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An experimental examination of the flow of irrelevant information across markets

Lucy F. Ackert[1] | **Brian D. Kluger**[2] | **Li Qi**[3] | **Lijia Wei**[4]

[1]Michael J. Coles College of Business, Department of EFQA, Kennesaw State University, Kennesaw, Georgia

[2]Department of Finance, Carl H. Lindner College of Business, University of Cincinnati, Cincinnati, Ohio, USA

[3]Department of Economics, Agnes Scott College, Decatur, Georgia

[4]School of Economics and Management, Wuhan University, Wuhan, China

Correspondence
Lucy F. Ackert, Michael J. Coles College of Business, Department of EFQA, Kennesaw State University, Kennesaw, Georgia.
Email: lackert@kennesaw.edu

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Abstract
Our study uses an experimental method to provide insight into the flow of information across two asset markets that are fully segmented. In our asset markets, two separate sets of participants trade an identical asset in different markets. We then introduce a shock to fundamentals in one market to examine the response of traders in the second market. Because there is no fundamental shock in the second market, we can separate information-based reactions from responses due to changes in underlying fundamental values. With the separation across markets, we observe whether information relating to a fundamental shock that only affects the shocked market is transmitted to the non-shocked market. Our evidence suggests that traders in one market are observing behavior in the other contemporaneous market. After an information shock, price efficiency declines but improves by the end of trading.

KEYWORDS
asset market experiment, information reaction, segmented markets

JEL CLASSIFICATION
C92, G1

1 | INTRODUCTION

Stock markets can sometimes be excessively volatile and prone to mispricing (Shiller, 1990, 2000). These findings are of significant concern to policymakers because they imply the misallocation of resources. One source of poor market outcomes may be trader overreaction to misinformation (Camerer & Weigelt, 1991). Traders may look at the experiences of others and wonder if the same forces will shape their future. In the interconnected, globalized marketplace of the 21st century, traders face challenges when they attempt to discern what information is relevant to value the assets they hold or trade. Researchers who seek to understand how traders use information in naturally occurring markets also face challenges because the arrival, timing, and relevance of information cannot be controlled. In this article, we use an experimental method to examine if and how trading in one market impacts behaviors and outcomes in another separated market.

Observation of trade in a separated market may affect both the equilibrium price and the speed to which the market reaches the equilibrium price. Qi and Ochs (2009) report that the observation of another market can lead to improved outcomes. Their experimental evidence indicates that prices in a market reflect relevant information in another market, even if the markets are legally separated. When markets are legally separated, local firms can separate claims to cash flows into two streams, one flowing to domestic investors and the other to outsiders. In Qi and Ochs, the two experimental asset markets are fully segmented in that traders can only trade in their own market, though they can observe trading in both markets.

Another possibility, not considered by Qi and Ochs, is that irrelevant information may be transferred across markets. Irrelevant information or even inefficiency in one market may be transmitted to the other market. Information mirages, where traders mistakenly interpret happenstance price movements as responses to information and then drive prices away from fundamentals, have been observed experimentally (e.g., Camerer & Weigelt, 1991), but not in segmented markets.

This study reports on an experiment designed to examine whether and how market participants use information from another market that they observe, but do not transact in. In our design, the markets are fully segmented. Initially, two sets of participants trade assets with identical dividend claims. We then introduce a shock to fundamentals in one market that is immaterial to pricing in the other market. This design allows us to study whether traders react to irrelevant information. Because there is no fundamental shock in the second market, any observed reaction there must be based on the informational connection to the first market.

Although examinations of naturally occurring markets can certainly provide insight into behavior, the inability to control information in the environment is problematic. Experiments are a promising methodology for studying the reaction to information across separated markets because the timing and nature of news releases across markets in the laboratory can be managed. Our design allows us to provide insight into the reaction to *irrelevant* information across segmented markets. In our markets, all traders within each market share common information and are restricted to trade in only one market throughout the experiment.

As Qi and Ochs (2009) note, some nations restrict share ownership by foreigners, in which case the markets are segmented. Our design closely parallels that of Qi and Ochs. As in their setting, our experiment includes two sets of traders, and each trades in only one of two separate markets. There are two assets, the trading currency and a risky asset with a one-period life whose value is determined by a state-dependent liquidating dividend. Qi and Ochs provide private information about the state of nature to a subset of participants in one market and find that the private information transfers to the other market. Unlike Qi and Ochs, the shock in our setting is only relevant to asset values in the shocked market and is irrelevant to traders in the second market. We restrict the allowed trading venue to see how and whether the transmission of a fundamental shock that only affects the shocked market is transmitted to the non-shocked market. With distinct traders in each market, we can manipulate the release of fundamental information.

Our experiment includes three treatments. In our first treatment, traders in one market experience a shock to fundamental value after several periods of trading. Traders in the first market are informed of this shock, and there is no change in fundamentals or information release in the second market. However, all traders freely observe all bids, asks, and trades in both markets. In the second treatment, traders in the first market again experience and are informed of a shock, but now traders in the second market are fully informed of the nature of the shock in the first market. As well, they are informed that there is no change in their own market. In the first two treatments, we can investigate whether the second market responds to information that is relevant in the first market, but irrelevant in the second market. Finally, in our third, control treatment, there is no shock to fundamentals and no difference in information across markets.

We find that, after the shock in the first market, price efficiency declines at first but recovers by the end of trading. In addition, we observe no immediate or long-term impact on allocational efficiency.[1] We find no evidence to suggest that traders in the non-shocked market overreact to irrelevant information. However, they are watching the other market, perhaps to gain a better understanding of market behavior, and there is an informational connection between the separated markets. We see that prices and pricing efficiency are correlated across the two contemporaneous markets. Furthermore, when information is publicly available, observed trading prices and traders' price predictions respond to prior pricing errors in the other market also suggesting that traders are considering all the information that is available to them.

2 | LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Many experimental studies have examined trading behavior and pricing in laboratory asset markets, including Plott and Sunder (1982) and Forsythe and Lundholm (1990). Typically, the research investigates whether asset prices converge to theoretical predictions and efficiently reflect information in a single market. However, there are fewer examinations of multi-market trading, particularly regarding reactions of traders to information across markets.

A subset of these multi-market experimental studies examines financial contagion and because of the historical experience in the United States, bank runs are of particular interest. With an experimental method, researchers can manipulate the conditions likely to produce panic. Though observation of others' actions should prevent bank runs, Kiss et al. (2014) report that bank runs are more likely when others are observed to make bank withdrawals. Researchers also find that observation of panic is contagious (Brown et al., 2017; Chakravarty et al., 2014; Duffy et al., 2019). Trevino (2020) posits that contagion can be driven through two

[1]Other research finds that double auction markets perform well in conveying private information to uninformed traders. These studies also consider allocational efficiencies (e.g., Ackert et al., 2002; Copeland & Friedman, 1987; Plott & Sunder, 1982). Our design differs in that we consider connections across fully separated markets.

channels. First, there is information that is relevant to fundamental values. Second, there is social learning in which case traders make decisions based on noisy information from the observation of others. She concludes that people do not use fundamental information optimally, but rather rely on others even if the socially derived information is irrelevant.

