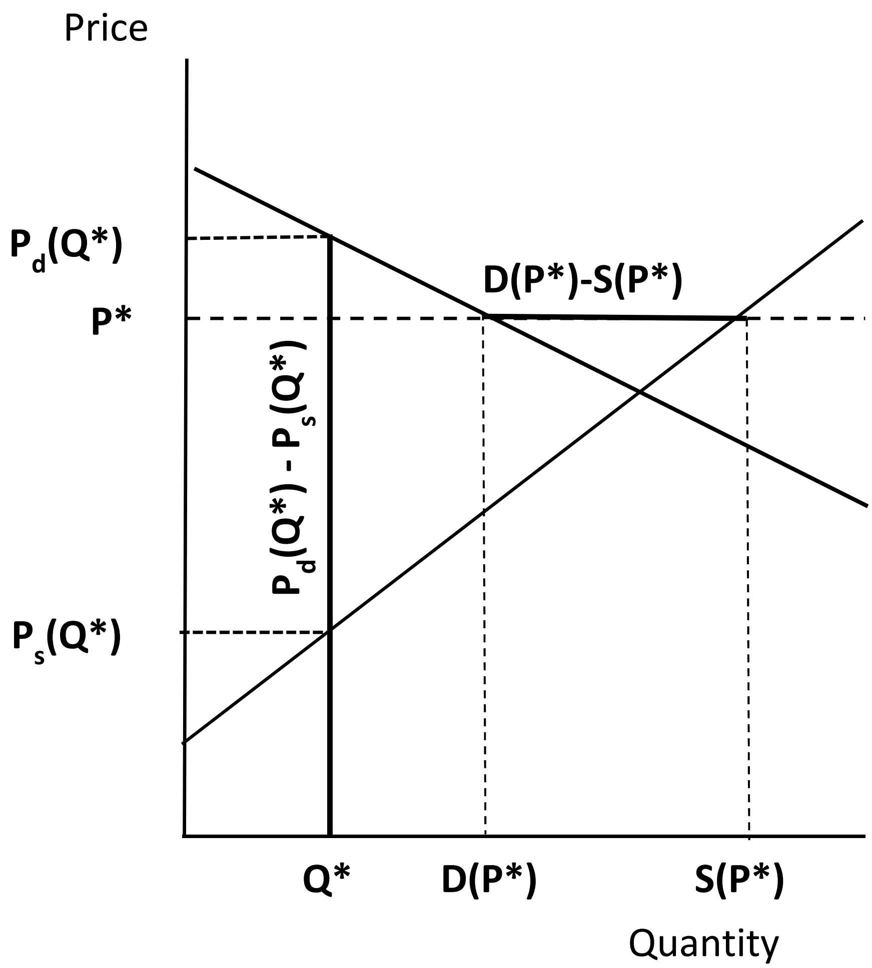

Figure 2: Types: Demander prices and supplier costs in a market.

