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Consumption Smoothing and Price Predictability with Heterogeneous Traders in Experimental Asset Markets*

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Abstract

We design an experiment to study the determinants of price movement and consumption smoothing behavior across asset markets populated with varying proportion of traders having induced motive to smooth consumption. The extent of over-pricing is higher when traders with no induced motive to trade are present. Price predictability is higher in the presence of traders with induced motive to smooth consumption. Participants motivated to minimize consumption fluctuations are able to do so with the inclination being more for those having lower initial endowment. With fixed prices, traders are able to smooth consumption not only intertemporally but also across dividend states. Within the dynamic asset pricing framework, our design also allows

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us to compare complete and incomplete asset markets. We find that prices are comparatively well-behaved and consumption smoothing “works” better in the setting where the asset market is complete than under incomplete markets.

JEL Classification Numbers: C91, C92, D84, D91, G12

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1 Introduction

Asset markets are an integral part of modern economies. The reason for engaging in trade might differ across individual investors. Some of them might exchange assets in the pursuit of pure capital gains: buying at low prices and selling at higher prices. Others might use asset markets to generate a smooth stream of intertemporal consumption that would help cushion income fluctuations over time. That is, they buy assets when income is high and sell them to generate cash when income is low.

The idea that people dislike having fluctuations in their consumption when experiencing short run income fluctuations features prominently in the Permanent Income Hypothesis (Friedman (1957)). In the presence of short run income fluctuations, people would want to smooth their consumption across periods by consuming only a fraction of their current income and allocating their remaining income on precautionary activities. There are many ways in which people do precautionary activities. They may, for example, place their remaining income on saving and deposit. Alternatively, they may also invest their remaining income in security market and utilize the security returns to boost their consumption when experiencing a negative income shock. This paper focuses on the role of stock trading as a consumption smoothing instrument and the investigation of the associated price dynamics in these asset markets.

Specifically, we are interested in answering the following set of questions. First, do asset prices deviate from the intrinsic value of the underlying asset? If so, would the deviation be the same across markets populated with varying proportion of agents with differing trading motives, where some of them primarily want to smooth consumption and others want to engage in speculation? Second, would consumption smoothing ability of agents with the induced motive to smooth consumption be affected by the composition of agents with differing trading motives in the market? Third, to the extent that the aggregate output is predictable, do asset prices have a predictable component as well? Fourth, is it possible to link the extent of price predictability to the number of agents in the marketplace who are primarily trading to offset the income fluctuations over time?

In order to answer the above questions, we design an experimental asset market that is close to the setting under consumption-based general-equilibrium asset-pricing approach (Stiglitz (1970), Lucas (1978), Breeden (1979)). Knowing the answers to these questions would provide insights into which naturally occurring markets are more prone to mispricing and might provide rationale for what contributes to price predictability.

We consider an environment with an indefinite horizon economy with a single perishable consumption good and a long-lived asset. While laboratory markets are much simpler in structure than actual asset markets in the field, they provide an invaluable controlled setting where certain hypotheses can be empirically tested and confounding factors can be isolated. The endowments, income processes, as well as dividends paid by the asset are perfectly observed in the experiments. Deviations in prices due to variation in the underlying dividend process can be computed with precision and we can compare this measure across different markets. Uncertainty with regards to the dividend paid by the asset or the price of the asset can be introduced into and removed from an environment in which other factors are held constant.

There is a vast experimental literature on asset pricing that has significantly enhanced our understanding of price formation in markets. Early studies, including Plott et al. (1982), Forsythe et al. (1982), Friedman et al. (1984) motivated agents to trade by providing heterogeneous dividend values. They found that market prices effectively aggregate private information about dividends and tended to converge toward rational expectations values. Smith et al. (1988) introduced a particular class of asset market that tends to generate price bubbles.[1] Researchers had shown that the phenomenon of asset price bubble is robust to a variety of changes in the market structure (see, e.g., King et al. (1993), Van Boening et al. (1993), Porter and Smith (1995), Caginalp et al. (1998), Lei et al. (2001), Dufwenberg et al. (2005), Haruvy and Noussair (2006), Haruvy et al. (2007), Hussam et al. (2008), Kirchler et al. (2012)).[2] In all of these studies, a market was created for a dividend-paying asset with a lifetime of a finite number of periods, and the asset structure was common

[1]A bubble is typically defined as "trade in high volumes at prices that are considerably at variance from intrinsic values". This definition is given by King et al. (1993).

[2]For a review of the literature, see Sunder (1995) or Duxbury (1995) as well as chapters 29 and 30 in Plott and Smith (2008).

knowledge. The volume of trade was substantial and a sustained duration of prices that greatly exceeded the fundamental value before finally crashing to prices close to fundamental values near to the end of the experiment was the typical empirical pattern observed. Another strand of literature studies the static capital asset pricing model in the laboratory with only asset-derived income and no labor/endowment income (Bossaerts and Plott (2002), Asparouhova et al. (2003), Bossaerts et al. (2007)).

In our experiments, several participants are motivated to engage in trade in order to offset income fluctuations they face over time. Thus, the primary reason for exchange for these participants in our setting is to mainly perform consumption smoothing, a feature which is absent in the experimental asset pricing literature, except two recent papers, Asparouhova et al. (2016) and Crockett and Duffy (2015). Both of these studies consider multiple period and indefinite horizon setting to study dynamic asset pricing and consumption smoothing in the laboratory. Asparouhova et al. (2016) induced preference for consumption smoothing by paying only for the last period, forfeiting payments in all periods that end not being terminal. This perishable feature of payments (cash) at the end of the interim periods is meant to capture the notion that the remaining cash not used as medium of exchange must be spent solely on consumption in that period. Perishable consumption good is an important feature of the consumption-based general-equilibrium dynamic asset-pricing framework. In contrast, to create an induced motive for consumption smoothing, Crockett and Duffy (2015) imposed a schedule of final payments to participants that is non-linear in period earnings.

This paper contributes to the literature in several ways. Unlike Crockett and Duffy (2015) and Asparouhova et al. (2016), we depart from the focus on testing the predictions of Lucas (1978) model. Instead, we introduce another type of traders with constant income vis-á-vis those with income fluctuations in a Lucas consumption based asset pricing framework, thereby varying the motivation to trade. This enables us to observe the behavior of traders with and without the induced motive to smooth consumption. This introduces heterogeneity in traders' objectives, which is more representative of the markets outside the laboratory. To the best of our knowledge, ours is the first paper to study the impact of different proportion of traders with induced motive to smooth consumption, more specifically with regards to the role of traders insulated from income shocks. Secondly, we add another dimension by varying the initial asset endowments of the traders in order to obtain insights on how portfolio adjustment decisions affect the consumption smoothing activity of the individuals. Thirdly, we also investigate the implications of dividend uncertainty and price uncertainty.

Another major departure from the previous two studies is the fact that in addition to complete markets, we now investigate asset markets that are incomplete: people cannot trade Arrow-Debreu securities corresponding to every state of nature. Previous papers dealt with complete markets only: Crockett and Duffy (2015) considered markets with only one asset and no fundamental risk, while Asparouhova et al. (2016) had two assets and two states of nature.

To keep the analysis and experimental design simple, traders are told about the exogenous uncertainty with regards to the dividend process and they must learn to take into consideration the endogenous uncertainty, i.e., the price process. Also, from the outset, agents know the income shock that they will receive in each period. We further simplify the setting by having only one security market open in any session that traders could exchange their assets. Cash plays a dual role within a period: as medium of exchange and as consumption good. While cash is perishable at the end of an interim period, the assets are long-lived and are the only intertemporal store of value. Similar to Asparouhova et al. (2016), we pay participants only for the cash in the last period to mimic the perishability of cash. Motivation for trade is provided to certain participants by making their income process variable over time. Other traders are insulated from income shocks by having their endowment of income constant in each period.

We present several results. First, we find that the asset is overpriced compared to the risk-neutral fundamental value in all our sessions. In the presence of traders who do not experience any endowed income fluctuation over time, the extent of overpricing is higher and the variability of prices is larger. This is in comparison to markets where all agents have induced motive to smooth consumption in order to offset income fluctuations. Second, traders experiencing endowed income fluctuations were naturally aware of the need to smooth their income across periods through trading. We observe consumption smoothing behavior for these type of agents. Those traders having a constant stream of income do not show signs of such behavior. A certain subset of traders who do not experience any income variability over time are able to exploit the predictability of prices by buying low and selling high where the change in state primarily propels the variation in prices. In sessions where we fix the price and let agents buy/sell to the experimenter instead of engaging in an asset market, we find that individuals show preference for consumption smoothing not only over time but also across dividend states. Third, prices co-move with the underlying dividend state of the asset. We find strong evidence that prices have a significant predictable component in all our treatments. Close to 50% of the variation in prices can be explained by changes in the dividend state in the presence of agents for whom the primary motivation to trade is to smooth consumption.

The remainder of the paper is organized as follows. Section 2 reviews the related background research and discusses questions that we ask in our study. In section 3, we describe the design and procedures of the experiment, and in section 4 we present the data. Section 5 summarizes our findings.

2 Background

The experiment is designed specifically to answer four research questions related to price dynamics, price predictability and consumption smoothing behavior in asset markets. Asparouhova et al. (2016) and Crockett and Duffy (2015) have already provided us with the framework to induce consumption smoothing conduct in the laboratory. Both document considerable support for the predictions emerging out of the consumption-based general-equilibrium models of dynamic asset pricing. Specifically, Asparouhova et al. (2016) test the predictions of the Lucas intertemporal asset pricing model (Lucas(1978)) and find features in the data that are consistent with the most important predictions. Agents trade assets to smooth consumption and insure against risk, and there exists an equity premium that is counter-cyclical. They also report that prices are excessively volatile.[3] As opposed to the model, which

[3]The term *excessive volatility* is used to denote the fact that a large fraction of price movements is unrelated to the changes in the underlying dividend state (LeRoy and Porter (1981), Shiller (1981)).

predicts that changes in the dividend state should explain 100% of price changes, they find the corresponding value to be merely 18%. In markets with a single security which pays a constant dividend each period, Crockett and Duffy (2015) find support for the claim that the frequency, magnitude, and duration of asset price bubbles can be reduced by the presence of an incentive to intertemporally smooth consumption in an otherwise identical economy.

Markets outside the laboratory are likely to be populated with individuals where some of them trade in the pursuit of capital gains while others use the asset market primarily to offset income fluctuations that they experience over time. With the hope of mimicking such an environment, we create treatments where we systematically vary the number of traders who face intertemporal income variability and hence have induced motive to trade in order to smooth consumption. The first research question asks whether the dynamics of asset prices, including the magnitude of price changes as well as the determinants of this variation, differ as we vary the number. We also investigate whether prices deviate from intrinsic values. Specifically, our first research questions is,

Research Question 1: *Do differences in the price dynamics across markets depend on the proportion of agents having an induced motive to offset the income fluctuations by trading assets?*

The setting used in our study enables us to investigate the predictability of asset prices. The sufficient amount of control in our experiments allows us to contribute to the debate on whether market efficiency and price predictability can co-exist in asset markets. The original accounts of the Efficient Market Hypothesis stated that prices must not be predictable (Samuelson (1973), Malkiel (1999)); investors would trade to exploit the predictability and in the process eliminate it. Using historical data from the field, several studies have documented that prices have a significant predictable component (Campbell and Shiller (1988), Fama and French (1988), Lo and MacKinlay (1988), Bernard and Thomas (1989), Fama (1990)).

The phenomenon of price predictability has been explained primarily in terms of cognitive biases in investor decision making (De Bondt and Thaler (1985), Daniel et al. (1998), De Long et al. (1990)). Another potential explanation for predictability is that the correct general equilibrium model of asset returns is consistent with the variation of returns over time. Extending the Lucas (1978) framework, Balvers et al. (1990) and Cecchetti et al. (1990) build models that demonstrate that predictability is not inconsistent with the concept of efficient markets. They argue that the interplay between consumption smoothing and risk correction can generate mean-reverting behavior of stock returns. In order to maximize expected utility, investors attempt to smooth consumption by adjusting their required rate of return for financial assets. The main message from these intertemporal models based on consumption smoothing is that stock returns can be predicted to the extent that there is predictability in the endowment process. Because we can perfectly control and observe the endowment process in laboratory markets, we can compute measures of predictability with greater precision. More importantly, we can compare this measure across markets differing in the proportion of investors whose primary aim is to smooth consumption. This constitutes our next research query.

Research Question 2: *Are prices predictable, in the sense that changes in the dividend state explain the variation in prices? Is price predictability higher in markets where traders participate in asset trading primarily to smooth consumption?*

The next question that we are interested in is concerned with the behavior of traders in markets where agents with and without the intertemporal income fluctuations are present. We expect that traders who face income variability would attempt to smooth their consumption stream by taking part in trading activity via the asset market. Lower trading volume is expected out of agents who have constant income flow throughout and these traders are more likely to engage in speculative trades than the ones having income fluctuations. Also, if prices are predictable, it is possible that certain traders are able to make use of this predictability for their own benefit. We seek to identify the characteristics of these traders too as part of the third research question.

Research Question 3: *In markets where different types of traders co-exist, do we see a clear difference in trading behavior of agents with endowed income fluctuations who would have induced motive for consumption smoothing and agents without endowed income fluctuations who would not have induced motive for consumption smoothing? Are there traders who are able to exploit the feature of price predictability* *in markets for their own benefit?*

There are several sources of uncertainty in our setup. A laboratory investigation allows us to create treatments designed specifically to test the implication of a particular uncertainty in question on the relevant variables of interest. Our last research question is aimed at understanding the effect of eliminating asset price uncertainty by fixing the price at which an individual can buy/sell to the experimenter. Thus, there is no asset market in the strict sense; participants only engage in exchange of securities at fixed prices with the experimenter who acts as an intermediary. The setting collapses to that of individual-choice and presents subjects with the simplest of environments. The economy is still indefinite-horizon and cash remains perishable at the end of a period to provide sufficient incentive for agents to smooth consumption.