Unlike prior studies, the information shock in our design is relevant, but only to traders in one market.[2] Our design allows us to provide insight into the reaction to irrelevant information across segmented markets and as such differs in important ways from multi-market experimental studies reported in the extant literature. Some prior researchers consider two assets that trade in integrated markets (e.g., Charness & Neugebauer, 2019; Fisher & Kelly, 2000). For example, in Duffy et al.'s (2021b) experiment, all traders are permitted to trade two assets, one of which experiences a stock split. Prices do not appropriately adjust to the split, which the authors attribute to a difficulty thinking proportionally. As another example, in Noussair and Popescu's (2021) investigation of multi-market trading, asset prices are correlated across two markets after a shock. Unlike our environment, observed behavior can, at least in part, be explained by traders' desire to diversify. The ability to diversify risk reduces mispricing in multiple asset markets (Duffy et al., 2021a).

Other prior experimental studies also allow some traders to transact in two markets concurrently (Ackert et al., 2011; Chelley-Steeley et al., 2015; Noussair & Popescu, 2021; Noussair & Xu, 2015). For example, Ackert, Mazzotta, and Qi allow some traders to transact in both markets and others in only one market. Noussair and Xu's focus is on the impact on information dissemination when there are insiders with private information. In Chelley-Steeley et al. the markets overlap, so that traders can transact in only one market during parts of the session but can transact in both markets during other parts of the session. In our markets, all traders within each market share common information and are restricted to trade in only one market throughout the experiment.

We build upon Qi and Ochs (2009) who report that the observation of another market can lead to improved outcomes. In their experiments, the two markets are fully segmented in that traders can only trade in their own market, though they can observe trading in both markets. Recall that when markets are legally separated, local firms can separate claims to cash flows into two streams, one flowing to domestic investors and the other to outsiders. As Qi and Ochs describe, many emerging capital markets create legally separated share markets to restrict foreign share ownership. Over time though, many countries have gradually relaxed restrictions on foreign share ownership.

The Chinese experience provides an interesting example. Prior to 2001 Chinese law dictated that local firms issue A shares to Chinese citizens who can *only* trade A shares with Chinese currency, Yuan; firms can also issue B shares to foreign investors who can *only* trade B shares with U.S. currency, as well as H shares which are traded with Hong Kong dollars. All shares carry the same economic and voting rights but are strictly separated between domestic and foreign investors. Starting in 2001, Chinese investors who already had a foreign currency savings account were allowed to trade B shares. Since then, more investment restrictions have been removed including initiatives that allowed Qualified Foreign Institutional Investors to trade A-shares (2002), Qualified Domestic Institutional Investors to trade H-shares (2006), and the

[2]As more fully described in the following section of the article, we implement a shock to asset value by manipulating the interest rate. While other experimental studies examine interest rate policy (e.g., Bao & Zong, 2019; Fischbacher et al., 2013; Giusti et al., 2016; Kryvtsov & Petersen, 2021), our goal is to provide insight on the use of irrelevant information across separated markets.

"Stock Connect" program that allowed Hong Kong and overseas investors to trade eligible SSE listed A-shares through the Shanghai-Hong Kong (SH-HK) connect (2014).

Despite gradual relaxation of investment restrictions, pricing differences persisted for Chinese securities. Dual-listed Chinese companies (trading on both mainland and the Hong Kong exchanges) display significant pricing differences between A shares and H shares, indicating that the capital market is far from fully integrated.[3] In fact, different pools of investors continue to exist even with relaxed restrictions. According to a Forbes report, "A shares trading is mainly 'retail'—that is, carried out by individual Chinese investors.....H-share ownership is mainly institutional.....Foreign ownership of A-shares is only about 3%, whereas over 30% of H-shares are foreign-owned."[4] Further, investors in these markets exhibit different investor styles (risk preferences, demand elasticities, etc.).

While pricing anomalies often defy traditional financial theories, it is worth noting that firms dual list across different exchanges to reach different investor groups and to avoid political risks. For example, many views that China's tech giants (Alibaba, JD.com, and Baidu.com) dual list (in both United States and Hong Kong) to avoid potential U.S. sanctions and de-listings of major Chinese technology companies amidst rising political tensions and United States–China trade disputes.[5] These observations suggest that trading regulations continue to result in distinct (and even segregated) investor groups who hold and trade assets from the same underlying dividend flows.

The vast, prior experimental literature suggests that asset markets efficiently aggregate information in many settings. While knowledge of others' behavior can lead to irrational contagion, Qi and Ochs (2009) report that observation of another separated market can actually improve outcomes. Our goal is to examine whether irrelevant information from one market impacts outcomes in another. Given findings reported in the literature, we expect that traders will adjust efficiently to own market information. However, the findings on cross-market effects are disparate and, thus, we present related hypotheses in the null form. Our hypotheses are as follows:

Hypothesis 1. *Observation of the other separated market does not impact prices, trading volume, or efficiency.*

Hypothesis 2. *Price and allocative efficiency in Market 1 (the shocked market) adjust to the shock in both Private and Public information treatments when traders are informed of the shock.*

Hypothesis 3. *Price and allocative efficiency are not impacted by the shock in the market that experiences no shock (Market 2) for both Private and Public information treatments because the shock is irrelevant information.*

Hypothesis 4. *Traders' prediction errors are not impacted by the shock.*

[3]See https://www.forbes.com/sites/georgecalhoun/2020/08/30/a-strange-new-bubble-in-chinese-a-shares-a-is-for-arbitrage/?sh=7fc63b214e7a. Previous studies document significant covariance in the price movement of Chinese A and B shares (Chakravarty et al., 1998; Chui & Kwok, 1998; Kim & Shin, 2000), even though the prices of A and B shares diverge.

[4]https://www.forbes.com/sites/georgecalhoun/2020/08/30/a-strange-new-bubble-in-chinese-a-shares-a-is-for-arbitrage/?sh=7fc63b214e7a.

[5]https://www.cnbc.com/2021/03/26/chinas-dual-listed-tech-giants-have-lost-about-60-billion-collectively.html. https://www.bloomberg.com/news/articles/2020-08-21/alibaba-investors-swap-u-s-shares-for-hong-kong-amid-crackdown.

3 | EXPERIMENTAL DESIGN

Thirty asset market sessions were conducted at a large Chinese university. The experimental design, summarized in Panel A of Table 1, includes three treatments. In all treatments, a risky asset is simultaneously traded in two segmented markets, as described more fully below. Traders could participate fully in the double auction market to which they were assigned, but they could only observe activity in the other, concurrent market. As explained subsequently, information available to traders is manipulated across treatments.