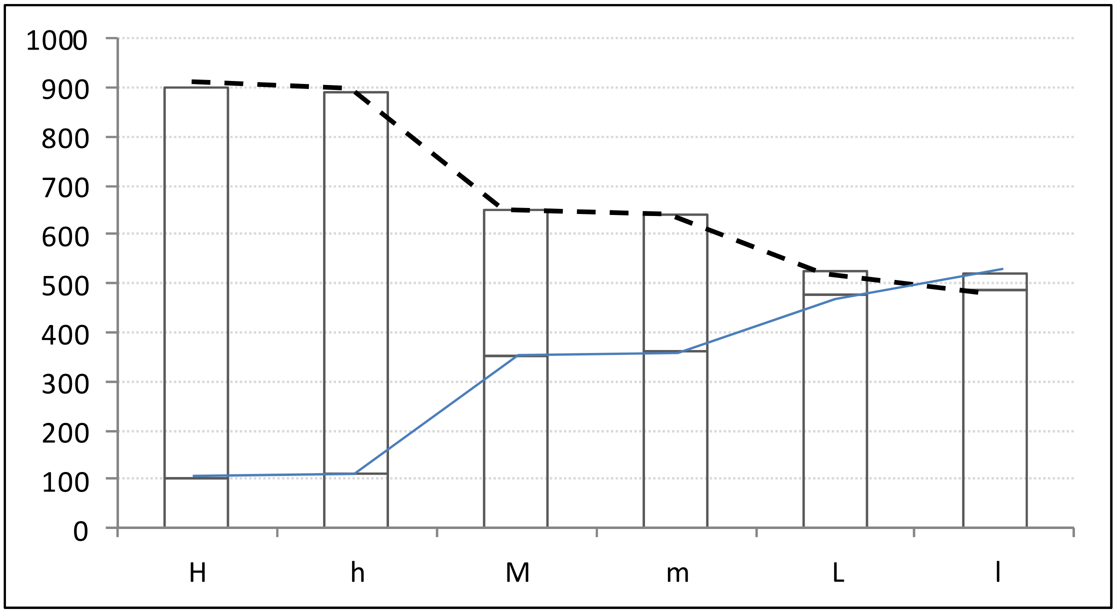

Figure 3: Equilibrium, mean and median prices each period.