Research Question 4: *Does a simpler environment, where asset price uncertainty is absent, results in a different strategy being used by agents with respect to their consumption smoothing behavior?*

3 Experimental Design

3.1 General Structure

The data for this study were gathered from 15 experimental sessions conducted at the Nanyang Technological University (NTU), Singapore.[4] There were 16 participants in all sessions but one where we had only 14 participants. Thus, in total we had 238 participants. They were recruited from the population of undergraduate students at NTU from various majors ranging from Social Sciences, Business and Economics, Humanities, Engineering, and Sciences. No subject participated in more than one session of this experiment. The sessions lasted approximately two hours and participants earned on average S\$24.20 in addition to a show-up fee of S\$2.[5]

[4]Prior approval from the Institutional Review Board (IRB), NTU was obtained.

[5]Payoffs, inclusive of the show-up fee, ranged from S\$2 to S\$70.80 with a standard deviation of S\$11.64.

We implemented an indefinite horizon economy with a single perishable consumption good in each period. The standard procedure (Camerer and Weigelt (1996)) was used to induce discounting in the laboratory. We randomly determined whether a period was terminal. This ending procedure induced discounting with a discount factor equal to the probability of continuation. Assuming that subjects are expected utility maximizers with time-separable preferences, a stochastic ending time is (theoretically) equivalent to discounting over an infinite time horizon. At the end of each period, a six-sided die was rolled in public view of all participants. If the die roll was 6, we terminated the economy; otherwise, we continued to the next period. Thus, we had an indefinite horizon economy with a constant termination probability of 1/6 per period.

In the experiment, the consumption good was represented by cash which was "made" perishable in each period. That is, at the end of every non-terminal period, any remaining cash holdings disappeared. Only cash held at the end of the randomly determined terminal period was credited to participants' final payout accounts (and hence "consumed"). Thus, we did not literally have consumption every period; participants in our experiments faced the same optimization problem as if they actually had to consume every period.

We also implemented the following termination protocol introduced in Asparouhova et al. (2016). It was announced that the experimental session would last until a pre-specified time and there would be as many replications of the economy as could be fit within the time limit. If a replication ended at least ten minutes before the announced ending time of the session, a new replication would begin; otherwise, the experimental session would end. If a replication was still running ten minutes prior to the indicated ending time of the session, we announced before market opened for trading that the current period would be either the last one (if the die turned up 6) or the next-to-last one (if the die turned up 1-5). This termination rule ensured that the laboratory economy was stationary.[6]

Each period, an asset market was opened where agents could buy and sell securities. The asset was long-lived and carried forward to the next period if the current

[6]For a detailed discussion on the termination protocol, see Asparouhova et al. (2016). They showed that the termination rule produces pricing as if the economy were to continue forever.

period was non-terminal. In the event that the current period turned out to be terminal, all securities expired worthless. Participants in our experiment belonged to one of the four types of traders as mentioned in Table 1. The table summarizes the types of traders, traders' per period exogenous income, and traders' initial endowment of assets at the beginning of a replication.

Agent type	**Per period exogenous income ($)**	**Initial assets (units)**
I	$0 in odd periods and $15 in even periods	20
II	$15 in odd periods and $0 in even periods	5
III	$7.5 in odd and even periods	20
IV	$7.5 in odd and even periods	5

Table 1: Types of Traders, per period exogenous income, and initial assets

Thus, the characteristic of a trader differed across two dimensions. The first dimension is whether she started out with a relatively larger endowment of assets (*asset-rich*) or smaller endowment (*asset-poor*). Types I and III were *asset-rich* while types II and IV were *asset-poor*. The second dimension was the nature of the income shock received in each period. Type-I and Type-II traders received income every alternate period. On the other hand, the other two types did not have any income fluctuations across periods. Participants only knew their own endowment of assets and the process of income shocks; they were not informed about others' characteristics.

We varied the number of the different types of traders in each session.[7] Summary information about each session is given in Table 2. For each session, indexed by identification number in the first column, the table indicates the experimental treatments we implemented in the second column and the number of replications in each session in the third column, along with the number of periods in the fourth column. It also lists the number of different types of traders per session in the fifth column. The parameters of the experiment, that include, the initial endowment of assets, the income shock in each period, the number of different types of traders per session, etc, were chosen to ensure that the aggregate amount of initial cash endowment given by the prevailing patterns of the income shocks[8] and the total

[7]We elaborate on this issue later (Subsection 3.3) when we discuss the various treatments we implemented.

[8]The exact amount of cash in the economy in each period consisted of the total initial cash

number of assets in the economy remained constant across periods and sessions.[9]

Table 2: Summary data, all experimental sessions.

Session	Treatment	Number of replications	Number of periods (Total within session, minimum across replications, maximum)	Subject count by type of trader (type I, type II, type III, type IV)
1	Baseline *(BL)*	3	(22,2,12)	(8,8,0,0)
2	Baseline *(BL)*	3	(17,1,13)	(8,8,0,0)
3	Baseline *(BL)*	3	(17,1,9)	(8,8,0,0)
4	Constant Income *(CI)*	6	(20,1,7)	(0,0,8,8)
5	Constant Income *(CI)*	2	(19,7,12)	(0,0,8,8)
6	Constant Income *(CI)*	1	(16,16,16)	(0,0,8,8)
7	Mixed Market *(MM)*	3	(23,3,11)	(4,4,4,4)
8	Mixed Market *(MM)*	1	(10,10,10)	(4,3,3,4)
9	Mixed Market *(MM)*	4	(18,1,13)	(4,4,4,4)
10	Constant Dividend *(CD)*	4	(20,3,7)	(8,8,0,0)
11	Constant Dividend *(CD)*	4	(19,3,7)	(8,8,0,0)
12	Constant Dividend *(CD)*	4	(19,2,8)	(8,8,0,0)
13	Fixed Price *(FP)*	5	(20,1,9)	(8,8,0,0)
14	Fixed Price *(FP)*	2	(14,4,10)	(8,8,0,0)
15	Fixed Price *(FP)*	2	(18,2,16)	(8,8,0,0)
Total		47	(272,1,16)	

All accounting and trading were done in Singapore dollars. The market was computerized and we used the continuous double auction trading rules (Smith, 1962) implemented with the z-Tree computer program (Fischbacher (2007)).[10]

3.2 Timing of the sessions

The sequence of events in sessions was as follows. Upon arrival, subjects were seated at visually isolated computer workstations. Instructions were read aloud and sub-

endowments generated by the prevailing patterns of income shocks in each period plus the cash from dividends obtained from the securities held in each period. Thus, depending on the realization of the dividend, the exact amount of cash varied across periods.

[9]Sessions 8 and 13-15 are the only exceptions. This is because we only had 14 traders in session 8. The number of assets per-trader was also constant in sessions 1-12. The number of assets in the economy (as well as per-trader) was not constant for sessions 13-15 which constituted a treatment that was fundamentally different from all the other treatments implemented in sessions 1-12. Please refer to Subsection 3.3 for details.

[10]Trading took place through anonymous, electronic continuous open book system.

jects also received a copy of the instructions.[11] Participants familiarized themselves with key aspects of trading in the open-book double auction mechanism (placing bids and asks, order cancellations, understanding the transaction determination protocol, etc.) through one mock replication of our economy during the instructional phase of the experiment. Activity during the mock replication did not count toward final earnings.

After the instructional phase was completed, the paid phase of the experiment began with the first replication of the economy. Agents received their initial endowments of the asset and cash. The market unfolded period by period, with each such period being terminal with 1/6 probability. Every period, each subject entered with holdings of the asset from a prior period, and received cash, in the form of income, with the magnitude depending on the prevailing pattern of income shock, and dividends. A period lasted for three minutes, within which all subjects were free to purchase and sell units of the asset at any time provided that they do not violate the short-selling (negative holdings) constraint. In addition, subjects were required to maintain a positive cash balance to make any purchases. If engaging in a trade would violate either the short sale or cash balance constraint, the computer program prohibited individuals from doing so.[12] Termination uncertainty resolved at the conclusion of each period, after subjects established their assets and cash holdings for that period.

Thus, each period, a subject had to decide how to re-distribute her wealth across cash and assets. She knew that there was a given chance (1/6) that the replication would end that period, at which point she would earn the cash she was holding, but the assets she still had in her portfolio became worthless. With the remaining chance (5/6), the economy moved to a subsequent period, and the subject forfeited her cash as it was perishable and thus could not be carried forward to the new period. Subjects were allowed to carry the assets over to the next period; this would generate new cash (in the form of dividends) in the new period.

Within each experimental session, we conducted as many replications as possible within the time allotted.[13] Whenever a replication terminated and there was still

[11] A sample copy of the instructions is provided in the Appendix.

[12] No borrowing or short sales are standard restrictions in asset market experiments.

[13] Following completion of the last replication, subjects also participated in the standard risk-

time left in the session, we initiated a new replication. Thus, the termination protocol was only applied to at most one of the replications in a session. If a replication ended naturally (i.e., through the roll of the die) close to the 10-minute mark before the end of a session, we did not start a new replication. We paid for two of the replications, randomly chosen after the conclusion of the experiment. If a session ended with exactly two replications, then we paid for both. If a session only had one replication, we paid two times the earnings from the sole replication.

3.3 Treatments

We implemented five (5) treatments and conducted three (3) sessions for each of them. Table 3 summarizes all five treatments. We refer to sessions 1-3 as the *Baseline (BL)* treatment. In each session, half of the participants were assigned the role of Type-I trader and the other half were assigned the role of Type-II trader. Thus, each subject had an induced motive to trade in order to offset the income fluctuations across periods. A single long-lived asset was available for trading in the marketplace that paid, in each period, a stochastic dividend of 1 ECU when the state of nature was good and 0 ECU when the state of nature was bad. The states were equally likely and the dividend was common for all units and subjects.

The composition of the experimental sessions are shown in Table 2. Sessions 4-6 constituted the *Constant Income (CI)* treatment, and sessions 7-9 constituted the *Mixed Market (MM)* treatment. These sessions differed from the *BL* treatment in the composition of the traders by type. In sessions 4-6, half of the subjects were assigned the role of Type-III trader and the other half were assigned the role of Type-IV trader. The *MM* sessions had four traders of each type.[14] Thus, in the *BL* sessions, 100% traders had an induced motive to minimize the income fluctuations due to the alternating income cycle across periods. In contrast, this percentage is only 50% for *MM* sessions and 0% under *CI* treatment. A comparison of these three treatments allowed us to investigate the effect of composition of the asset market in

elicitation task (Holt and Laury (2002)).

[14]The sole exception was session 8, where we managed to recruit only 14 subjects. There were seven traders having income fluctuations across periods while seven had constant income each period. So, the proportion of traders in the market with induced motive to smooth consumption across periods was still 0.5.

Table 3: Summary of treatments.

Treatment	Composition of agent types	Dividend per share (ECUs)	Asset price (ECUs)
Baseline *(BL)*	I, II	0 or 1 (equal probability)	Market determined
Constant Income *(CI)*	III, IV	0 or 1 (equal probability)	Market determined
Mixed Market *(MM)*	I, II, III, IV	0 or 1 (equal probability)	Market determined
Constant Dividend *(CD)*	I, II	0.5	Market determined
Fixed Price *(FP)*	I, II	0 or 1 (equal probability)	2.5

terms of the proportion of traders with the induced motive to smooth consumption on asset price patterns, determinants of asset price movements across periods and consumption smoothing behavior.

Constant Dividend (CD) treatment comprised of sessions 10-12. These sessions were similar to the *BL* sessions except that the long-lived asset available for trading paid a constant dividend of 0.50 ECU per period instead of a stochastic dividend. Given the fact that the expected dividend from a unit of the asset is the same in *BL* and *CD* sessions, a direct comparison between these two treatments enabled us to study the effect of dividend uncertainty on the dynamics of asset prices and the consumption smoothing behavior.

Sessions 13-15 constituted the *Fixed Price (FP)* treatment. These sessions were similar to the *BL* sessions except that we eliminated the price and liquidity uncertainty of the asset. Participants could buy or sell the asset to the experimenter at an exogenous fixed market price of 2.5 ECU.[15] This price corresponded to the risk-neutral fundamental value of a unit of the asset at any instant. This is because the asset was long-lived in an infinite horizon economy with a discount

[15]Provided that they did not violate the short sale or positive cash balance constraints.

factor of 5/6. Thus, if a trader held a unit of the asset today, it was worth $(0.5)(5/6) + (0.5)(5/6)^2 + ... = (0.5)(5/6)(\frac{1}{1-5/6}) = 2.5$ in terms of expected payoff.

We do, however, note that constant prices are obviously not realistic. Nevertheless, by running *FP* treatment, we would be able to eliminate the influence of price uncertainty on trading activities, and this would allow us to cleanly study whether; (a) subjects show preferences for consumption smoothing in the simplest trading environment and (b) they engage in consumption smoothing more vigorously. Thus, this treatment essentially serves as our litmus test to ensure that our subjects fully grasped the need to smooth consumption when experiencing income shocks. Note that in *FP* treatment, the uncertainty with respect to the dividend in each period remained as the asset paid a stochastic dividend and the uncertainty with respect to the planning horizon arising due to our indefinite horizon economy was still present as well. We kept these two features of uncertainty intact to facilitate comparison with our baseline treatment.