Each session included two markets (Market 1 and Market 2) in which a risky asset was traded for fifteen 2-min periods. Each market was organized as a sequence of computerized double auction markets, implemented using the Zurich Toolbox for Readymade Economic Experiments (*Z-tree*) software (Fischbacher, 2007).[6] Upon arrival, traders received a set of instructions.[7] A verbal reading of the experimental instructions was prerecorded for consistency. The recorded instructions were broadcasted aloud, and traders followed along. After an experimenter addressed any procedural and technical questions, two practice periods were completed prior to the start of the compensated trading periods.

TABLE 1 Experimental design

Panel A: Interest rates					
			Interest rate		
			Periods 1–5	**Periods 6–15**	
Treatment		**Number of Sessions**	**Both Markets (%)**	**Market 1 (%)**	**Market 2 (%)**
1	Private Information	10	100	300	100
			100	300	100
2	Public Information	10	100	300	100
			100	300	100
3	No Shock	10	100	100	100
			100	100	100

Panel B: Dividend payoffs per period		
	Dividend for trader type X	**Dividend for trader type Y**
State I ($p = .50$)	300	50
State II ($p = .50$)	100	150
Expected payoff	200	100

Note: A session includes two markets, each with eight traders and 15 trading periods. Of the eight traders in a market, four take each trader type. An information shock relating to the interest rate paid on francs held (before dividends) occurs in Treatments 1 and 2 after Period 5. Panel A contains the interest rates paid on francs in each market. Panel B shows the distribution of asset liquidation values, which varies by trader type (X or Y).

[6]This software is provided to experimental researchers by the University of Zurich, Institute for Empirical Research in Economics. See http://www.iew.unizh.ch/ztree/index.php.

[7]The complete instructions are included in the Appendix in English. The instructions were translated to Chinese and cross-checked by two native Chinese speakers.

At the beginning of each trading period, each trader in all sessions was endowed with two shares of a risky asset as well as 1000 francs, the experimental currency. Participants could either post single or multiple bids and asks for units of the risky asset referred to as "stock," or they could act as price-takers. Traders were not permitted to short sell or borrow additional capital. While traders could see the activity in both markets in real time, they were permitted to post or accept offers only in the market to which they were assigned, Market 1 or Market 2. Eight traders were randomly assigned to each market as participants entered the trading laboratory.

Each market included four traders of each of two trader types (X and Y) with different potential dividend payoffs, as summarized in Panel B of Table 1.[8] The possible earnings and number of each type of trader was public information. Traders also learned that the dividends were equally likely, randomly determined, and intertemporally independent. Thus, the expected payoff was easily computed each period by type, as shown in Panel B of Table 1. The observed dividend was always identical across Market 1 and Market 2 in a trading period. In addition, at the beginning of each session, traders learned that the franc balance held at the end of a period, but before dividends were paid, earned interest at a rate of 100%. Thus, each franc held would be worth two francs at the end of a period. In all treatments, traders were fully aware of the applicable interest for period-end francs held and the computer program automatically computed each trader's total earnings at the end of a trading period.

After the earnings for the completed period were calculated and tracked, the next period commenced. Subjects' initial share and cash balances were reset to two shares and 1000 francs. This sequence was repeated 15 times. Additionally, prior to the start of each period, subjects were asked to record predictions of the average trading price in both markets for the upcoming period. Subjects received a fixed payment of 50 RMB (approximately $0.08 in U.S. dollars) for each period that a prediction was made and there was no bonus (penalty) for accurate (inaccurate) forecasts.

In the No Shock treatment, the 15 trading periods proceeded as described. However, in both the Private and Public Information treatments, traders were given additional written instructions at the end of trading Period 5. In the Private Information treatment, traders in Market 1 learned that for the remainder of the trading periods, the interest rate for Market 1 would increase to 300%, so that each franc held at period end increased by a factor of four. Traders in Market 2 were told that nothing was changing in their market, and they were not informed of the change in Market 1. In contrast, in our Public Information treatment, traders in both markets learned that for the remainder of the trading periods, the interest rate would increase to 300%, so that each franc held at period end increased by a factor of four, *only* in Market 1. In the Public Information treatment, all traders also learned that the interest rate in Market 2 remained at 100% as nothing was changing in Market 2.

The 480 participants were university students with a variety of majors. All were inexperienced in that none had participated in an earlier session. Traders earned from 35.85 RMB ($5.74) to 69.51 RMB ($11.12) for participating, with an average [median] payout of 54.23 RMB (50.62 [RMB]) ($8.68 [$8.10]). This includes the show-up fee of 15 RMB ($2.40). The sessions required approximately 1½ h to complete. At the conclusion of each session, a trader's final earnings, that is the sum of the earnings over the 15 periods, was privately displayed on the computer screen. Traders completed a post-experiment questionnaire that elicited subject

[8]Two trader types with different dividend payoffs provide a rationale for trade. In addition, asset allocation predictions can be made. Trader type X has a higher expected payoff so asset holdings should move toward X.

attributes including sex, educational background, economic status, and reactions to the experiment. Each participant completed a payment confirmation receipt and left the room. Participants were informed of their earnings (privately) and funds were posted to their Wepay accounts later that day.[9]

4 | RESULTS

4.1 | Market outcomes

In this section, we begin with descriptive data and summary statistics to assess market outcomes for each of our three treatments.[10] Figures 1–3 show the price sequences for all 10 sessions of each of the three treatments (Private Information, Public Information, and No Shock). Markets 1 and 2 prices are shown in the top and bottom panel of each figure.

Whether the shock is publicly announced or privately announced to Market 1 traders does not affect the information provided to participants trading in Market 1, so any differences between the Private or Public Information treatments should be evident in Market 2 prices after trading Period 5. Recall that the interest rate shock occurs after the fifth period and the Market 1 expected dividend per share drops from 100 francs to 50 francs in Period 6.[11] In Panel B of Table 1, we see that the expected values for traders of type X and Y are 200 and 100 francs. Because type X traders value the asset more highly, holdings of shares are expected to move toward them. The predicted fundamental value is 100 but francs earned through dividend payments do not earn interest, whereas francs held in cash will be worth two francs at the end of trading in Periods 1–5 and without a shock. With an expected value of 200 and interest rate of 100%, traders of type X will be willing to pay a fundamental value of 100. With an interest rate shock and assuming traders in a market react only to relevant information, each franc held in cash will be worth four francs at the end of trading in period so the price should converge to 50 francs.

As we see in Figures 1 and 2, prices were substantially higher than the fundamental value before the shock, suggesting that the markets had not equilibrated prior to the shock. After the shock, Market 1 prices fall as expected in both the Private and Public Information treatments, but the prices take several periods to approach the aftershock fundamental value. As Period 10 approaches, most sessions seem to adjust to the shock. By this time, prices are generally lower than 50 francs, perhaps reflecting risk aversion among traders.

The lower charts in Figures 1–3 present the Market 2 price sequences for each session. The interest rate shock occurs after Period 5 in the Private and Public Information treatments. In the Private Information treatment, Market 2 traders are not informed about the existence of the shock in the other market, whereas in the Public Information treatment both Market 1 and Market 2 traders are aware of the shock. In Figures 1 and 2, we observe prices well above the

[9]Wepay is an electronic payment system that is widely used in China. Cash transactions have become uncommon.