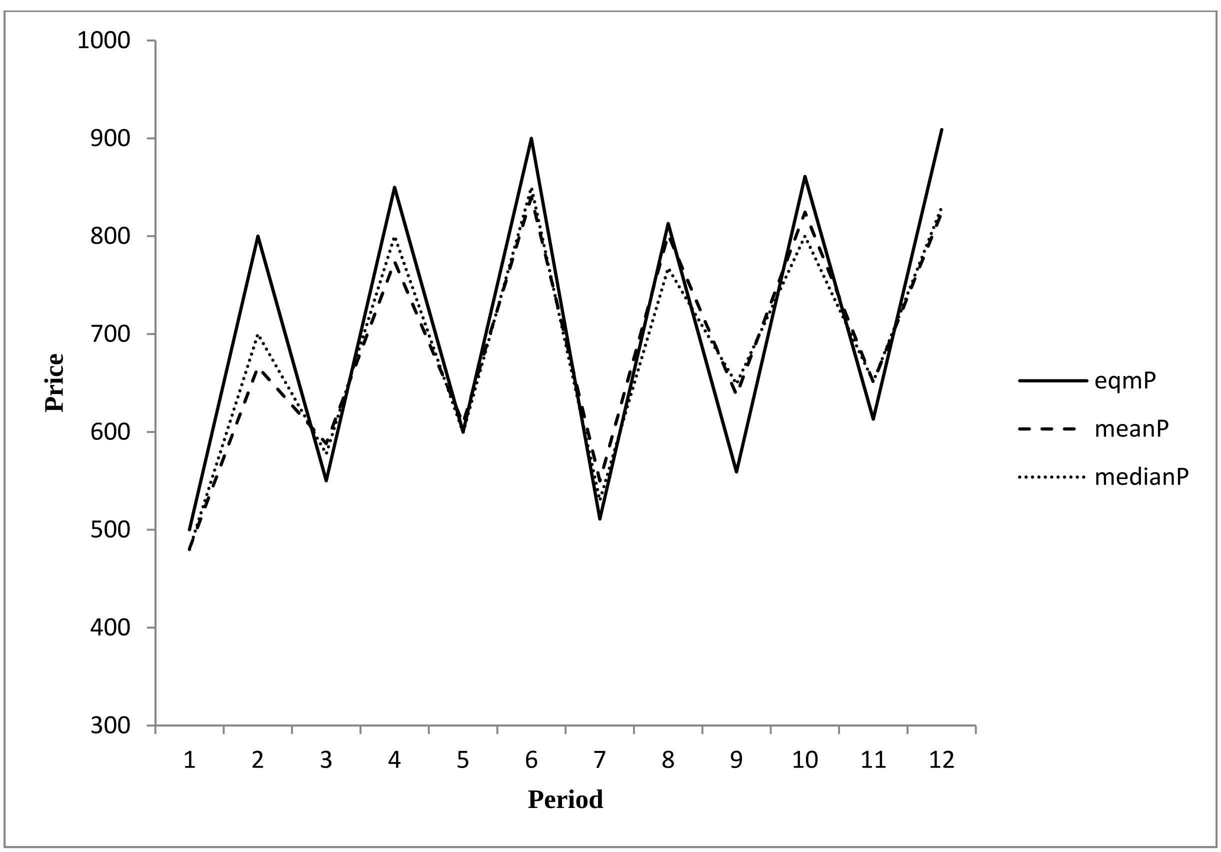

Figure 4: The number of traders by high (H_p), middle (M_p) and low (L_p) redemption value types involved in trades taking place in each of the time intervals.

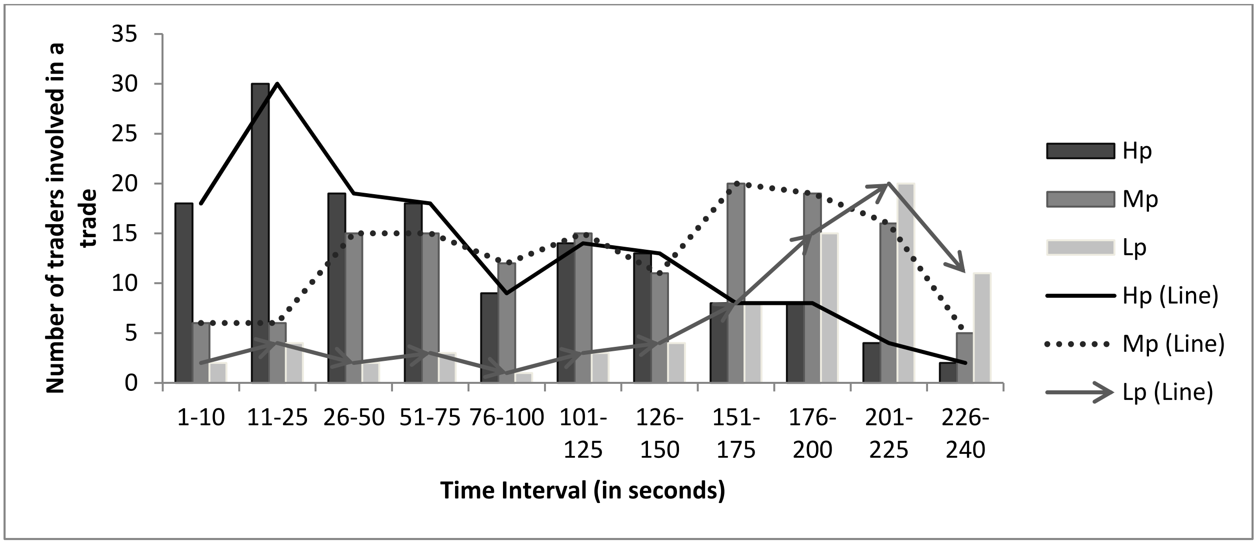

Figure 5: Proportion of type H_pR and M_pR traders involved in trades till tth second (as a proportion of H_pR + M_pR types).