To summarize, every replication within a session had the setting of an indefinite horizon economy with a single perishable consumption good in each period. Thus, there was uncertainty regarding the planning horizon in all of our treatments. *BL*, *CI*, *MM* and *FP* sessions were characterized by dividend uncertainty due to the presence of the risky asset. In contrast, *CD* sessions had a risk-free security for trading which paid a constant dividend each period. Uncertainty about future prices was present in all treatments except *FP* sessions. Finally, all traders in treatments *BL*, *CD* and *FP* had income fluctuations across periods, while only half of the participants were provided with an induced motive to offset the income swings in *MM* treatment. *CI* sessions had zero traders with the induced motive to smooth consumption across periods.

Treatments *BL*, *CI* and *MM* were designed in order to address our first three research questions, whereas treatment *FP* was needed to answer the fourth research question. For analysis on the impact of dividend uncertainty on prices and consumption smoothing behavior, we implemented the *CD* treatment. This also allowed us to understand the differences in the characteristics of price and consumption smoothing between a complete market (*CD*) and an incomplete market (*BL*).

4 Results

In this section, we present the most prominent empirical patterns observed in our experimental data. While subsection 4.1 compares asset price dynamics across treatments, subsection 4.2 analyzes the factors affecting the price swings between trading periods in each treatment. Findings on trading volume and activity across treatments are documented in subsection 4.3. The final subsection provides observations with respect to consumption smoothing and trading strategies across different types of traders.

4.1 Transaction prices across treatments

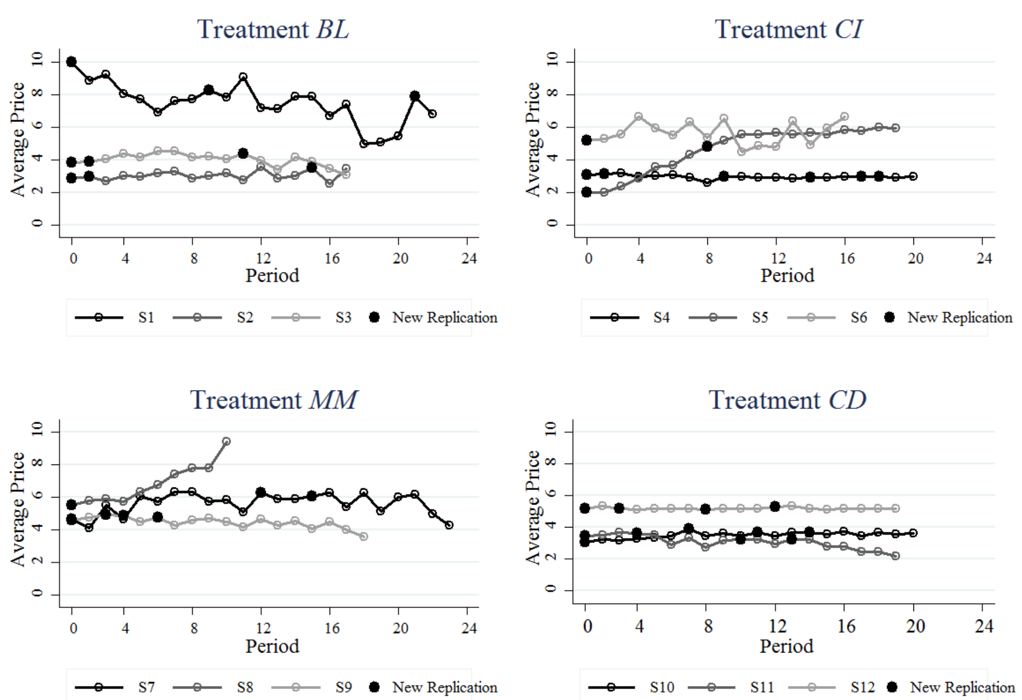

Figure 1: Time series of transaction prices of the asset by treatment; averages per period for each session. Solid dots represent the first period of a new replication.

Table 4: Period-average transaction prices across treatments.

Treatment	Mean	Standard deviation	Minimum	Maximum	No. of observations
BL	5.09	2.18	2.53	10	56
CI	4.31	1.44	1.99	6.65	55
MM	5.44	1.13	3.55	9.43	51
CD	3.91	0.95	2.19	5.34	58

Table 5: Period-average transaction prices across treatments, sub-divided by periods.

Treatment	First period	Final half	Final period	τ	p-value
BL	5.28	4.74	4.46	-0.07	0.438
CI	3.32	4.33	3.81	0.41	< 0.0001
MM	5.21	5.61	5.30	0.01	0.941
CD	4.06	3.84	3.91	-0.12	0.217

τ from test for monotonic trend.

The time series of mean transaction prices by period in each of the *BL* sessions, as well as in the three other treatments *CI*, *MM*, and *CD*, are given in Figure 1. The panels in the figure show that prices are consistently higher than the risk-neutral fundamental value of 2.5 in all treatments. Tables 4 and 5 list the period-average transaction prices across the four treatments. Table 4 provides the period average prices, their standard deviation, the minimum and the maximum prices, and the number of observations (periods) for all treatments. From Table 4 we can observe that the mean price, as well as the standard deviation, are lowest in the sessions where the asset pays a constant dividend. Table 5 gives the period average prices for the initial period, the final half of the periods, and the final period. The numbers confirm the visual impression obtained from Figure 1.

Table 5 provides further insights into the trend of the transaction prices over time in each of the four treatments. In the sessions where all traders have an induced motive to offset the income fluctuations across periods (*BL* and *CD* sessions), prices decline over time. In the other sessions, average transaction prices go up over time. The Kendall τ values and the significance levels (p-values) are reported in the last two columns of Table 5. A positive significant trend is observed for the *CI* treatment

Table 6: Per-period Mispricing Measures across treatments: first and final periods.

Treatment	$(\overline{P_t} - FV_t)/FV_t$				$MedianP_t - FV_t$			
	First pd.	Final pd.	τ*	p-value	First pd.	Final pd.	τ*	p-value
BL	1.11	0.78	-0.08	0.429	2.78	1.96	-0.08	0.429
CI	0.33	0.52	0.41	< 0.0001	0.85	1.33	0.40	< 0.0001
MM	1.08	1.12	0.005	0.967	2.76	2.88	-0.002	0.993
CD	0.62	0.57	-0.12	0.219	1.57	1.41	-0.12	0.235

*τ from test for monotonic trend.

which suggests that the extent of mispricing grows over time in the environment with traders who have no induced motive to smooth consumption in order to offset the periodic income fluctuations. The main conclusion we draw from the data with respect to transaction prices and mispricing is stated below as Result 1.

Result 1: (i) *Transaction prices are higher than the risk-neutral fundamental value in all treatments.* (ii) *The extent of the mispricing is larger in the presence of traders without induced motive to smooth consumption.*

Thus, consumption smoothing essentially acts as an instrument to dampen the mispricing of the asset. Table 6 shows the relative deviation of mean prices from the risk-neutral fundamental value for the first and final periods. It also provides the deviation of median prices from the fundamental value in each period. Thus, we use the following two per-period measures of mispricing: $(\overline{P_t} - FV_t)/FV_t$ and $MedianP_t - FV_t$, where $\overline{P_t}$ is the mean price in period t, FV_t is equal to the risk-neutral fundamental value of 2.5 and $MedianP_t$ is the median price in period t. It also gives the Kendall τ values for each measure of mispricing along with the p-values from the test for the presence of monotonic trend for each treatment. The positive values for the per-period measures of mispricing in Table 6 imply overpricing of the asset compared to the constant risk-neutral fundamental value. The magnitude of overpricing increases significantly in the absence of traders with induced motive to trade in order to smooth consumption.

Table 7 provides results from the OLS regression of the per-period measures of

Table 7: OLS regression of per-period mispricing measure on treatment dummies and market risk aversion.

Explanatory Variables	$(\overline{P_t} - FV_t)/FV_t$	$MedianP_t - FV_t$
"*CI*" Treatment Dummy	0.339***(0.092)	0.844*** (0.229)
"*MM*" Treatment Dummy	0.441*** (0.104)	1.114*** (0.258)
"*CD*" Treatment Dummy	0.030 (0.063)	0.078 (0.157)
Market's Avg. Risk Aversion	-18.96*** (1.827)	-47.43*** (4.547)
Market's Avg. Risk Aversion Squared	1.520*** (0.146)	3.805*** (0.363)
Period	0.023* (0.012)	0.061** (0.030)
Constant	59.31*** (5.698)	148.3*** (14.19)
Number of Observations	220	220
R^2	0.428	0.437

*significant at 10%, **significant at 5%, ***significant at 1%

mispricing on treatment dummies and market average risk aversion. The baseline category is the *BL* treatment. The coefficients on *CI* and *MM* dummies are significant and positive while the coefficient on *CD* dummy is insignificant. Both the *BL* and *CD* treatments are populated with traders all of whom have income fluctuations across periods. There is no significant difference in the extent of mispricing across these two treatments. Thus, after controlling for the risk aversion level in the market, the extent of mispricing is significantly higher for *CI* and *MM* sessions where Type-III and Type-IV traders are present.

4.2 Determinants of price movement between periods and price predictability

The next result compares the magnitude of price movement between periods across our treatments.

Result 2: *The magnitude of price change between periods is greater in the presence of traders without the induced motive for consumption smoothing.*

We regress the change in the period-average price ($P_t - P_{t-1}$) on treatment dummies with *BL* as the baseline treatment. We include additional regressors that we believe might affect the change in prices across periods. They are, the change in the dividend state dummy (with no change = 0, Good-to-Bad = −1, Bad-to-Good = +1) and the lagged excess demand, which is defined as ($B_{t-1} - O_{t-1}$), where B_{t-1} is the total number of offers to buy (bids) and O_{t-1} is the total number of offers to sell (asks) in period $t-1$; the period number. Column "Pooled" of Table 8 contains the estimated values of the regression coefficients obtained from pooling the data from all treatments. The other columns contain the regression results for each treatment. The estimates for *CI* and *MM* dummies in column "Pooled" are significant and positive, implying that the size of the change in the average price between periods is larger for sessions where Type-III and Type-IV traders are present.

The regression results show that prices have a significant predictable component and markets populated with traders who have induced motive to smooth consumption have higher predictability.

Result 3: (*i*) *Transaction prices co-move with the dividend state. That is, they are generally higher in good dividend periods and lower in bad dividend periods.* (*ii*) *A larger proportion of the variability of asset prices could be explained by the changes in the dividend state in the presence of traders with the induced motive to smooth consumption.*

In the periods of good dividend, the average transaction prices are 5.28 for *BL*, 4.20 for *CI* and 5.73 for *MM* markets.[16] The prices are, however, 4.86, 4.59, 5.02 for *BL*, *CI* and *MM* treatment respectively in the periods when no dividend is paid. This implies that the average transaction prices are generally higher in good state periods, with an exception in *CI* markets.[17]

[16]As there is only one state in *CD* sessions and price is fixed in *FP* treatment, we focus on the other three treatments here.

[17]This is caused partly by the presence of a purely coincidental unbalanced distribution of dividend states across periods. Recall that at the beginning of every period we draw randomly the dividend state, thus it is possible that either a streak of bad or good dividend states is drawn in earlier periods. In our *CI* markets, it happened to be the case that good dividend states

Table 8: OLS regression of change in period-average transaction price. Standard errors are in parentheses.

Explanatory Variables	Pooled	*BL*	*CI*	*MM*	*CD*
Change in State Dummy#	0.689*** (0.067)	0.784*** (0.142)	0.605*** (0.135)	0.724*** (0.084)	
"*CI*" Dummy	0.191* (0.105)				
"*MM*" Dummy	0.226** (0.103)				
"*CD*" Dummy	0.089 (0.089)				
Lagged Excess Demand	0.006*** (0.002)	0.002 (0.004)	0.010*** (0.003)	0.015*** (0.004)	-0.002 (0.002)
Period	-0.004 (0.012)	-0.007 (0.027)	0.002 (0.023)	-0.013 (0.018)	0.004 (0.017)
Constant	-0.064 (0.108)	-0.058 (0.196)	0.072 (0.124)	0.283** (0.130)	-0.066 (0.073)
Observations	182	47	46	43	46
R^2	0.465	0.498	0.431	0.612	0.017

#None=0; Good-to-Bad=-1;Bad-to-Good=+1; *significant at 10%, **significant at 5%, ***significant at 1%

Table 9: OLS regression of change in period-average transaction price on change in state dummy. Standard errors are in parentheses.

Explanatory Variables	*BL*	*CI*	*MM*
Change in State Dummy#	0.755***	0.525***	0.620***
	(0.113)	(0.134)	(0.088)
Constant	-0.108	0.118	0.089
	(0.072)	(0.071)	(0.076)
Number of Observations	47	46	43
R^2	0.496	0.359	0.480

#None=0; Good-to-Bad=-1;Bad-to-Good=+1; ***significant at 1%

Table 9 presents the OLS regression of the change in the period-average transaction price on the dummy variable of the change in the dividend state. The effect of a change in the dividend state is substantial and significant ($p < 0.001$) in each treatment. The magnitude of the effect is higher in sessions with the presence of Type-I and Type-II traders (0.755 in *BL* and 0.62 in *MM*) than in sessions where these traders are absent (0.525 in *CI*). Changes in the dividend state explain roughly 50% of the variability of the asset prices in markets where traders of Type-I and Type-II are present ($R^2 = 0.496$ in *BL* and $R^2 = 0.48$ in *MM*). On the other hand, only roughly 36% of the variability of asset prices is explained by changes in the dividend state when the market is populated by traders of Type-III and Type-IV only.