[10]We created the figures using DataGraph and the analysis tool used is R from https://www.r-project.org/. The experimental data are available upon request.

[11]As an approximation, we refer to the expected share dividend as the fundamental value and are ignoring any potential effects of risk aversion on share values.

Panel (a):

Panel (b):

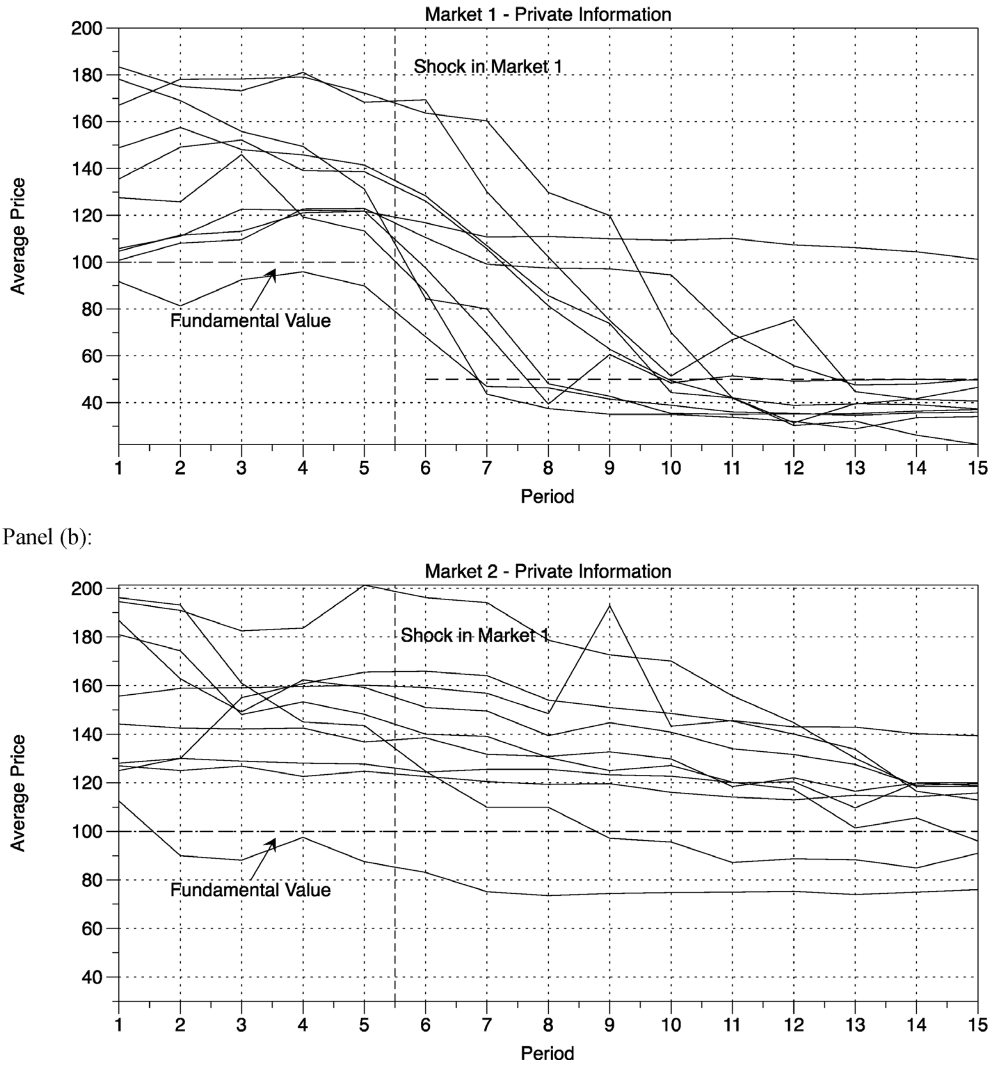
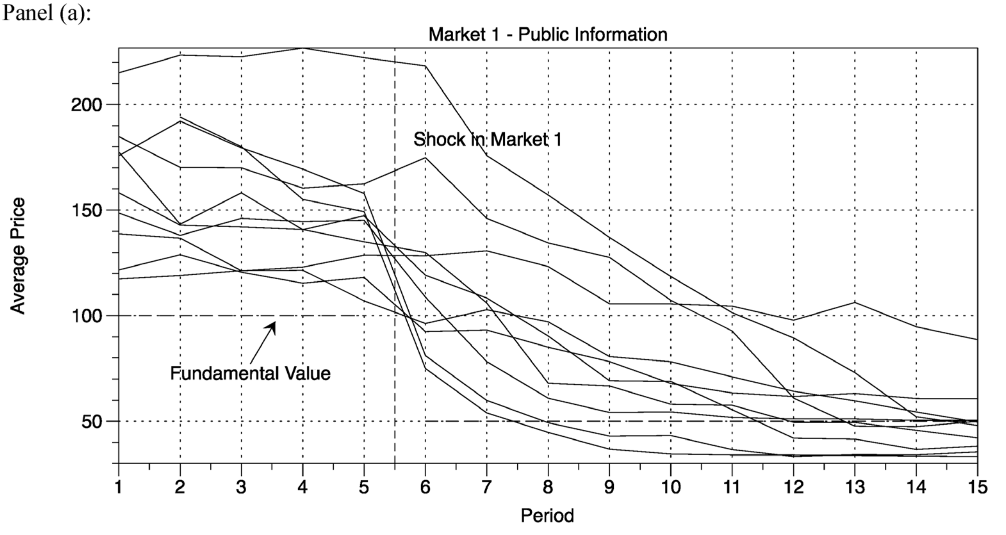


FIGURE 1 Average prices paths for each of the 10 sessions of the private information treatment. Panel (a) shows the Market 1 prices and Panel (b) shows the Market 2 prices. The interest rate shock occurs after Period 5 in Market 1. The fundamental share value before the shock is 100 francs. After the shock, the Market 1 fundamental value falls to 50 francs. The fundamental value in Market 2 is unaffected

fundamental value before the shock. The fundamental value is 100 francs in Market 2, both before and after the Market 1 interest rate change. After the shock, Market 2 prices do not seem to react dramatically in most sessions in the two treatments that include an interest rate shock. In both Figures 1 and 2, the prices in many sessions appear to decline gradually toward the fundamental value.