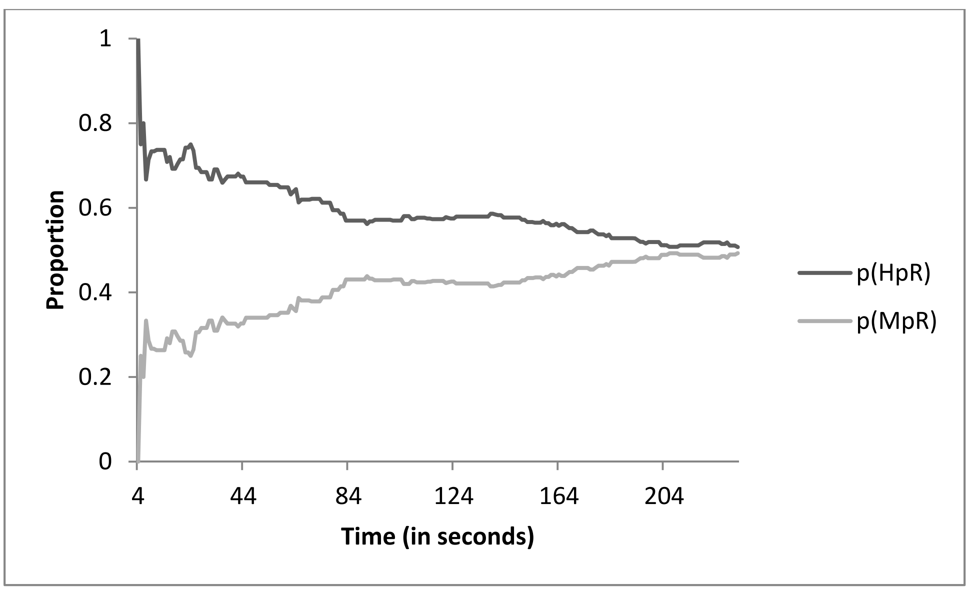

Figure 6: Gains from exchange over time.

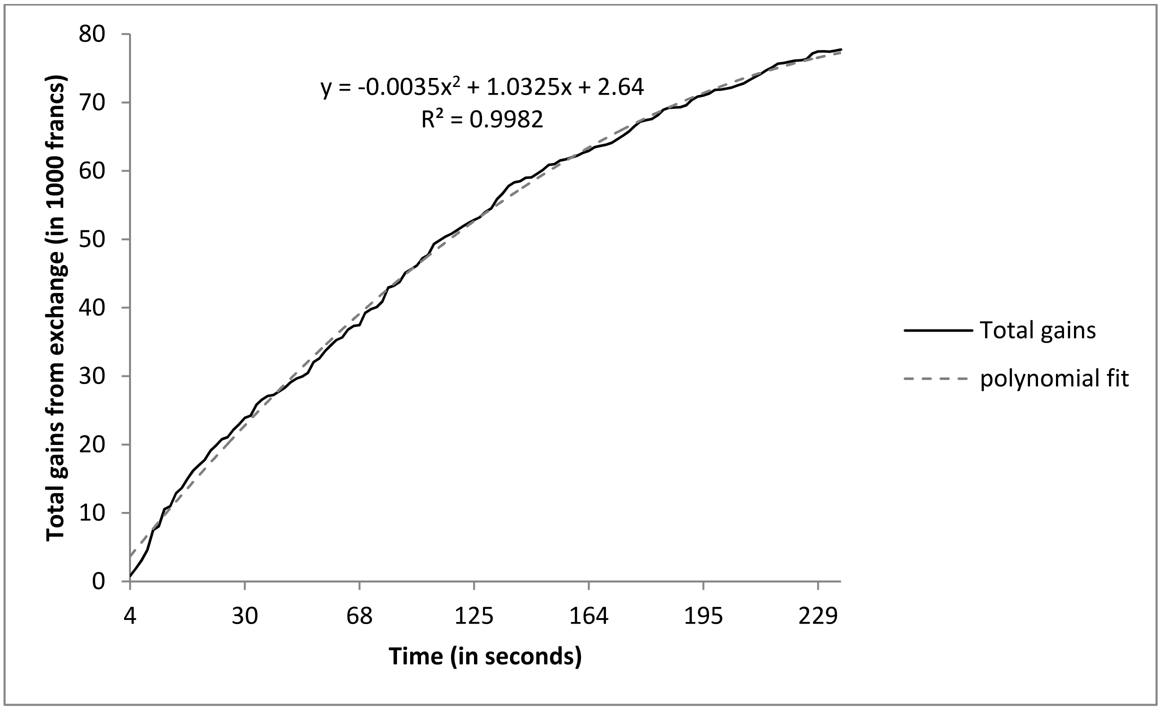

Figure 7: The number of high (R) and low (r) exchange rate traders involved in trades taking place in each of the time intervals.