In order to further understand the effect of dividend states on transaction prices, we classify the differences in the dividend state in period t relative to that in period $t-1$ into the following categories: (1) Good-to-Bad, (2) Bad-to-Good, (3) Good-to-Good, and (4) Bad-to-Bad. We then evaluate the change in the period-average price under these four categories. As is evident from Table 10, when the state changes from Good-to-Bad, prices go down significantly in each treatment. The p-values from a Wilcoxon-signed rank test are 0.002, 0.084 and 0.001 for *BL*, *CI* and *MM* treatments, respectively. Similarly, state changes from Bad-to-Good are accompanied by significant price increases (with p-values < 0.01 in all of the three

were mostly realized in the early periods when the average transaction price was at a reasonably moderate level and bad dividend states were mostly realized in the final periods when the average transaction price was relatively high.

Table 10: Change in average transaction prices, sub-divided by change in the dividend states.

Treatment	Change in Dividend State	Mean	Standard Deviation	p-value	No. of obs.
BL	Good-to-Bad	-0.89	0.70	0.002	12
	Bad-to-Bad	-0.23	0.45	0.116	13
	Good-to-Good	0.06	0.52	0.552	13
	Bad-to-Good	0.61	0.26	0.008	9
CI	Good-to-Bad	-0.41	0.75	0.084	12
	Bad-to-Bad	-0.11	0.36	0.465	4
	Good-to-Good	0.16	0.29	0.008	20
	Bad-to-Good	0.64	0.52	0.007	10
MM	Good-to-Bad	-0.49	0.35	0.001	14
	Bad-to-Bad	-0.39	0.33	0.043	7
	Good-to-Good	0.26	0.51	0.046	13
	Bad-to-Good	0.77	0.48	0.008	9

treatments). Comparing the magnitude of price changes across Good-to-Bad and Bad-to-Good states, we find an asymmetric reaction. Prices fall more than they rise in markets where all traders have the induced motive to offset the income fluctuations between periods (-0.89 vs. 0.61). In markets where traders having no income fluctuations are present, the opposite is true (-0.41 vs. 0.64 for *CI* and -0.49 vs. 0.77 for *MM*).

Prices do show a negative (positive) drift when the states in consecutive periods are Bad (Good). While this drift is insignificant in our *BL* sessions (p-values> 0.1), the upward movement in prices is significant in the *CI* treatment when the successive periods experience good dividends. Both, the downward trend when the consecutive periods experience bad dividends and the upward trend when the consecutive periods experience good dividends, are significant in the *MM* treatment (p-values< 0.05). The significant momentum in prices despite the state persistence in the *CI* and *MM* sessions imply that, in addition to the change in the dividend state, there are other forces at play that drive price to change between periods.

As shown previously in Table 8, the coefficient estimates for the "lagged excess demand" variable in *CI* and *MM* treatments are positively significant, albeit rather small in magnitude. This means that a market in which bids (asks) substantially exceed the asks (bids) tends to display increasing (decreasing) prices. This pattern has been documented in several earlier studies that investigate bubbles and crashes in experimental markets (Smith et al. (1988), Lei et al. (2001)). What makes our finding interesting is that we only observe this pattern in *CI* and *MM* treatments. These are sessions where Type-III and Type-IV traders, who do not have any income fluctuations across periods, are present. Thus, the excess demand in period $t-1$ happens to be a significant predictor of the price changes in period t only when the market is populated with at least some traders having no induced motive to trade. In contrast, when all traders have an induced motive to smooth consumption as a result of income fluctuations across periods (as in treatments *BL* and *CD*), the lagged excess demand ceases to affect price changes significantly. Tables 8 and 9 together present a coherent effect of the "lagged excess demand" variable in explaining the change in period-average transaction prices. The addition of this variable as a regressor considerably increases the R^2 in *CI* and *MM* treatments (0.359 to 0.431 and 0.48 to 0.612, respectively). However, the R^2 remains unchanged in the *BL* treatment.

4.3 Trading activity

Given the presence of traders who have induced motive to trade in each period in order to neutralize the income shocks they experience, we would expect trading volumes to be relatively high in treatments *BL*, *MM*, *CD* and *FP*. This is because in these treatments, traders with strong desire to trade in order to smooth consumption across periods are present. Obviously, consumption smoothing is not the only thing that motivates traders to trade. The pursuit of capital gains through speculative trading is also another important motive. This implies that even in the absence of induced motive to smooth consumption in order to neutralize the income shock (e.g. in our *CI* sessions), trading volumes could still be high. This is something that can also be found in the standard setting of Smith et al. (1988) where the income-shock induced motive to smooth consumption is absent. Result 4 below summarizes the observations of the trading activities.

Table 11: Trading volume across treatments.

Periods	*BL*	*CI*	*MM*	*CD*	*FP*
1 and 2					
Mean	25.7	37.3	29.9	35.7	97.8
St. Dev.	8.3	10.2	12.8	6.2	23.5
Min.	11	17	9	23	54
Max.	46	65	56	51	134
≥3					
Mean	22.4	24.4	20.4	32.6	90.4
St. Dev.	9.0	8.7	9.3	6.6	26.8
Min.	8	11	7	18	29
Max.	42	41	47	49	163

Result 4: *There are substantial trades in each period and across treatments. Compared to the baseline, more trades take place in treatments without dividend uncertainty or with fixed prices. Trading activity is higher when the dividend state is good than when it is bad.*

The average trading volume, measured as the number of securities bought and sold, per period for each treatment is listed in Table 11. In all treatments, there is substantially large trading and the volume is visibly higher for periods 1 and 2 (initial periods). Since the average supply is 200 assets, this means $10\% - 15\%$ of available securities are traded in each period. In the *CD* treatment, trading volume is higher than in the other treatments *BL*, *CI* and *MM*. We also find evidence that having a constant dividend results in a lower variance of trading activity in the market.

Table 11, however, does not present the correct numbers for purposes of comparison of trading activity across treatments for two reasons. First, the absolute levels of prices are different across treatments and hence, this might influence the total number of transactions each period. Second, in the *FP* treatment, participants could buy from or sell to the experimenter at a fixed price. Thus, the numbers for *FP* sessions in Table 11 should be divided by half before any comparison with other treatments is made.[18] We compute the dollar value of transactions per trader in

[18]It should also be noted that the liquidity uncertainty was absent in the *FP* treatment.

Table 12: Value of transactions per trader: average across periods. Data for all periods as well as for periods following the dividend state (bad or good) is presented (standard deviation are in parentheses).

Treatment	All periods	Bad state	Good state
BL	6.83 (2.74)	4.93 (1.65)	8.36 (2.49)
CI	6.92 (2.17)	5.54 (1.62)	7.49 (2.13)
MM	8.02 (4.13)	4.66 (1.63)	10.37 (3.71)
CD	8.29 (2.52)	-	-
FP	7.25 (2.02)	7.07 (2.25)	7.44 (1.78)

each period that takes into account the above two factors.[19] This could be interpreted as the amount of cash that is exchanged per trader every period. Table 12 gives the average value of transactions per trader in each of the treatments. Compared to baseline sessions, where both price uncertainty and dividend uncertainty are present, the value of transactions is higher in sessions without dividend uncertainty or price uncertainty. However, the difference is significant only for *CD* treatment (MW p-value=0.002) but not for *FP* treatment (MW p-value=0.116).

As Table 12 shows, trading activity is higher in periods with the asset paying a dividend of 1 ECU than in periods when the asset pays nothing as dividend. This is expected because in *Good* times traders have more cash and they engage in dealings where a larger amount of cash exchange hands. While the activity is significantly greater in sessions *BL*, *CI* and *CD* (with MW p-values < 0.001), the difference is insignificant for the sessions with no price uncertainty and no liquidity uncertainty (MW p-value=0.539).

4.4 Consumption smoothing, speculative transactions and trader strategies

Figure 2 plots the evolution of the average consumption for each type of trader. The vertical axis measures the average cash (ECU) held at the end of each period averaged across all sessions in the same treatment with concatenated replications

[19] In order to facilitate comparison with other treatments, we assign 1/2 weight to the purchase/sale of an unit of the asset in *FP* sessions.

within a session. The horizontal axis is the period. Solid lines denote average consumption in data and the dotted lines capture the average consumption under autarky (no trade).[20] Compared to the fluctuations in consumption over time under autarky, the fluctuations in consumption are far less for Types-I and II. This shows evidence of consumption smoothing over odd and even periods in an attempt to offset the income fluctuations experienced by these traders. Types-III and IV traders have constant income and thus have no fluctuation in wealth due to income shocks.

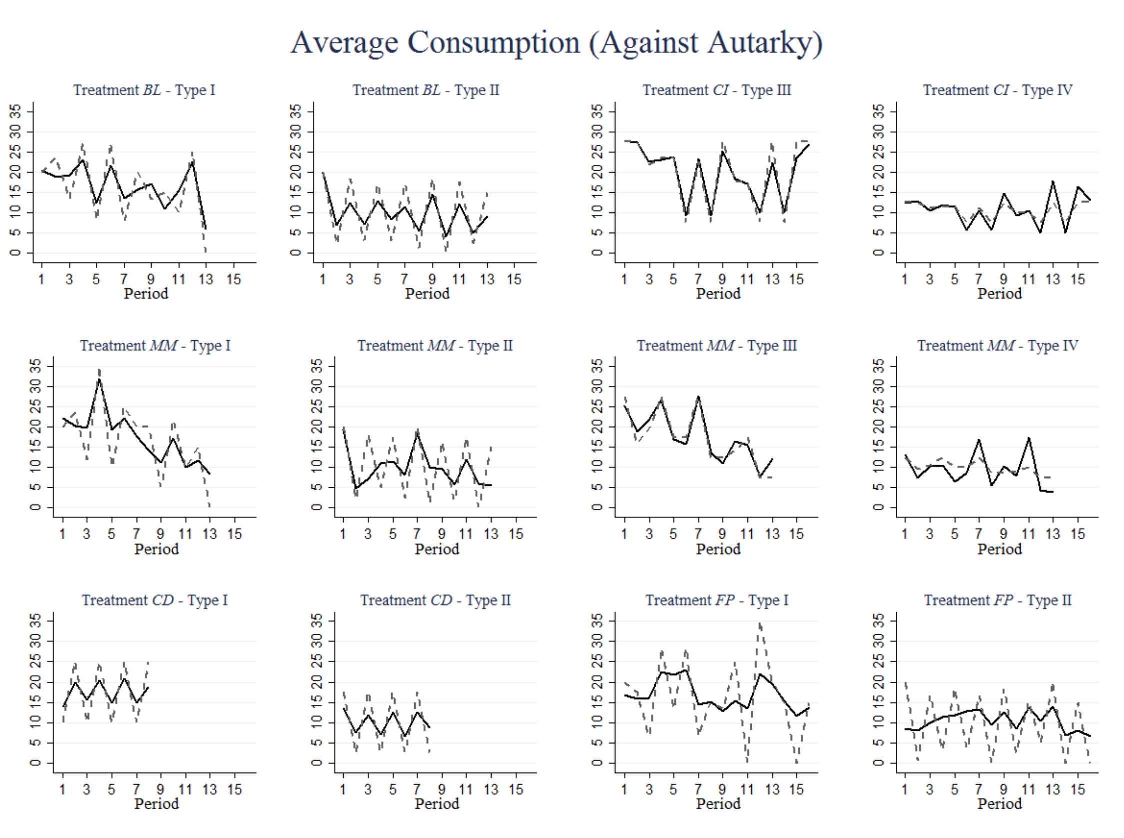

Figure 2: Average consumption for each type of trader in the five treatments. Solid lines denote average consumption in the data and dotted lines denote average consumption under autarky.

The visual impression obtained from Figure 2 is corroborated by Table 13 which

[20]The autarky values for consumption of different types of agents depends on states, except in *CD* sessions. We use the sequence of realized states across all sessions to compute their autarky consumption.

Table 13: Average consumption across dividend states and across even/odd periods. Autarky numbers are in parentheses.

Treatment	Trader Type	Dividend State		Period	
		Bad	Good	Even	Odd
BL	Type I	9.52 (8.40)	24.57 (25.32)	19.36 (23.80)	16.63 (12.90)
	Type II	5.48 (6.60)	15.43 (14.68)	6.64 (2.20)	14.50 (18.23)
CI	Type III	9.71 (7.50)	26.90 (27.50)	18.97 (18.33)	24.17 (24.27)
	Type IV	5.29 (7.50)	13.10 (12.50)	9.57 (10.21)	11.80 (11.69)
MM	Type I	9.49 (8.57)	25.98 (25.50)	20.85 (24.57)	17.82 (13.57)
	Type II	5.59 (6.43)	14.50 (14.50)	7.60 (2.39)	13.49 (18.39)
	Type III	9.72 (7.50)	26.19 (27.50)	17.92 (17.07)	20.62 (21.07)
	Type IV	5.14 (7.50)	13.47 (12.50)	7.83 (9.89)	11.85 (10.89)
CD	Type I	-	-	20.17 (25.00)	14.81 (10.00)
	Type II	-	-	7.33 (2.50)	12.69 (17.50)
FP	Type I	14.66 (9.23)	19.78 (25.19)	18.36 (22.20)	16.17 (12.59)
	Type II	8.97 (5.77)	11.19 (14.81)	9.59 (1.80)	10.53 (18.15)

provides the detailed entries of the average consumption across dividend states and across even/odd periods along with their autarky counterparts. After trade, the difference in consumption between odd and even periods is considerably lesser than the corresponding difference under autarky for Type-I and II traders. This pattern is however, not observed for Type-III and IV agents, with Type-IV agents showing signs of larger fluctuations in consumption after trade than under autarky. These observations are consistent across treatments. The main finding with respect to consumption smoothing conduct is summarized in the next result.