Average prices for the No Shock treatment are presented in Figure 3. Panels a and b of the graph present Markets 1 and 2 prices, though in this treatment there is no real difference between the markets, except for the labels, because there is no interest rate shock. As we observed for the first two treatments, prices are high relative to the fundamental value up to the

Panel (a):



Panel (b):

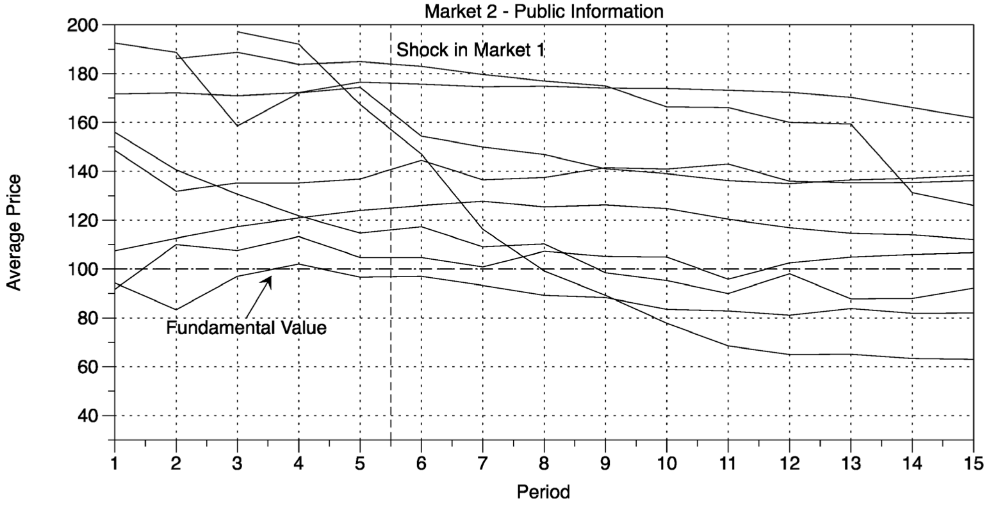
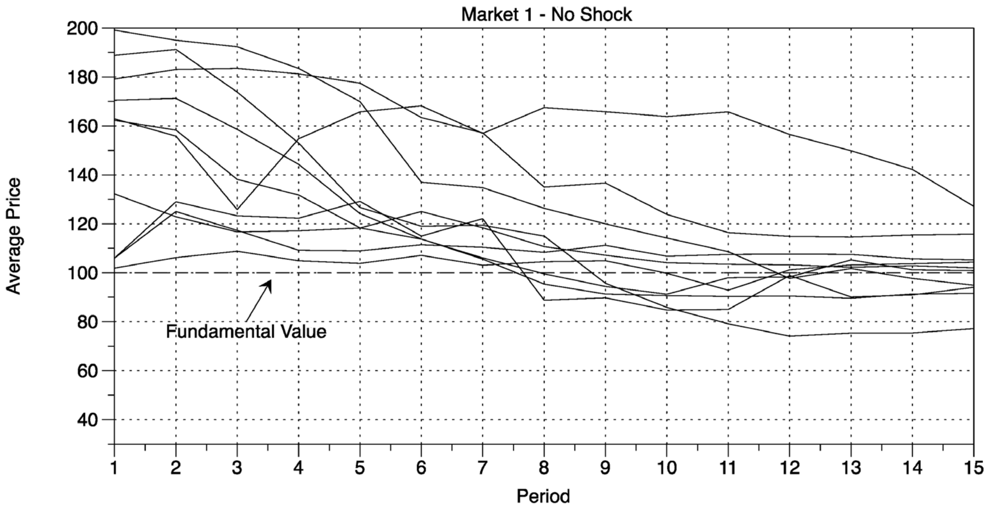


FIGURE 2 Average prices paths for each of the 10 sessions of the public information treatment. Panel (a) shows the Market 1 prices and Panel (b) shows the Market 2 prices. The interest rate shock occurs after Period 5 in Market 1. The fundamental share value before the shock is 100 francs. After the shock, the Market 1 fundamental value falls to 50 francs. The fundamental value in Market 2 is unaffected

fifth period. For most sessions, prices declined after trading Period 5 and approached the fundamental value, 100 francs, as the session progressed.

Table 2 presents summary statistics for early (1–5), middle (6–10), and late (11–15) trading periods for each of the three treatments (Private Information, Public Information, and No Shock) and each market (1 and 2). Trading volume is the average number of trades per period. We also include two measures of efficiency. The first, relative absolute deviation (RAD), is a measure of price efficiency often used to measure the presence and severity of asset market bubbles (Stöckl et al., 2010). RAD is calculated as:

Panel (a):



Panel (b):

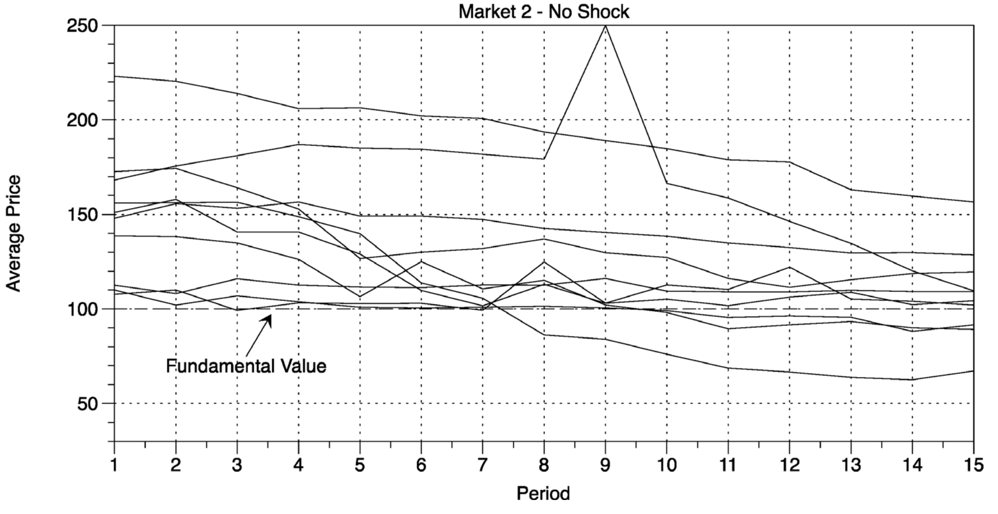


FIGURE 3 Average prices paths for each of the 10 sessions of the control treatment in which there was no information shock. Panel (a) shows the Market 1 prices and Panel (b) shows the Market 2 prices. There is no shock in this treatment, and the fundamental share value is 100 francs in both Market 1 and Market 2

$$\mathrm{RAD} = \frac{1}{N}\sum_{p=1}^{N} \frac{|\overline{P_p} - V_p|}{\overline{V_p}}, \tag{1}$$

where $\overline{P_p}$ is the average trading price in period p, V_p is the fundamental value in period p, and $\overline{V_p}$ is the fundamental value averaged over the N trading periods. For Table 2, N is five periods in each calculation. The lower RAD, the closer prices are to tracking the fundamental values. Finally, we include a measure of allocational efficiency. Recall that there are two types of traders in our experiment, X and Y. The expected payout per share is higher for the X traders (200 francs) than for the Y traders (100 francs). So, in terms of allocational efficiency, the aggregate expected payout per period is higher when all shares are held by type X traders. Thus, the percentage of shares held by type X subjects (PCTX) can be interpreted as a measure of allocational efficiency.