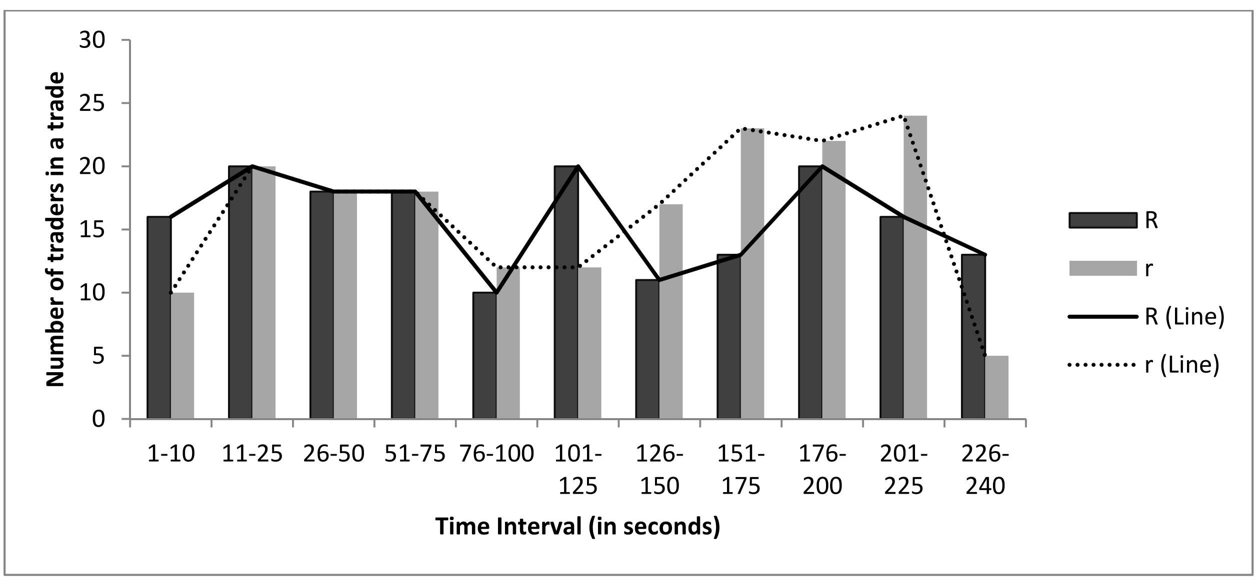

Figure 8: The number of acts by high (H_p), middle (M_p) and low (L_p) redemption value types in each of the time intervals.