Result 5: *Traders with income fluctuations in alternating periods smooth con-*

Table 14: Difference in within-replication consumption between odd and even period.

Treatment	Type of Trader	Trade	Autarky	Signed-rank p-value	No. of obs.
BL	Type I	-2.07	-10.53	0.018	7
	Type II	7.65	16.12	0.018	7
CI	Type III	2.97	3.45	0.612	7
	Type IV	1.35	0.86	0.612	7
MM	Type I	-1.99	-9.39	0.018	7
	Type II	8.86	16.4	0.043	7
	Type III	1.98	5.61	0.176	7
	Type IV	4.87	1.4	0.028	7
CD	Type I	-5.52	-15	0.002	12
	Type II	5.52	15	0.002	12
FP	Type I	-1.66	-6.06	0.093	8
	Type II	0.27	17.23	0.012	8

sumption over time.

Table 14 provides the magnitude of the difference in consumption between even and odd periods as well as the difference between these even and odd periods and their respective autarky consumption, with each replication being a unit of observation.[21] Regardless of the characteristic of the asset market, for Type-I and Type-II agents, the (absolute) differences in consumption across even/odd periods after trading are statistically smaller than the differences in consumption across periods under autarky. For these traders, the p-values from Wilcoxon rank-sum test are < 0.05 in *BL* and *MM* sessions and < 0.01 in *CD* sessions. In contrast, these numbers are not statistically different for traders with constant income (with p-values > 0.1). For Type-IV traders, the difference in consumption across periods is in fact significantly higher than the difference in consumption under autarky for *MM* treatment (p-value < 0.05).

Further evidence is obtained from Table 15 which presents, for each type of agent, the values for net changes in assets per trader across the change in dividend states and across even and odd periods. As is evident from the table, Type-I traders

[21] To compute these differences, we ignore replications which last only for one period.

Table 15: Net change in assets, across change in states and across even and odd periods.

Treatment	Trader Type	Change in State		Period	
		Good-to-Bad	Bad-to-Good	Even	Odd
BL	Type I	0.17	0.04	0.86	-1.03
	Type II	-0.17	-0.04	-0.86	1.03
CI	Type III	-0.56	0.10	-0.21	-0.07
	Type IV	0.56	-0.10	0.21	0.07
MM	Type I	0.02	-0.17	0.53	-1.13
	Type II	-0.18	0.73	-0.80	1.32
	Type III	-0.46	-0.28	-0.18	-0.18
	Type IV	0.64	-0.31	0.43	0.04
CD	Type I	-	-	1.03	-1.53
	Type II	-	-	-1.03	1.53
FP	Type I	-1.97	1.81	1.15	-2.49
	Type II	-2.23	1.28	-3.08	2.78

are net buyers (sellers) of assets in even (odd) periods. That is, on average, they purchase assets when the income shock is positive and sell assets in periods when there is no income. Type-II agents have the opposite pattern. They are net buyers (sellers) of assets in odd (even) periods. For these traders, the entries also show that the magnitude of the net change in assets per trader is higher in treatments without dividend uncertainty and without price uncertainty. Type-III agents who do not experience income fluctuations between periods and are *asset-rich* are net sellers of assets in even as well as odd periods. On the other hand, Type-IV agents who also have constant income, but are asset-poor accumulate securities over time. Thus, they are predominantly net purchasers of assets.

Next, we turn our focus on the behavior of different types of traders in mixed markets which are more representative of markets outside the laboratory than any of the other treatments. In *MM* sessions, all four types of traders are present which allows us to rank these different types of traders in terms of their activity in the marketplace. We also find evidence of one type of trader being able to exploit the price predictability as reported earlier. The next result characterizes behavior of traders in the mixed markets.

Result 6: *In markets where all types of traders are present, the asset-poor traders with income fluctuations are the most active, followed by the asset-rich traders with income fluctuations. Asset-rich traders with constant income are the least active. Asset-poor traders with constant income capitalizes on the predictability of prices by buying when prices are lower (as state changes from Good-to-Bad) and selling when prices are higher (as state changes from Bad-to-Good).*

Focusing on the *MM* sessions, Table 15 shows that the absolute value of the net change in assets in even and odd periods taken altogether is highest for Type-II traders, followed by Type-I traders (2.12 vs. 1.66, respectively). The value is 0.36 for Type-III traders, thereby making them the least active of all agents. This is expected because these traders have no income fluctuation and hence there is no induced motive to trade in order to offset the variability in income. Also, these traders are *asset-rich* with relatively high number of assets as endowment. Thus, Type-III traders are most comfortably placed compared to other agents and hence have the least incentive to trade. While Type-I and Type-II agents engage in consumption smoothing across even/odd periods, Type-III traders are net sellers of assets over time.

Most striking observation is with respect to behavior exhibited by Type-IV traders. As is evident from Table 15, these traders are net buyer (seller) of assets when the state changes from Good-to-Bad (Bad-to-Good). We already know (from Result 3) that prices have a significant predictable component. It seems that Type-IV agents are able to make use of this predictability and systematically exploit it. This strategy is a potential explanation for the observed behavior of higher variability in consumption with trade than without. For traders of type-IV, income fluctuations come mainly from the changes in the dividend distribution. Instead of buying (selling) assets when they experience high (low) income due to change in states from Bad-to-Good (Good-to-Bad), agents IV sell (buy) their assets, thus resulting in exacerbation of the income gap between high and low income periods.

It might be true that Types-I and II are aware of the price predictability but are unable to capitalize on it as they are constrained to use the asset market for the sole purpose of consumption smoothing (the primary motivation for engaging in a trade for agents with income shocks). These traders (Types-I and II), being aware that there would be low income in the next period, would attempt to transfer wealth to the period of scarcity. As cash is perishable, the only way to transfer wealth to the next period is by increasing the inventory of the long-lived asset. Thus, agents might be willing to accept a lower rate of return in order to smooth consumption.

A vast majority of the naturally occurring markets are likely to have both types of traders: those who use the asset market to offset their income variability and those who are in the marketplace for capital gains by engaging in speculative trades. The above discussion implies that even though prices have a significant predictable component and that the predictability of price is vulnerable for exploitation by the speculative traders, the presence of agents who are in the marketplace only to smooth their intertemporal consumption ensures that the predictability does not wither away.

So far, we have discussed consumption smoothing in the context of offsetting income variation between periods. However, there could be another dimension along which agents might attempt to equalize consumption. Individuals might want to balance consumption in Good and Bad dividend states. While this would require quite a sophisticated strategy to be used by agents, the next result argues that this was indeed the case in the *FP* sessions. Taking away the price and liquidity uncertainty, thereby making the environment merely dependent on that of an individual decision making task facilitates the formation of a smooth stream of consumption.

Result 7: *In the absence of price uncertainty and liquidity uncertainty, traders' choices reveal preference for consumption smoothing over time and across dividend states.*

Table 13 numbers for the *FP* treatment lend support to the current result. Consumption smoothing across odd/even periods is very close to being perfect. For Type-I traders, the difference in average consumption across periods is only 2.19 as opposed to 9.61 under autarky. For Type-II traders, this difference is even smaller (0.94 in contrast to 16.35 under autarky). The difference in consumption between odd and even periods under trading and autarky within a replication are statistically significant for both types of traders (p-values from Wilcoxon rank-sum test are < 0.1 for Type-I agents and < 0.05 for Type-II agents; see Table 14).

In addition to consumption smoothing over time across even and odd periods, Table 13 also presents evidence for consumption smoothing across Good and Bad states. The gap in average consumption across dividend states is only 5.12 as opposed to 15.96 under autarky for Type-I traders while the difference is only 2.22 in contrast to 9.04 under autarky for Type-II traders. This provides strong empirical evidence that individuals show preference for a smooth stream of consumption, not only to offset the income variability between periods but also to offset the wealth swings due to (exogenous) realization of the dividend state. In other treatments, the inability of traders to smooth consumption across the dividend states is possibly due to the limitation imposed by the asset market, including the fact that prices are not fixed and hence must be forecasted by agents. In the *FP* sessions, individuals do not face any uncertainty with respect to prices or trading which makes it easier for them to smooth consumption. It should be noted, however, that the total number of assets in the economy is not constant in the *FP* treatment unlike that in the other treatments. Hence there are several contributing factors to the additional dimension of consumption smoothing behavior observed in *FP* against all other treatments.

The value for the change in net assets further corroborates the above result. On average, traders buy assets when they experience positive income shock in even periods for Type-I and odd periods for Type-II, as well as when the state changes from Bad-to-Good. Similarly, agents sell assets when they experience no income shock and also when the state changes from Good-to-Bad.

Next, we seek to identify the main aspects affecting the consumption smoothing behavior of traders. First, we define a consumption smoothing strategy. Specifically, trading of individual i in period t exhibits a consumption smoothing strategy (i.e. γ_t^i equal to 1) if $c_t^i < (>)\, y_t^i + d_t a_{t-1}^i$ when $y_t^i + d_t a_{t-1}^i > (<)\, y_{t-1}^i + d_{t-1} a_{t-2}^i$, where c_t^i is the final cash (consumption) at the end of period t, y_t^i is the exogenous income given to individual i at the start of period t, d_t is the dividend paid per unit of the asset at the start of period t, and a_{t-1}^i denotes the number of assets held at the start of period t. In other words, an agent reduces consumption fluctuations if he buys (sells) assets when his wealth increases (decreases) in period t. We define $\delta^i = \frac{1}{T}\sum_{t=1}^{T} \gamma_t^i$ as the proportion of individual per-period actions that are consistent

Table 16: OLS regression of δ_i.

Explanatory Variables	Coeff. Estimate	Std. Err.
Constant Income	-0.082*	0.043
Low Initial Asset	0.125***	0.026
Constant Income × Low Initial Asset	-0.331***	0.054
Mixed Market	-0.033	0.035
Constant Dividend	0.05	0.035
Fixed Price	0.066**	0.031
Risk	-0.001	0.006
Gender	0.004	0.024
Constant	0.601***	0.044
Observations	238	
R^2	0.44	

*significant at 10%, **significant at 5%, ***significant at 1%

with the consumption smoothing behavior. Thus, δ^i gives the extent of individual consumption smoothing.

Our final result summarizes the factors that provide an impetus to the activity of consumption smoothing. To support the result, we estimate an OLS model with δ^i as the dependent variable. There are several indicator variables as independent variables, namely; 'constant income', that takes a value of 1 if there is no induced income fluctuation between periods and 0 otherwise, 'low initial asset', that takes a value of 1 if asset-poor and 0 otherwise, an interaction between 'constant income' and 'low initial asset', 'mixed market', that takes a value of 1 for MM session and 0 otherwise, 'constant dividend', that takes a value of 1 for CD session and 0 otherwise, and 'fixed price', that takes a value of 1 for FP session and 0 otherwise.[22] Table 16 presents the coefficient estimates from the regression, based on which we make the following observation.

Result 8: *The percentage of transactions consistent with consumption smoothing behavior is higher when traders have fluctuating income process and relatively lower initial assets. This percentage is also larger when prices are fixed as opposed to endogenously determined prices.*

[22] In addition, a constant and two other variables: 'risk' (values from the risk elicitation task are used on a scale of 1-11 with 1 as highly risk-loving and 11 if highly risk-averse) and 'gender' (1 if male and 0 otherwise) are included as well.

As is evident from Table 16, the coefficient on 'constant income' is negative and significant (at 10% level). Thus, the absence of income fluctuations between periods has a negative effect on δ^i. The positively significant coefficient (p-value < 0.01) on 'low initial asset' imply that if traders are *asset-poor* as opposed to *asset-rich* then a higher fraction of transactions could be classified as being consistent with consumption smoothing activity. However, it should be noted that *asset-poor* traders include both Types-II and IV traders and hence not much could be interpreted from this coefficient.

The primary validation for the result comes from the coefficient on the interaction between 'constant income' and 'low initial asset' which is highly significant (p-value < 0.01) and negative. The marginal effect of having no income fluctuation is -0.41 (-0.08) if the trader is *asset-poor* (*asset-rich*). This implies that the effect of income fluctuations between periods on consumption smoothing is enormous when the trader is *asset-poor* (Type-II versus Type-IV). This effect is however, mild (but significant) when only *asset-rich* traders are considered (Type-I vs. III). Also, the marginal effect of lower initial asset endowment is $+0.13$ when traders have income fluctuations and -0.20 when traders have constant income each period. Thus, being *asset-poor* affects consumption smoothing positively for traders having income fluctuations: more transactions are consistent with consumption smoothing behavior for Type-II agents than Type-I individuals. On the other hand, being endowed with lower initial assets has a negative effect on minimizing consumption variability for traders having constant income: less transactions are consistent with consumption smoothing behavior for Type-IV agents than Type-III traders.

Thus, from the above discussion we conclude that the relative ranking of the various types of traders in terms of the extent of consumption smoothing, as measured by δ^i, is as follows: Type-II>Type-I>Type-III>Type-IV. Finally, a positive and significant coefficient on 'fixed price' suggests that removing price uncertainty has a favorable effect on consumption smoothing.[23]

[23] Further support is obtained from a separate regression with δ^i as the dependent variable, *BL* as the default treatment and indicator variables for other treatments.

5 Conclusion

We implemented an indefinite horizon economy in the laboratory with a single perishable consumption good in each period. The incentive to smooth consumption over time was provided to some individuals by subjecting them to income shocks. Agents could use the asset market in order to offset income fluctuations or engage in speculative trading. Thus, the setting was reminiscent of the consumption-based asset pricing models that are widely popular in macroeconomics/finance. Within this controlled environment, we studied the effect of the composition of asset market in terms of the proportion of traders with induced motive to smooth consumption on asset price dynamics and consumption smoothing behavior. We also investigated the implications of dividend uncertainty and price uncertainty in this setting. We believe that our research would complement the analysis of asset pricing that uses field data. Our findings are summarized below.