TABLE 2 Descriptive statistics

		Periods 1–5	Periods 6–10	Periods 11–15
Private Information Market 1	Volume	10.6	9.6	9.5
	RAD	0.38	0.77	0.32
	PCTX (%)	69.6	71.6	77.0
Private Information Market 2	Volume	9.4	9.5	9.5
	RAD	0.49	0.39	0.23
	PCTX (%)	63.5	71.4	80.6
		Periods 1–5	**Periods 6–10**	**Periods 11–15**
Public Information Market 1	Volume	8.3	9.5	8.6
	RAD	0.57	0.93	0.30
	PCTX (%)	59.5	54.8	55.3
Public Information Market 2	Volume	10.4	10.4	10.0
	RAD	0.52	0.36	0.30
	PCTX (%)	68.0	74.1	78.0
		Periods 1–5	**Periods 6–10**	**Periods 11–15**
No Shock Market 1	Volume	11.2	12.9	14.0
	RAD	0.45	0.21	0.12
	PCTX (%)	64.1	69.8	78.3
No Shock Market 2	Volume	10.7	12.5	13.5
	RAD	0.45	0.32	0.22
	PCTX (%)	67.1	70.1	75.8

Note: Average trading volume, relative absolute deviation (RAD) and the average percentage of shares held at end-of-period by type X traders (PCTX) are shown for the early, middle, and late periods. Averages are first calculated for each period of each session, and then averaged over the early periods (1–5), middle periods (6–10), and late periods (11–15). Finally, the averages are again averaged across sessions by treatment.

The descriptive statistics in Table 2 indicate that the volume of trade is somewhat higher in the No Shock treatment, which serves as our control treatment and provides a basis of comparison. As for price efficiency and allocational efficiency as measured by RAD and PCTX, we do not observe striking differences across treatments. Formal statistical tests for differences in trading volume, price efficiency, and allocative efficiency are presented in the following sections.

4.2 | Market independence

Although trading across markets is restricted, subjects can observe both offers and transaction prices in the other market in real time. Our Hypothesis 1 questions whether the ability to see the other market affects prices, volumes, or efficiency. To answer this, we consider the first five periods of each session. For these periods, the three treatments are identical. In the control treatment, there is no interest rate shock. In the other two treatments, the shock occurs after Period 5. Further, the asset traded in Market 1 and Market 2 has the same underlying characteristics and the interest rate on francs is the same in both markets. The asset in these markets has

TABLE 3 Market correlations

Panel A: Correlation between average Market 1 and Market 2 volume			
Ho: Correlation $\left(\overline{\text{Vol}}_{\text{area 1}}, \overline{\text{Vol}}_{\text{area 2}}\right) = \mathbf{0}$ **Ha:** Correlation $\left(\overline{\text{Vol}}_{\text{area 1}}, \overline{\text{Vol}}_{\text{area 2}}\right) \neq \mathbf{0}$			$\boldsymbol{n} = \mathbf{30}$
Correlation	***p*-value**	**Spearman rank correlation**	***p*-value**
0.14	.46	0.20	.29
Panel B: Correlation between average Market 1 and Market 2 price			
Ho: Correlation $\left(\overline{\text{P}}_{\text{area 1}}, \overline{\text{P}}_{\text{area 2}}\right) = \mathbf{0}$ **Ha:** Correlation $\left(\overline{\text{P}}_{\text{area 1}}, \overline{\text{P}}_{\text{area 2}}\right) \neq \mathbf{0}$			$\boldsymbol{n} = \mathbf{30}$
Correlation	***p*-value**	**Spearman rank correlation**	***p*-value**
0.49	<.01	0.49	<.01
Panel C: Correlation between average Market 1 and Market 2 RAD			
Ho: Correlation $\left(\overline{\text{RAD}}_{\text{area 1}}, \overline{\text{RAD}}_{\text{area 2}}\right) = \mathbf{0}$ **Ha:** Correlation $\left(\overline{\text{RAD}}_{\text{area 1}}, \overline{\text{RAD}}_{\text{area 2}}\right) \neq \mathbf{0}$			$\boldsymbol{n} = \mathbf{30}$
Correlation	***p*-value**	**Spearman rank correlation**	***p*-value**
0.51	<.01	0.49	<.01
Panel D: Correlation between average Market 1 and Market 2 PCTX			
Ho: Correlation $\left(\overline{\text{PCTX}}_{\text{area 1}}, \overline{\text{PCTX}}_{\text{area 2}}\right) = \mathbf{0}$ **Ha:** Correlation $\left(\overline{\text{PCTX}}_{\text{area 1}}, \overline{\text{PCTX}}_{\text{area 2}}\right) \neq \mathbf{0}$			$\boldsymbol{n} = \mathbf{30}$
Correlation	***p*-value**	**Spearman rank correlation**	***p*-value**
0.36	.05	0.24	.20

Note: Average transaction prices over the first five periods are computed for each session. The private information, public information, and no shock data are pooled, as there is no difference in the treatments over the first five periods. In Panel A, correlation between a session's Market 1 and Market 2 average volumes are computed and the null hypothesis is tested. Similar tests of correlations between prices, RAD, and PCTX are presented in Panels B, C, and D, respectively.

the same fundamental value and the information available to participants is identical in Periods 1–5. As such, if subjects pay no attention to the other market, deviation from mean behavior in Market 1 and Market 2 should be uncorrelated across sessions.

Table 3 presents evidence that one market is indeed affected by trader's access to information on other markets. Although the correlation estimate is positive, we cannot reject the corresponding null for correlation of zero between volumes in Market 1 and Market 2 (Panel A). We can reject the null that correlation between the average price in Market 1 (averaged over all transactions in the first five periods) and the average price in Market 2 equals zero (Panel B). Similarly, we can reject the null that the correlation between the Market 1 RAD and the Market 2 RAD equals zero (Panel C).[12] Correlation across markets for our measure of allocative efficiency, PCTX, are also positive, but the hypothesis tests are inconclusive.

[12]The correlation between Market 1 and Market 2 prices is quite close to the correlation between Market 1 and Market 2 RAD, because the fundamental value is the same in both markets prior to the shock. The difference is in how the measures are averaged. The average price in Market 1, for example, uses each transaction in periods 1 through 5 as a data point. The RAD is calculated by first calculating the average price per period, and then using those to evaluate Equation (1).

Our evidence suggests that traders in one market are observing behavior in the other contemporaneous market. The two markets are not independent. A connection between pricing behavior in Market 1 and the corresponding behavior in Market 2 is not necessarily a sign of widespread subject irrationality. Remember that in the first periods of the session, we often observe prices much higher than the expected value. The markets have not yet reached the theoretical equilibrium. Perhaps observing the other market is useful in learning how to value shares in one's own market. A possible interpretation is that if we suppose that prices follow an adaptive dynamic process on the way to equilibrium, our results suggest that the past prices in both markets are affecting the next period's prices in both markets.