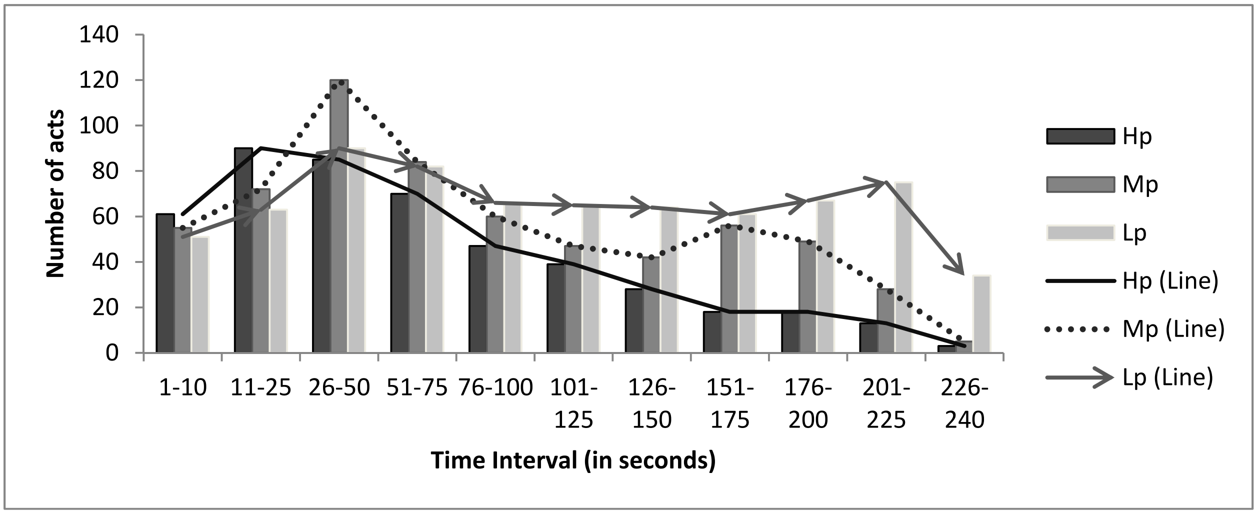

Figure 9: Profitability of market and limit order by types.

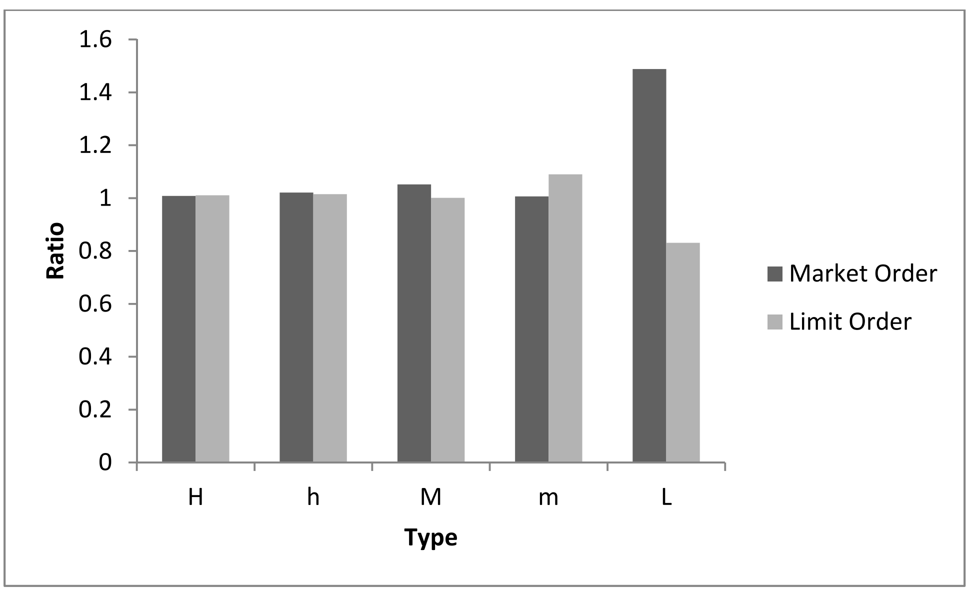

Table 1. Redemption values, costs, exchange rates for the subjects each period.

(a) Buyer side parameters

period	Buyer ID	121	123	125	127	129	131	Equilibrium
0 (practice)	redemption values	500	500	500	500	500	500	450
1		900	890	650	640	525	485	500
2		1190	950	940	825	785	1200	800
3		700	690	575	535	950	940	550
4		990	875	835	1250	1240	1000	850
5		625	585	1000	990	750	740	600
6		885	1300	1290	1050	1040	925	900
7		911	901	661	651	536	496	511
8		1203	963	953	838	798	1213	813
9		709	699	584	544	959	949	559
10		1001	886	846	1261	1251	1011	861
11		638	598	1013	1003	763	753	613
12		894	1309	1299	1059	1049	934	909
exchange rate 1-6		0.65 cent	2 cent	0.65 cent	2 cent	0.65 cent	2 cent	
exchange rate 7-12		2 cent	0.65 cent	2 cent	0.65 cent	2 cent	0.65 cent	