We observe that the transaction prices are higher compared to the (constant) risk-neutral fundamental value in all our treatments. The extent of mispricing is severe and the magnitude of the price change between periods is greater in the presence of traders without induced motive to smooth consumption. Prices co-move with the dividend state, thereby showing that prices have a significant predictable component. As the dividend process is perfectly observable in experiments, we are able to measure the exact proportion of the variability of asset prices explained by changes in the dividend state. While there is price predictability in all our treatments, it is higher in the presence of traders with induced motive to smooth consumption. In sessions where traders with constant income are present, prices are also affected by the lagged excess demand: a market thick (thin) with bids relative to asks tends to display increasing (decreasing) prices.

We find that there is substantial trade in our experiment. This is true even for the sessions where only traders with constant income are present. So, even without the presence of traders who have induced motive to trade, agents engage in asset exchanges. A higher amount of activity takes place when the dividend state is Good than when it is Bad, driven partly by the fact that prices are higher in periods with Good states than without. We also find strong evidence for consumption smoothing behavior for those who have induced motive to do so.

It is observed that prices are comparatively "well-behaved" in the setting where the asset market is complete than under incomplete markets. A potential reason could be that under incomplete asset market settings, there are multiple rational expectations equilibria which creates such pricing patterns. However, trading activity indicates that the main reason is "imperfect foresight". While trading should be the same, in principle, with dividend uncertainty and without, it is substantially higher in the latter case. Consumption smoothing "works" much better under constant dividend setting than with dividend uncertainty: with constant dividend, prices are less variable which aids individuals in planning ahead.

In markets where various types of traders are involved, individuals having income fluctuations over time are the ones who are most active. Agents having a constant income each period and relatively higher initial units of the security participate the least. Unconstrained by the requirement to smooth consumption in the wake of income fluctuations between periods, traders with constant income over time and relatively lower initial endowment of assets are able to exploit the predictability of prices by buying low and selling high where the high and low prices are governed by the change in underlying dividend process.

When prices are fixed and in the absence of liquidity uncertainty, individuals show preference for consumption smoothing not only over time but across dividend states as well. Eliminating uncertainties with regards to trading thus has a positive effect on overall consumption smoothing behavior of agents experiencing income fluctuations.

There are several avenues to pursue in future research. First, developing a theoretical model that considers the co-existence of different types of traders (with and without the induced motive to smooth consumption) is a potentially fruitful endeavor. Within this setting, generating predictions on asset price dynamics as a function of the proportion of traders with induced motive to smooth consumption would be insightful. Second, future experiments could inform us about the implications of introducing income growth in our setting, thereby creating the possibility of "rational" bubbles. Third, all of the experimental studies (including ours) that investigate markets populated with traders with induced motive to smooth consumption in order to offset income fluctuations consider long-lived bonds. It would be interesting to implement infinite-horizon economies in the laboratory with finite-maturity bonds within the framework of a dynamic general equilibrium asset-pricing model.[24]

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A Experimental Instructions (***For Online Publication***)

GENERAL INFORMATION

Dear participant, welcome to our experiment. **Please pay attention to the information provided here and make your decisions carefully. If at any time you have questions, please raise your hand and we will attend to you in private.**

Please note that unauthorized communication is prohibited. Failure to adhere to this rule would force us to stop the simulation and you may be held liable for the cost incurred in this simulation. You have the right to withdraw from the study at any point in time, and if you decide to do so your payments earned will be forfeited.

By participating in this study, you will be able to earn a considerable amount of money. The amount depends on the decisions you make.

At the end of this session, this money will be paid to you privately and in cash. It would be contained in an envelope (indicated with your unique user ID) together with a payment receipt acknowledging that you have been given the correct payment amount.

Each of you will be given a unique user ID and your **anonymity will be preserved** for the study. You will only be identified by your user ID in our data collection. All information collected will **strictly be kept confidential** for the sole purpose of this study.

TRADING STAGE

In this experiment, we are going to create an auction market in which you will trade units of a fictitious asset (hereinafter referred to as 'securities') that earn dividend for every period. **Please note that all securities are identical**.

The currency used in this market is called ECU (Experimental Currency Unit), which will be converted to Singapore dollars for your payment at the end of this stage with the following exchange rate:

You final capital	Reward
First 30 ECU and below	1 ECU=1.00 SGD
Above 30 ECU	1 ECU=0.30 SGD

To better understand the instruction below, please refer to Appendix A-1 and A-2 given to you.

1. Duration of the experiment

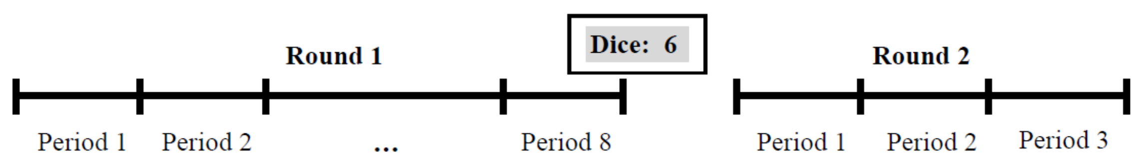
This experimental **session** consists of a number of replications of the same situation, referred to as trading ***rounds***. One ***round*** consists of a number of ***periods***. Each period lasts for 120 seconds.

The total number of rounds is **not known** beforehand. Instead, we determine whether the current round continues in the following manner. We will draw **a random number using a dice**. **If the number drawn is 1-5, we then proceed to the next period within the current round. If the number drawn is 6, the current round will terminate and the first period of a new round will start**.

Notice that the termination chance is time-invariant; it does not depend on how long the experiment has been going.

Prior to the real trading game, there will be a trial round consisting of 3 trading periods for you to practice.

Below is the illustration of the relationship between trading rounds and periods:



2. Dividend and Fundamental Value of the Securities

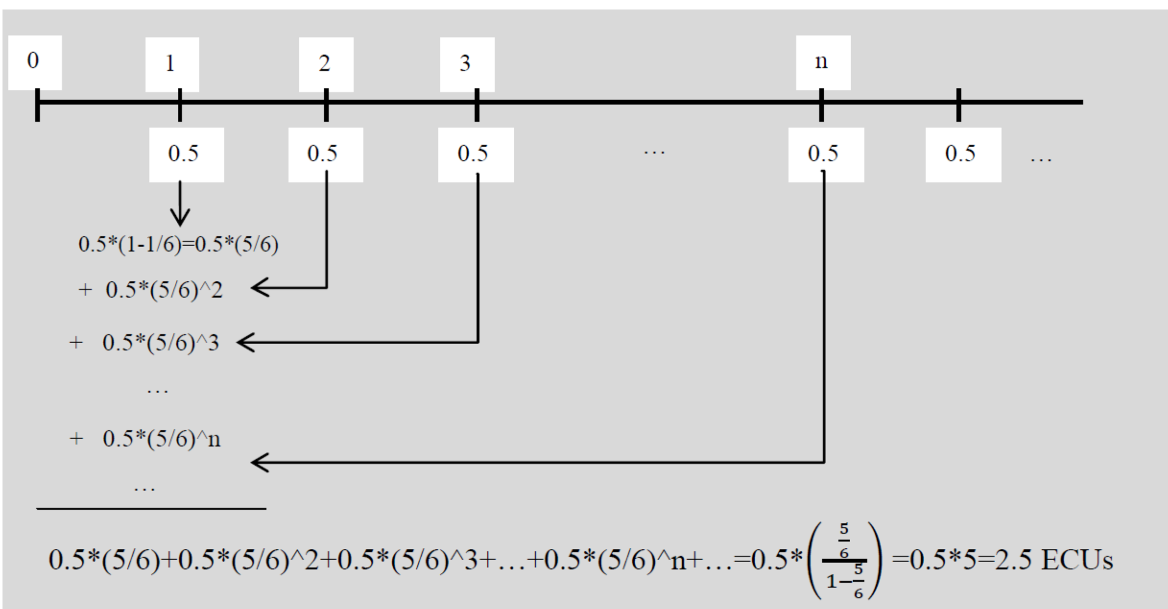
[*The following paragraph in all treatments except the 'Constant Dividend' treatment*] At the beginning of a period, each security in your inventory will be awarded dividend. The dividend income is added to your cash inventories immediately before trading starts. There are two possible dividend values per security: 0 or 1 ECU with equal probability of being drawn. Past dividends have no influence on this chance.

In each period the value of dividend is drawn by the computer randomly and will only be announced at the beginning of that period. The dividend is the same for each security and for each participant. The expected value of the dividend drawn in every period is

$$E(Dividend) = (0 \times 0.5) + (1 \times 0.5) = 0.5 \quad ECU$$

[*The following paragraph only in the 'Constant Dividend' treatment*] At the beginning of a period, each security in your inventory will be awarded dividend, and dividend income is added to your cash inventories immediately before trading starts. The dividends are always 0.5 ECUs. The dividend is the same for each security and for each participant.

Since there is a 1/6 chance that the round ends in the period when a security is bought and the maturity of the security is indefinite, the fundamental value of the security can be calculated as follows:



Hence, the **fundamental value** of a security is 2.5 ECUs.

3. Market Description

There are 16 traders in the market. At the start of each ***round***, you will be allocated ***securities*** which you can ***trade*** in the market.

[*The following sentences only for traders of type I and type III*] You will start this round with **20** securities. Other traders may start with different initial allocations.

[*The following sentences only for traders of type II and type IV*] You will start this round with **5** securities. Other traders may start with different initial allocations.

There will be two sources of fresh cash injection in each period. <u>**First**</u>, the securities you hold at the end of the previous period may pay **dividends** at the beginning of the next period. These dividends will be your source of cash in the next period. An exception would be for the **first period of every round**, where the dividend will always be 1 ECU. In subsequent periods, dividend value will be randomly determined.

<u>**Second**</u>, at the beginning of a period, you may be given **income**.

[*The following paragraph only for traders of type I*] You will receive income in every alternate period. In **odd periods** $(1^{st}, 3^{rd}, ...)$ you will receive **nothing**. In **even periods** $(2^{nd}, 4^{th}, ...)$ you will receive **15 ECUs**. This income is added to your cash inventory at the beginning of **every new period**. It will be made known beforehand in which periods you will receive income. Others may have a different income flow.

[*The following paragraph only for traders of type II*] You will receive income in every alternate period. In **odd periods** $(1^{st}, 3^{rd}, ...)$ you will receive **15 ECUs**. In **even periods** $(2^{nd}, 4^{th}, ...)$ you will receive **nothing**. This income is added to your cash inventory at the beginning of **every new period**. It will be made known beforehand in which periods you will receive income. Others may have a different income flow.

[*The following paragraph only for traders of type III and type IV*] You will receive **7.5 ECUs** as income in every period. This income is added to your cash inventory at the beginning of **every new period**. It will be made known beforehand in which periods you will receive income. Others may have a different income flow.

All in all, your total cash at the end of each period will be the sum of the dividend payment you receive from your securities, the income you receive for that period and the profit from trading. ***It is important to note that your cash in one period will expire and will not be carried forward to the next period; while your securities will always be carried over to the next period. However, securities expire at the end of each round and will not be carried forward to the next round***.

Note that **within a round**, you will therefore only receive securities endowment **once** at the start of the round. However, you will likely receive income **more than once** depending on the number of **periods** in that round.

4. Rules of the Experimental Market (Please refer to schematic diagram in Appendix A-3)

[*The following information in all treatments except FP*]

Trade is conducted in the form of a double auction market. During the trading period, you may **buy** or **sell** securities or you may do nothing. The trading is anonymous.

Basic concept of Bid and Ask:

The Bid price: represents the price that a buyer is willing to pay for a security.

The Ask price: represents the price that a seller is willing to receive for a security.

A trade or transaction occurs when the buyer and seller agree on (accept a Bid/accept an Ask) a price for the security.

Example:

*Submit a Bid at **x1** ECU*: means you are willing to buy a security at **x1** ECU.

*Submit an Ask at **y1** ECU*: means you are willing to sell a security at **y1** ECU.

*Accept a Bid at **x4** ECU*: means you agree to sell a security in exchange for **x4** ECU.

*Accept an Ask at **y5** ECU*: means you agree to pay **y5** ECU for a security.

Two ways to Buy:

- Submit a Bid: Input a price that you are willing to pay for one security as a bid (*Box E*) and click *'Submit Bid'*. The bidding price has to **be higher than or equal to** the highest current bid. Your bids will only be successful (you successfully buy a security) when another participant accepts your bid.

OR

- Accept an existing Ask: Select offer with the **lowest price** from the Ask List (*Box A*) and click on the *'Buy'* button at the bottom.

Two ways to Sell:

- Submit an Ask: Input a price at which you are willing to sell one security as an Ask (*Box B*) and click *'Submit Ask'*. The asking price has **to be lower than or equal to** the lowest current ask. Your security will be sold when another participant accepts your ask.

  OR

- Accept an existing Bid: Select bid with the **highest price** from the Bid List (*Box D*) and click on the *'Sell'* button at the bottom.

Note:

- You can submit multiple bids/asks. Each bid/ask is for one unit of security. You cannot accept your own bids/asks.

- The List of Bids (Asks) will be arranged according to the price in descending (ascending) order and the order of submissions in ascending (ascending) order.

- If your bids/asks are accepted by other traders, there will be a corresponding deduction/increase of cash from the cash account and increase/fall in the security holding in *Box H*. Note that you are only allowed to submit a bid/ask if you have sufficient cash/number of securities to trade. If you no longer have adequate cash on hand/security in the inventory to support your outstanding bid/ask, your bid/ask will be *invalidated*.