4.3 | Interest rate shock effects in Market 1

In our first two treatments, an interest rate shock is introduced after the fifth period in Market 1. Although our primary interest is to study the reaction of traders in Market 2, we first look at the effect of the shock on Market 1. Our Hypothesis 2 (in null form) is that Market 1 prices and allocations will react appropriately to the shock, because traders the shock is announced. As discussed earlier, the graphs in Panel a of Figures 1 and 2 present the price paths observed in Market 1 for the Private and Public Information treatments. The information treatment probably does not matter here, as traders in Market 1 possess the same information in both treatments. Before the shock, the prices are very often higher than the fundamental value of 100 francs. The interest rate change lowers the fundamental value to 50, but the price adjustment is not immediate. It takes several periods (perhaps a minimum of two and a maximum of eight periods from an inspection of Figures 1 and 2) to adjust. In several of our markets, the average price eventually fell below the fundamental value.

We now consider the price and allocational efficiency in the shocked markets. RAD, our measure of informational efficiency, is calculated over three intervals: Periods 1–5 (before the interest rate shock), Periods 6–10 (the middle periods), and Periods 11–15 (the last five periods). Table 4 presents paired *t*-tests comparing the same session RAD for each time interval. This table also contains similar tests comparing the allocative efficiency using PCTX averaged over the early, middle, and late trading periods.

The price efficiency results are consistent with our observations based on inspection of the price sequences presented in the figures. RAD increases across Periods 6–10 as compared to 1–5. That is, price efficiency declines immediately after the shock. But, by the end of the session, pricing has improved. RAD is then lower in Periods 11–15, as compared to RAD in Periods 1–5 or in Periods 6–10. Both differences are statistically significant at the .01 *p*-level.

The allocative efficiency measure, however, does not follow the same pattern. PCTX in early, middle, and late trading periods is not significantly different than PCTX in other trading subperiods. Our results indicate that the shock has little effect on allocative efficiency. PCTX does increase in the No Shock treatment as the experiment progresses, however, the change is not statistically significant.

4.4 | Interest rate shock effects in Market 2

Our primary research question is Hypothesis 3, which concerns what happens in Market 2 in response to the shock in Market 1. The price sequences for the Private and Public Information

TABLE 4 Shock effects on Market 1

Panel A: Price efficiency				
Ho: Market 1 RAD in periods $6-10=$ Market 1 RAD in periods $1-5$				$n=20$
Ha: Market 1 RAD in periods $6-10\neq$ Market 1 RAD in periods $1-5$				
Mean: $RAD_{6–10}$–$RAD_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.38	3.27	<.01	74	<.01
Ho: Market 1 RAD in periods $11-15=$ Market 1 RAD in periods $1-5$				$n=20$
Ha: Market 1 RAD in periods $11-15\neq$ Market 1 RAD in periods $1-5$				
Mean: $RAD_{11–15}$–$RAD_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.16	−1.71	.10	−51	.06
Ho: Market 1 RAD in periods $11-15=$ Market 1 RAD in periods $6-10$				$n=20$
Ha: Market 1 RAD in periods $11-15\neq$ Market 1 RAD in periods $6-10$				
Mean: $RAD_{11–15}$–$RAD_{6–10}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.53	−4.61	<.01	−92	<.01
Panel B: Allocative efficiency				
Ho: Market 1 PCTX in periods $6-10=$ Market 1 PCTX in periods $1-5$				$n=20$
Ha: Market 1 PCTX in periods $6-10\neq$ Market 1 PCTX in periods $1-5$				
Mean: $PCTX_{6–10}$–$PCTX_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.01	−0.42	.67	−5	.87
Ho: Market 1 PCTX in periods $11-15=$ Market 1 PCTX in periods $1-5$				$n=20$
Ha: Market 1 PCTX in periods $11-15\neq$ Market 1 PCTX in periods $1-5$				
Mean: $PCTX_{11–15}$–$PCTX_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.02	0.39	.70	12.5	.65
Ho: Market 1 PCTX in periods $11-15=$ Market 1 PCTX in periods $6-10$				$n=20$
Ha: Market 1 PCTX in periods $11-15\neq$ Market 1 PCTX in periods $6-10$				
Mean: $PCTX_{11–15}$–$PCTX_{6–10}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.03	1.19	.25	24	.34

Note: Market 1 RAD is calculated for each of the sessions with shocks, for Periods 1–5, for Periods 6–10, and Periods 11–15, as reported in Panel A. Similarly, Market 1 PCTX is averaged over these intervals, as reported in Panel B. Paired *t*-tests and Wilcoxon signed rank tests are performed to compare the RAD and PCTX over the three intervals.

treatments are contained in Panel b of Figures 1 and 2. If the markets are connected, the shock in Market 1 may be transmitted to Market 2. If Market 2 participants mistakenly believe that the changing prices in Market 1 reflect a change in fundamentals in Market 2, there would be contagion, and the RAD in Market 2 would rise in response to the shock in Market 1. We do not observe this form of contagion. We do not observe a sharp drop in prices in Market 2 as a result of the shock in Market 1 in either the Public or the Private treatment.

Another possibility is that the shock in Market 1 disrupts the information aggregation process in Market 2. If we conjecture that Market 2 prices move more quickly toward fundamentals because Market 2 participants are able to observe Market 1, then a shock in Market 1 may well disrupt the process. But to properly assess this, we need to compare both information treatments to the No Shock treatment.

In the control, there is no shock and the interest rate in both markets remains at 100%, so the expected share payoff is constant at 100 francs throughout each session. As discussed previously, Figure 3 presents average prices for the No Shock markets, our control treatment. As in the two other treatments, prices in the early portion tend to be quite a bit higher than the fundamental value of 100 francs. In later periods average prices move closer to fundamentals, although how fast and how close to 100 francs varies across sessions.

Table 5 contains the results of hypothesis tests comparing efficiency in the early, middle, and late stages of the No Shock treatment.[13] The results indicate that without an interest rate shock, both informational and allocational efficiency improve with repetition, at $p < .01$. This is not too surprising as the No Shock market environment is stationery, which ostensibly is a better condition for learning.

We now perform tests to provide evidence on the significance of differences in the behavior across our three treatment groups for Market 2. Tables 6 and 7 report comparisons of price efficiency using RAD and allocative efficiency using PCTX across treatment pairs.

For Table 6 we use a Kruskal–Wallis nonparametric test of the null hypothesis that the magnitude of the average RAD for the Private Information treatment is equal to the average RAD for the Public Information treatment. The hypothesis tests are performed comparing RAD across the treatments using the first five periods, and again for the middle five periods, and finally for the last five periods. A similar procedure is used to compare the Private Information treatment to the No Shock treatment, and the Public Information treatment to the No Shock treatment. For each paired comparison, Table 6 reports two-sided p-values. The corresponding hypothesis tests comparing allocative efficiency using average PCTX are presented in Table 7.

Since the No Shock, Private Information, and Public Information treatments are identical prior to the shock, there should be no difference in either informational or allocational efficiency in Periods 1–5, and as reported in the first columns of Tables 6 and 7, this is borne out in the Kruskal–Wallis tests on both average RAD and PCTX calculated using those periods.