(b) Supply side parameters

period	seller ID	122	123	126	128	130	132	Equilibrium
0 (practice)	costs	400	400	400	400	400	400	450
1		100	110	350	360	475	515	500
2		410	650	660	775	815	400	800
3		400	410	525	565	150	160	550
4		710	825	865	450	460	700	850
5		575	615	200	210	450	460	600
6		915	500	510	750	760	875	900
7		111	121	361	371	486	526	511
8		423	663	673	788	828	413	813
9		409	419	534	574	159	169	559
10		721	836	876	461	471	711	861
11		588	628	213	223	463	473	613
12		924	509	519	759	769	884	909
exchange rate 1-6		0.65 cent	2 cent	0.65 cent	2 cent	0.65 cent	2 cent	
exchange rate 7-12		2 cent	0.65 cent	2 cent	0.65 cent	2 cent	0.65 cent	

Table 2. Convergence of market price across periods (Linear Regression).

Number of observations					48
F (5, 43)					3.07
Prob > F					0.0185
R-squared					0.1334
Root MSE					78.564
	coefficient	Robust SE	t	Prob >t	95% confidence interval
B_{11}	-32.01	61.40	-0.52	0.61	[-155.83 91.80]
B_{12}	-120.83	97.04	-1.25	0.22	[-316.54 74.88]
B_{13}	24.06	35.15	0.68	0.50	[-46.82 94.93]
B_{14}	-79.33	25.32	-3.13	0.00	[-130.40 28.26]
B_2	-6.75	14.75	-0.46	0.65	[-36.51 23.00]

Table 3. Average trading time (in seconds) for the different types.

Type	High exchange rate (R)	Low exchange rate (r)
H_p	77.90	71.39
M_p	110.43	135.54
L_p	175.09	161.41

Table 4. Series of binomial tests for whether the proportion of first type traders is less than or equal to the second type traders in each row (involved in trades) and for each of the time intervals.

comparison	Time Interval (in seconds)					
	1-25	26-50	51-100	101-150	151-200	201-240
H_pR vs M_pR	0.003	0.5	0.832	0.225	0.975	0.817
H_pR vs L_pR	0	0.029	0.002	0.001	0.398	0.999
M_pR vs L_pR	0.017	0.029	0	0.01	0.014	0.986
H_pr vs M_pr	0	0.173	0.168	0.726	0.992	0.999
H_pr vs L_pr	0	0	0.001	0.035	0.949	0.998
M_pr vs L_pr	0.647	0.004	0.016	0.009	0.206	0.424
H_pR vs H_pr	0.386	0.754	0.832	0.168	0.5	0.207
M_pR vs M_pr	0.042	0.398	0.168	0.653	0.685	0.937
L_pR vs L_pr	0.793	0.079	0.841	0.647	0.97	0.185
H_pR vs M_pr	0	0.398	0.5	0.358	0.992	0.991
H_pR vs L_pr	0	0.002	0.016	0.004	0.949	0.985
H_pr vs M_pR	0.007	0.246	0.5	0.583	0.975	0.952
H_pr vs L_pR	0	0.006	0	0.016	0.398	1
M_pR vs L_pr	0.083	0.002	0.001	0.023	0.366	0.91
M_pr vs L_pR	0.327	0.048	0.002	0.004	0.004	0.76

Table 5. Summary of all possible binary comparisons (for trades).