- After submitting a bid/ask, you have the option to **withdraw** your bid/ask by **selecting your bid/ask (in blue color)** and clicking on the "*Withdraw Bid (Ask)*" button in *Box F (Box C)*.

- You will receive messages *(Box G)* about your successful actions.

- At the start of a period, the screen will display the Dividend Drawing Page (*Appendix A-1*). At the end of a period, the screen will display a summary page (*Appendix A-2*).

[*The following information only in treatment FP*]

During the trading period, you may **buy** or **sell** securities or you may do nothing. The trading is anonymous.

Basic concept of Bid and Ask:

The Bid price: the price that the experimenter is willing to pay for a security, in this case fixed at 2.5 ECU.

The Ask price: the price that the experimenter is willing to receive for a security, fixed at 2.5 ECU.

Buy from Experimenter: means you indicate your willingness to buy a security from the experimenter.

Sell to the Experimenter: means you indicate your willingness to sell a security to the experimenter.

To Buy: The price per unit of security is fixed at 2.5 ECUs. You can buy a security by clicking the "*Buy from experimenter*" button. Your bid will only be successful (you successfully buy a security) when the experimenter accepts your bid.

To Sell: The price per unit of security is fixed at 2.5 ECUs. You can sell a security by clicking the "*Sell to experimenter*" button. Your security will be sold when the experimenter accepts your ask.

Note:

- The experimenter will execute submitted offers to buy and sell according to the order of submissions.
- You can submit multiple bids/asks. Each bid/ask is for one unit of security.
- The list of bids (asks) will be arranged according to the order of submissions in ascending (ascending) order.
- After submitting a bid/ask, you have the option to **withdraw** your bid/offer by **selecting your bid/ask (in clue color)** and clicking on the "Withdraw Bid (Ask)" button in *Box F (Box C)*.
- You will receive messages *(Box G)* about your successful actions.
- If your bids/asks are accepted by the experimenter, there will be a corresponding deduction/increase of cash from the cash account and increase/fall in the

security holding in *Box H*. Note that you are only allowed to submit a bid/ask if you have sufficient cash/number of securities to trade. If you no longer have adequate cash on hand/security inventory to support your outstanding bid/ask, your bid/ask will be *invalidated*.

- At the start of a period, the screen will display the Dividend Drawing Page (*Appendix A-1*). At the end of a period, the screen will display a summary page (*Appendix A-2*).

5. Trading Profit

Your earnings for a round are determined by the cash you are holding at the last period of that round.

So, if you end a period without cash, and the round terminates at that period, you will earn zero ECU for that round. This does not mean, however, that you should always end one period with only cash and no securities. If you do so and that period is not the terminal period, you will not receive dividends in the next period. Consequently, you start the next period without cash (since cash cannot be carried over periods) unless you receive income in that next period.

We will run as many rounds as can be fit in the allotted time for the experiment. If the ongoing round has not been terminated within 10 minutes before the end of the session, then we will throw the dice. If 1-5 is drawn then we move to the next period and that period will be the last period. If 6 is drawn, then the current period is the terminal period.

Two randomly chosen rounds will be selected to determine your final payment from this experiment. However, if we only have one round for the entire two (2) hours, then you will receive twice the amount of earnings from that round. If there are exactly two (2) rounds, then you will receive the sum of earnings from these two rounds.

DECISION PROBLEM STAGE

In this part of the experiment you will be asked to make a series of choices. How much you receive will depend partly on chance and partly on the choices you make.

The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

For each line in the table in the next page, please state whether you prefer option A or option B. Notice that there are **10 lines** in the table but just **one line** will be randomly selected for payment. You do not know which line will be paid when you make your choices. Hence you should pay attention to the choice you make in every line.

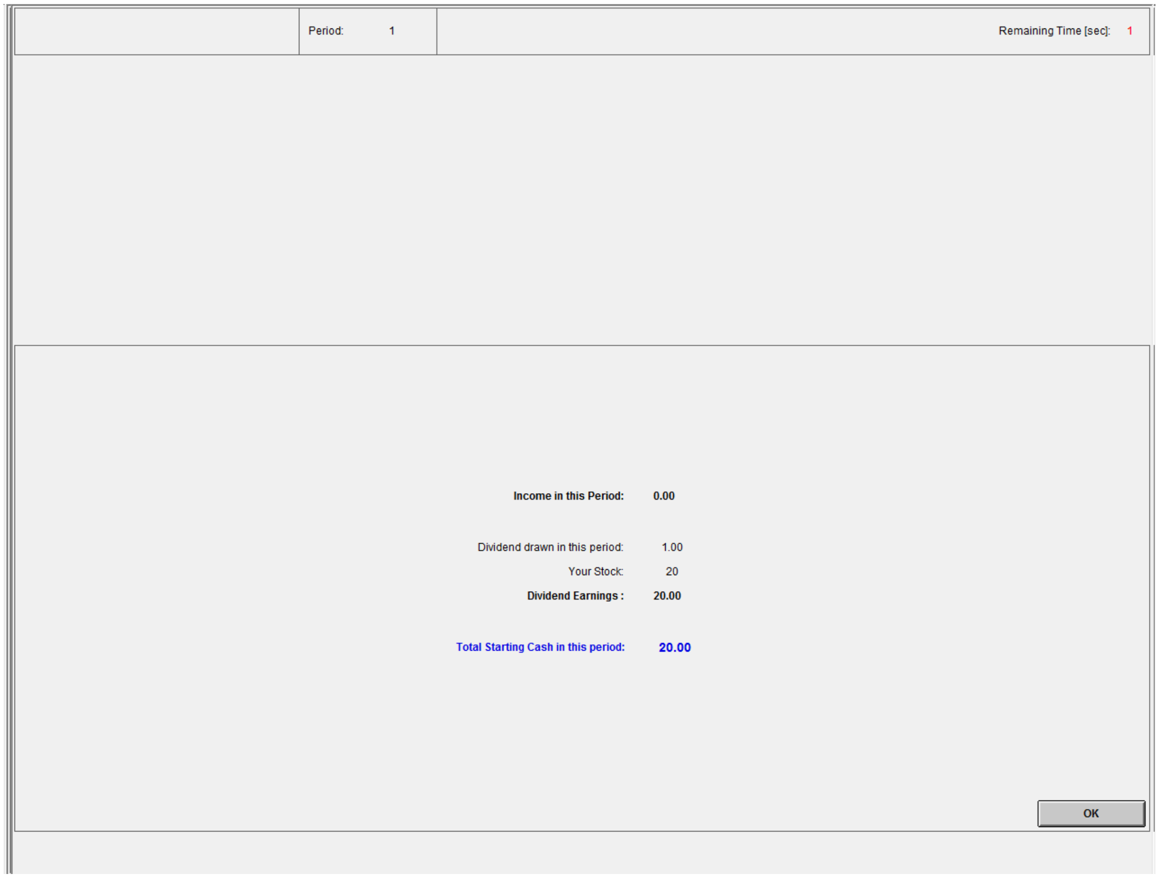
Reward Scheme

After you have completed all your choices, the computer will randomly select a line in the table.

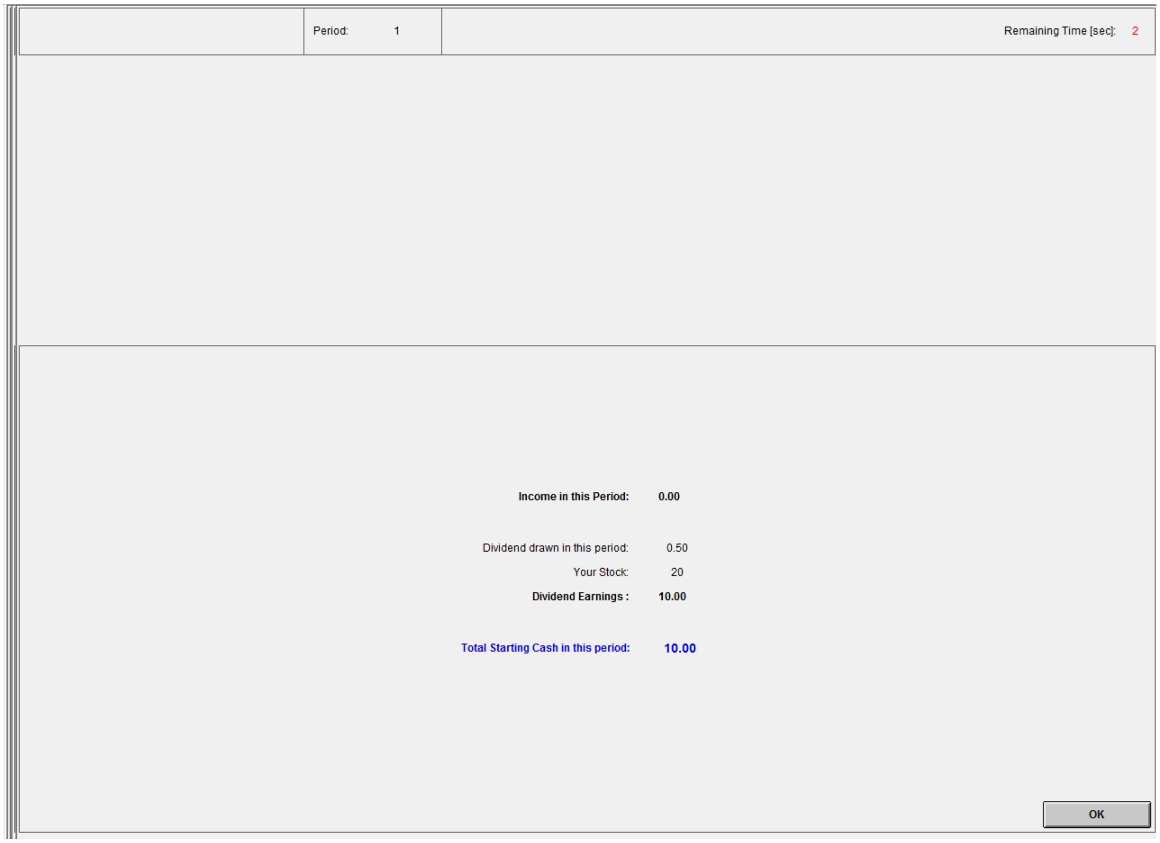
Your earnings for the selected line depend on which option you chose: If you chose option A in that line, you will receive 1 SGD. If you chose option B in that line, the computer will randomly determine if your payoff is 0 or 3 SGD with the probabilities stated in option B in that line.

If you have any questions, please raise your hand and we will attend to you in private.

Appendix A-1: Dividend Drawing Screen (shown before trading starts in each period)