	H_pR	M_pR	L_pR	H_pr	M_pr	L_pr
H_pR	xxx	R (0.00)	R (0.09)	* (0.99)	R (0.00)	R (0.00)
M_pR	-----------	xxx	R (0.92)	C (1.00)	R (0.00)	R (0.00)
L_pR	-----------	------------	xxx	C (0.73)	* (0.06)	* (0.00)
H_pr	-----------	------------	------------	xxx	R (0.01)	R (0.03)
M_pr	-----------	------------	------------	------------	xxx	* (0.99)
L_pr	-----------	------------	------------	------------	------------	xxx

xxx: no comparison possible
R (C): row (column) type trades earlier compared to column (row) type
*: indeterminate
The p-values of the test Bf – Bi >= 0 described in section 3.2 are included in parentheses. The initial point is taken to be at 25 seconds and final is at the close of the trading period.

Table 6. Average act time (in seconds) for the different types.

Type	High exchange rate (R)	Low exchange rate (r)
H_p	68.54	64.31
M_p	82.59	88.07
L_p	114.82	103.93

Table 7. Number of market, limit and total orders by types.

	Market orders	Limit orders	Total number of orders
H	42	30	72
h	36	35	71
M	28	42	70
m	35	35	70
L	24	27	51
l	13	9	22

Table 8. Effect of experience on various aspects of the market. All entries are in seconds.

Type	Avg. Trading Time		Market orders		Limit orders	
	experienced	inexperienced	experienced	inexperienced	experienced	inexp
H	50.15	74.09	42.88	75.04	62.50	72.90
h	74.85	89.87	79.62	96.57	70.08	82.86
M	121.07	125.05	106.58	140.19	131.29	115.36
m	109.54	130.27	113.15	144.32	105.92	116.23
L	180.89	169.73	159.91	162.62	213.86	174.35
l	133.33	167.62	175	161.13	81.25	178
Low exchange rate (r)	109.71	116.11	111.61	115.56	107.56	116.63
High exchange rate (R)	99.33	109.24	89.43	109.90	110.16	108.56

Table 9. Profitability by type, experience level among limit and market orders.

Type	Average ratio among Limit orders		Average ratio among Market orders		Overall average ratio	
	experienced	inexperienced	experienced	inexperienced	experienced	inexperienced
H	1.03	0.99	1.05	0.98	1.04	0.99
h	1.03	1.01	1.05	1.01	1.04	1.01
M	1.00	1.00	1.10	1.01	1.04	1.01
m	1.06	1.10	0.85	1.10	0.96	1.10
L	1.37	0.64	1.56	1.43	1.48	0.95

Appendix.

Instructions to subjects

Instructions

In this experiment you will make decisions to trade one unit of a commodity. Some of you will be buyers and some of you will be sellers. Trading will occur in a sequence of periods. You will remain in the same assignment (as a buyer or seller) throughout the experiment. The prices at which you are able to trade in each trading period will determine your earnings in francs (experimental currency) which will be converted to US dollars at a specified exchange rate. The exchange rates each period will be displayed on your screen. It may or may not be different for different periods and across the participants. You should keep track of your exchange rate each period and your franc earnings each period. At the end of the experiment, you will be paid the total of the dollar earnings that you have earned each period. You will be given a complete description about trading using the software in a moment and will have enough time to get used to the trading interface when we conduct the practice period.

If you have any question, please raise your hand and we will come and assist you.

Buyer-specific instructions

You have a private market where you can sell a unit of the commodity (to the experimenter) at a certain price. You will start out with no unit of the commodity but, some endowment of francs that will let you buy a unit in the public market at a certain price and re-sell it to the experimenter through your private market. The endowment of francs will be taken away at the end of a period. You earn the difference in the price at which you sell in your private market and the price at which you are able to buy the unit from the public market. If you do nothing, you earn nothing.

Seller-specific instructions

You start out with 1 unit of the commodity and no endowment of francs. You need to sell the unit in the public market at a certain price and then go to your private market and buy from the experimenter so that you again end up with 1 unit of the commodity before the trading period terminates. You earn the difference in the price at which you are able to sell in the public market and the price at which you buy from the private market. If you do nothing, you earn nothing.