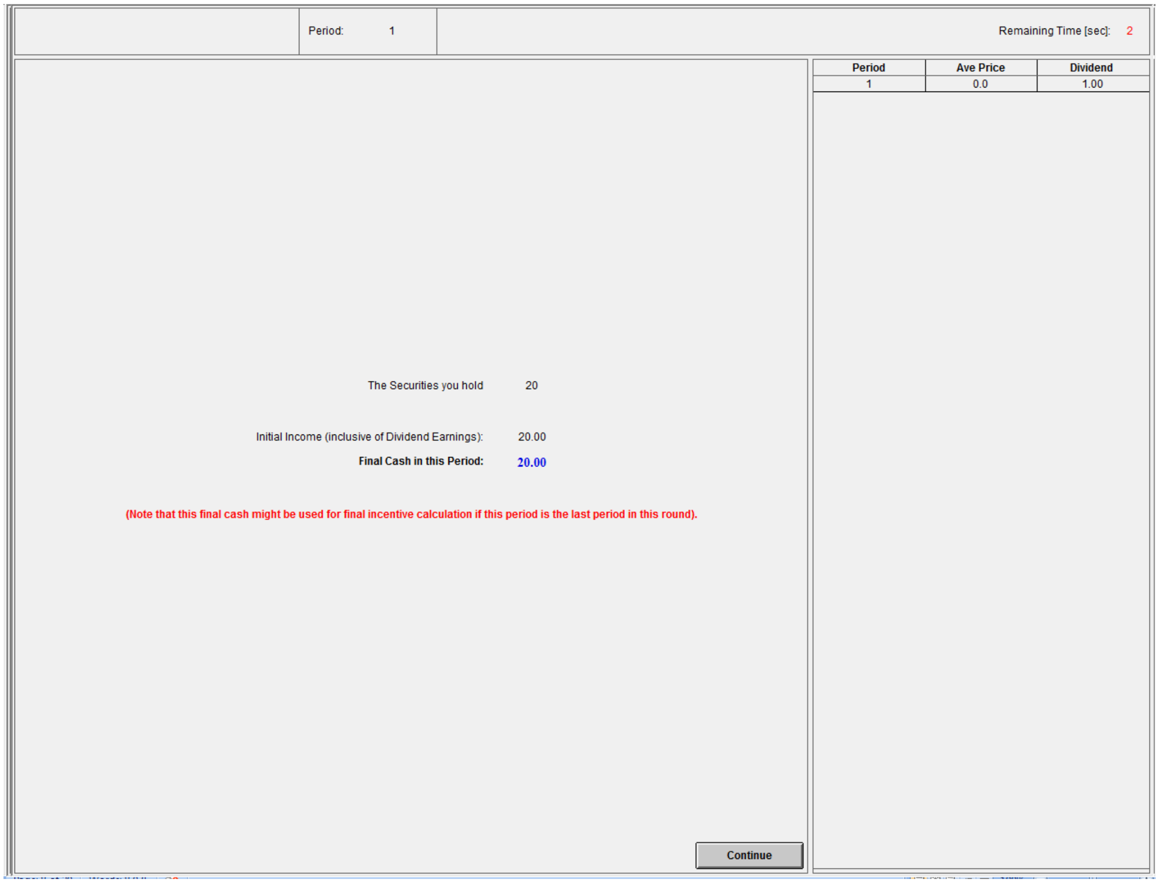


Treatments *BL*, *CI*, *MM* and *FP*

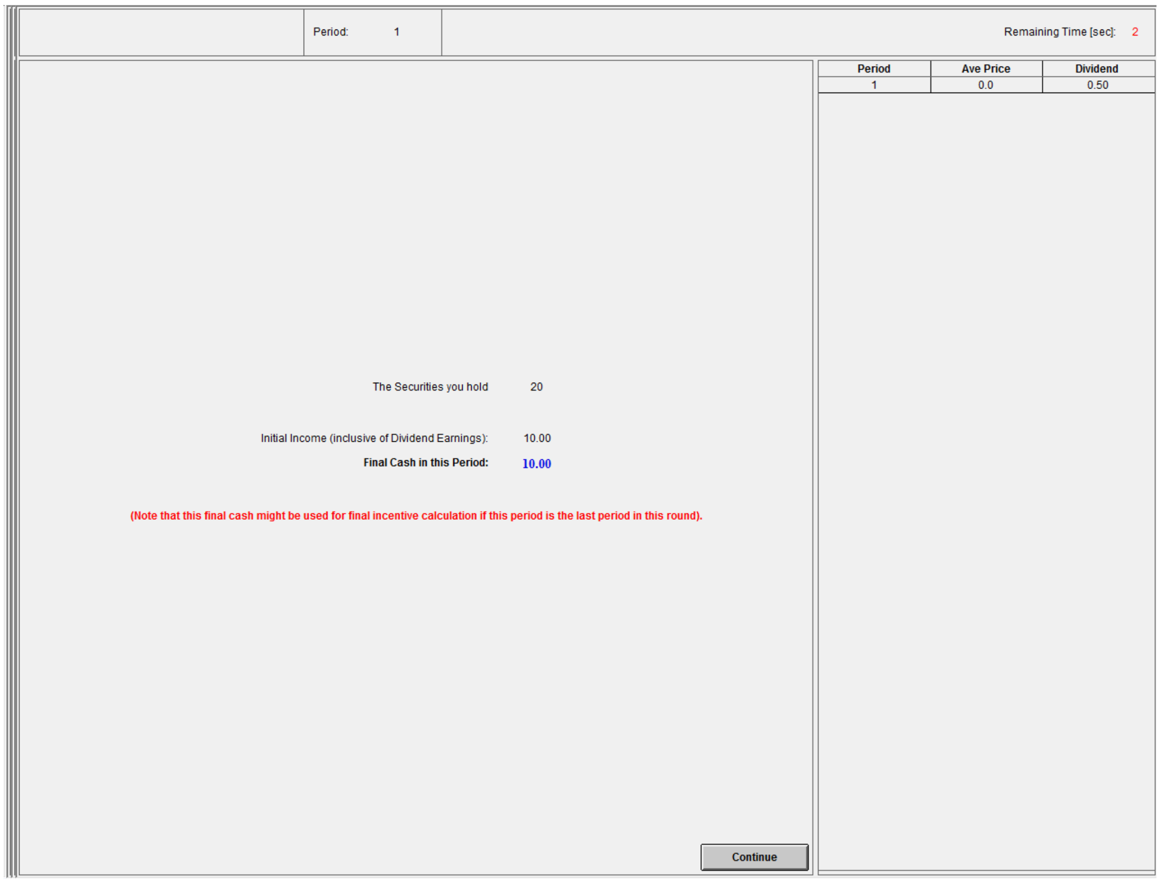


Treatment *CD*

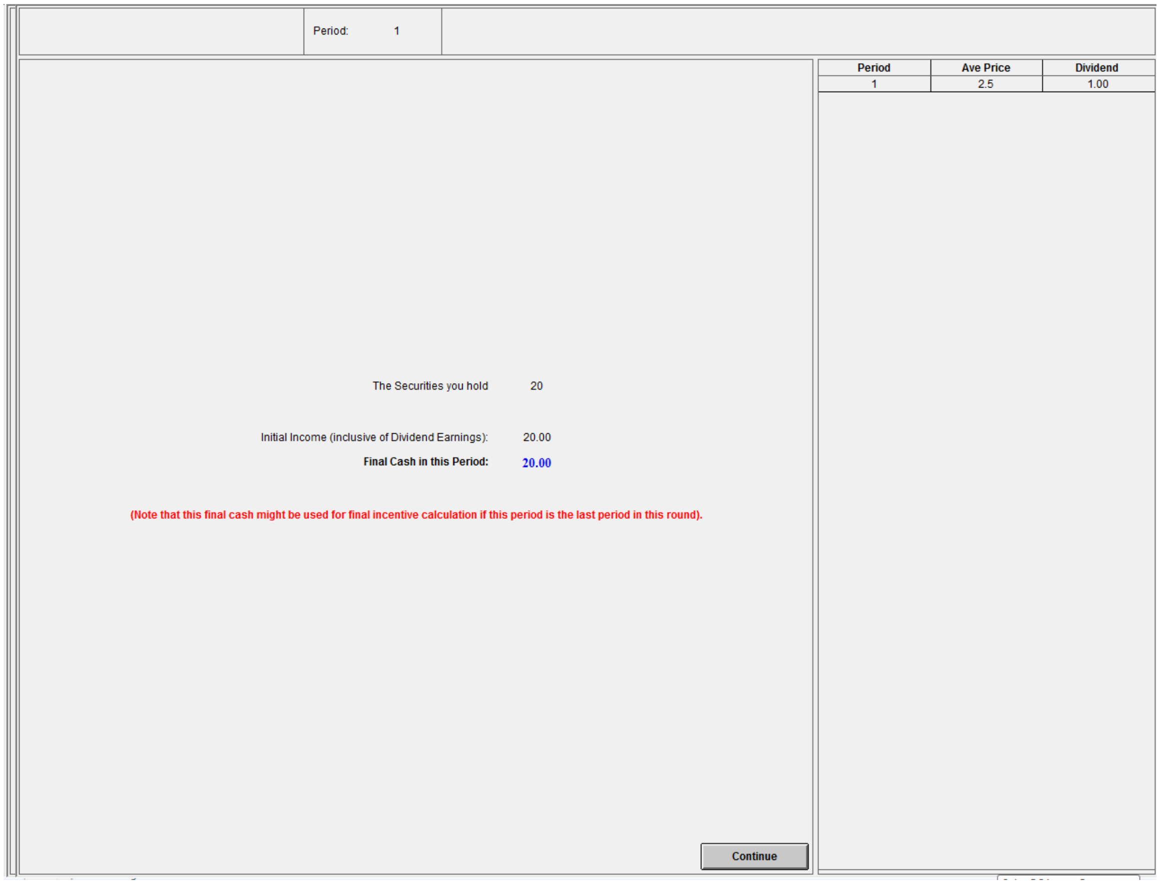
Appendix A-2: Trading Summary Screen (shown after trading ends in each period)



Treatments *BL*, *CI* and *MM*

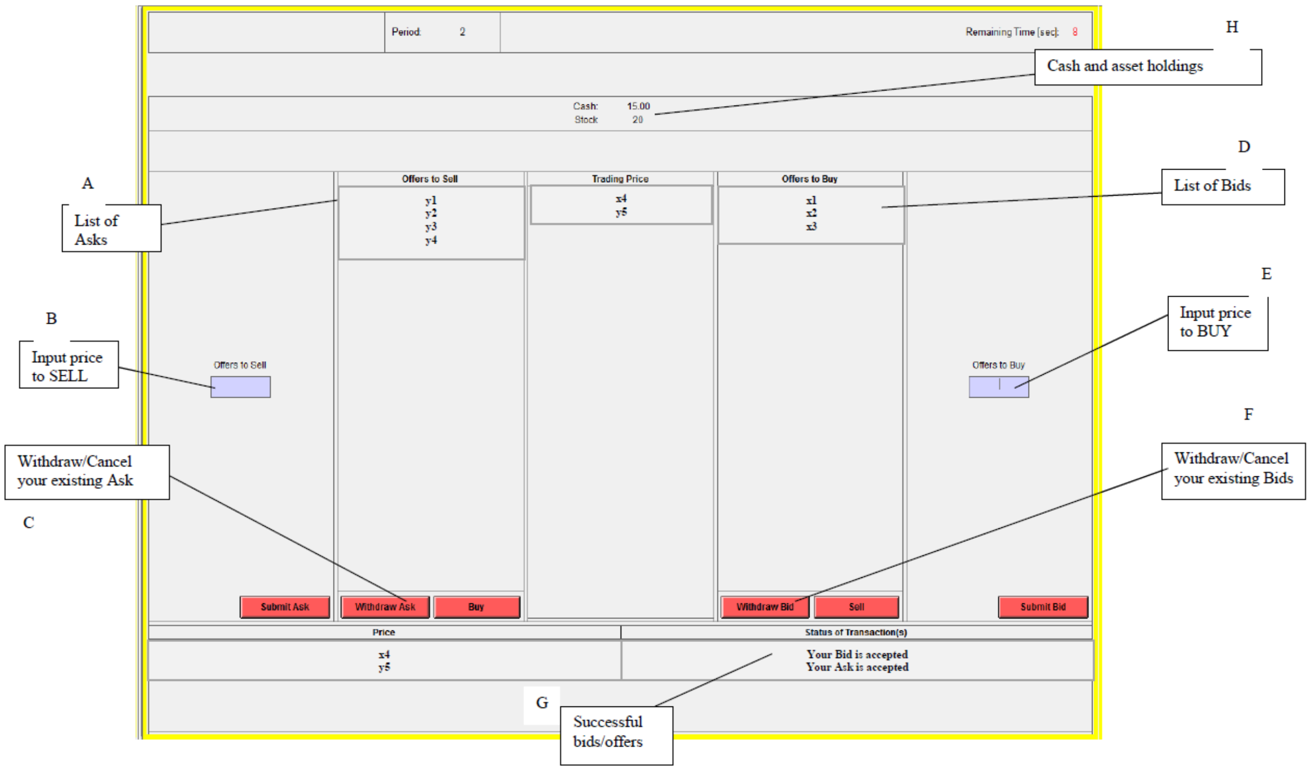


Treatment *CD*

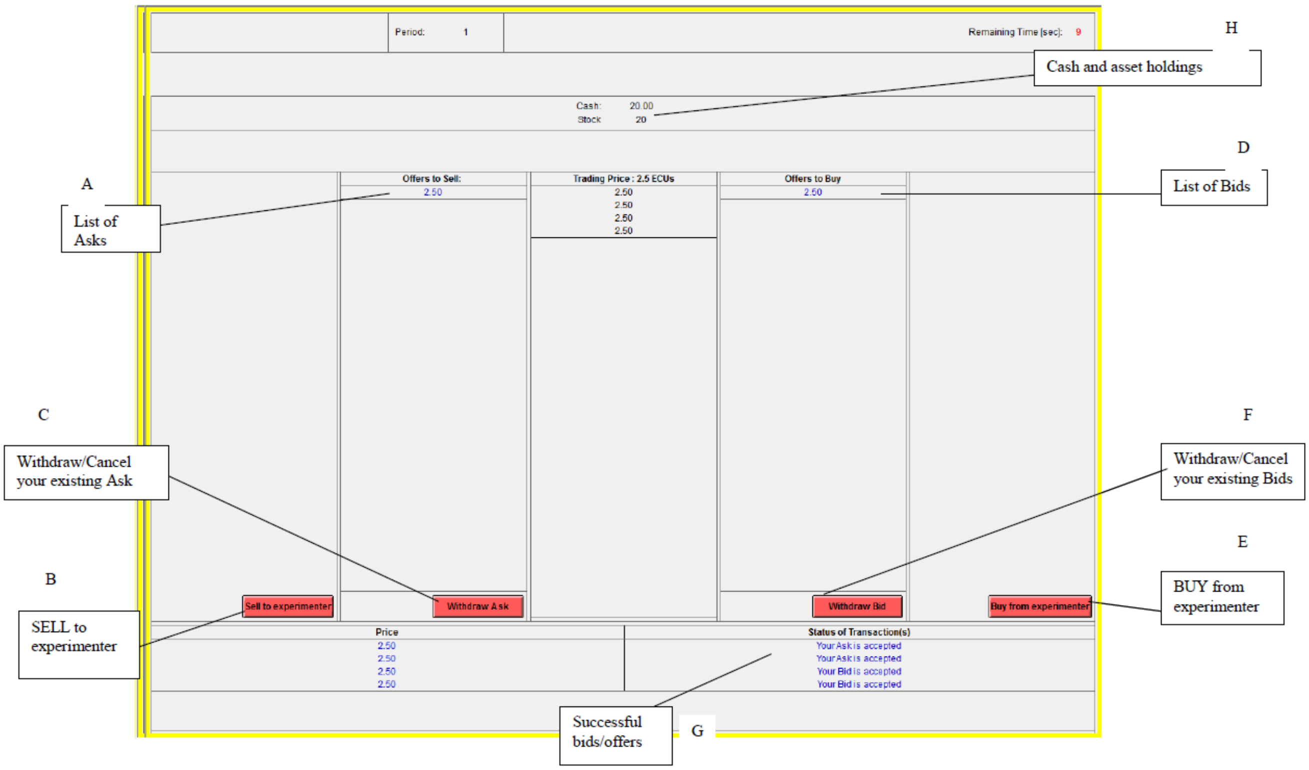


Treatment *FP*

Appendix A-3: Schematic Diagram of Trading Page



Treatments *BL*, *CI*, *MM* and *CD*



Treatment *FP*