After the shock, however, traders may react to the experience of the other market. If the equilibration speed in Market 2 is affected by the shock in Market 1, Market 2 RAD would be higher in both the Private and the Public information treatments, as compared to the No Shock treatment. Just after the shock, in Periods 6–10, the average RAD is lowest in the No Shock treatment 0.316, then 0.359 in the Public Information treatment, and 0.387 in the Private information treatment. This pattern is what would occur if the shock in Market 1 slows the speed at which prices move to fundamentals in Market 2. Prices would be closest to efficient in the No Shock treatment. We do observe this in both Periods 6–10 and in Periods 11–15, however, none of these differences are significant based on the Kruskal–Wallis test. Thus, we find no strong evidence to indicate that the interest rate shock impacted overall informational efficiency on our markets. The shock in Market 1 did not disrupt pricing in Market 2 enough to produce a significant difference between the RAD in the shock treatments and the RAD in the No Shock treatment.

Consistent with the informational efficiency results, we have no evidence that the interest rate shock has any effect on allocative efficiency in Market 2. We test the null hypothesis of no difference in allocative efficiency as measured by PCTX. As reported in Table 7 for each paired

[13]The tests are conducted by pooling the data from Market 1 and Market 2 and may overstate significance due to the non-zero correlation across the markets, as documented earlier in the article. To examine the robustness of the results reported in Table 5, we re-computed tests of price and allocative efficiency for Market 1 and Market 2 separately. The results are generally similar to those reported in the article for the pooled data.

TABLE 5 Efficiency in the no shock treatment

Panel A: Price efficiency				
Ho: RAD in periods 6 – 10 = RAD in periods 1 – 5				$n = 20$
Ha: RAD in periods 6 – 10 ≠ RAD in periods 1 – 5				
Mean: $RAD_{6–10}$–$RAD_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.19	−3.87	<.01	−80	<.01
Ho: RAD in periods 11 – 15 = RAD in periods 1 – 5				$n = 20$
Ha: RAD in periods 11 – 15 ≠ RAD in periods 1 – 5				
Mean: $RAD_{11–15}$–$RAD_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.27	−5.14	<.01	−99	<.01
Ho: RAD in periods 11 – 15 = RAD in periods 6 – 10				$n = 20$
Ha: RAD in periods 11 – 15 ≠ RAD in periods 6 – 10				
Mean: $RAD_{11–15}$–$RAD_{6–10}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
−0.09	−2.37	.03	−66.0	.01
Panel B: Allocative efficiency				
Ho: PCTX in periods 6 – 10 = PCTX in periods 1 – 5				$n = 20$
Ha: PCTX in periods 6 – 10 ≠ PCTX in periods 1 – 5				
Mean: $PCTX_{6–10}$–$PCTX_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.05	2.93	<.01	57.0	<.01
Ho: PCTX in periods 11 – 15 = PCTX in periods 1 – 5				$n = 20$
Ha: PCTX in periods 11 – 15 ≠ PCTX in periods 1 – 5				
Mean: $PCTX_{11–15}$–$PCTX_{1–5}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.11	4.28	<.01	84	<.01
Ho: PCTX in periods 11 – 15 = PCTX in periods 6 – 10				$n = 20$
Ha: PCTX in periods 11 – 15 ≠ PCTX in periods 6 – 10				
Mean: $PCTX_{11–15}$–$PCTX_{6–10}$	**Paired *t***	***p*-value**	**Wilcoxon**	***p*-value**
0.07	4.33	<.01	93.5	<.01

Note: Control RAD is calculated for each of the sessions in the no shock treatment for Periods 1–5, 6–10, and 11–15, as reported in Panel A. similarly, the control PCTX is averaged over these intervals, as reported in Panel B. Market 1 and Market 2 data are pooled. Paired *t*-tests and Wilcoxon signed rank tests are performed to compare the RAD and PCTX over the three trading period intervals.

comparison and trading subperiod. The Kruskal–Wallis test does not reject the null for any of the treatment pairs.

4.5 | Traders' prediction errors

To provide further insight into how traders in one market react to their observations of behavior in a contemporaneous market, at the beginning of each trading period we asked subjects to provide predictions of the average trading price in both markets for the upcoming period. Tables 8 and 9 report average prediction error (PE) for Periods 1–5, 6–10, and 11–15 calculated

TABLE 6 Informational efficiency in Market 2

	Average RAD Periods 1–5		Average RAD Periods 6–10		Average RAD Periods 11–15	
Private	0.495		0.387		0.230	
Public	0.517		0.359		0.295	
No Shock	0.450		0.316		0.221	
Comparison	χ^2	*p*-value	χ^2	*p*-value	χ^2	*p*-value
Private Public	0.05	.82	0.28	.60	0.37	.55
Private No Shock	0.37	.55	1.65	.20	0.69	.41
Public No Shock	0.28	.60	0.28	.60	1.65	.20
	Average RAD Private		**Average RAD Public**		**Average RAD No shock**	
Comparison	χ^2	*p*-value	χ^2	*p*-value	χ^2	*p*-value
Periods 1–5 Periods 6–10	1.46	.23	0.97	.33	0.82	.36
Periods 1–5 Periods 11–15	6.22	.01	1.85	.17	2.06	.15
Periods 6–10 Periods 11–15	2.77	.10	0.28	.60	0.14	.71

Note: Average RAD, for Periods 1–5, 6–10, and 11–15 are calculated for Market 2 by treatment. Kruskal–Wallis nonparametric tests are performed to compare the RAD in the private information treatment with the public information treatment, the private with the no shock, and the public with the no shock treatment. In all cases the null hypothesis is that the magnitude of the RAD is likely to be the same across the treatments. In all cases, the null hypothesis is that the magnitude of the RAD is likely to be the same across the periods.

by treatment, for both the traders' own market predictions and for the other market predictions. The average PE is computed as

$$PE = \frac{1}{5}\sum_{i=1}^{5}\frac{1}{N}\sum_{j=1}^{N}\frac{|\overline{P_i} - Fij|}{\overline{P_i}}, \qquad (2)$$

where N is the number of subjects, $\overline{P_i}$ is the period's average trading price and F_{ij} is the prediction of average trading price of subject j in period i.

We now consider Hypothesis 4, comparing prediction errors in markets with and without the shock. Tables 8 and 9 report the results for traders in Markets 1 and 2.

Panel A of each table reports average PEs for Periods 1–5, 6–10, and 11–15 by treatment. In Panel B, we conduct paired t tests, and report p-values the null hypothesis of no difference across predictions made by participants for each set of periods, early, middle, and late. We observe that after the shock at the end of Period 5, traders PEs significantly increase for predictions of Market 1, for both traders in Market 1 and Market 2. This finding is consistent with results reported earlier for RAD.

TABLE 7 Allocative efficiency in Market 2

	Average PCTX Periods 1–5		Average PCTX Periods 6–10		Average PCTX Periods 11–15	
Private	0.635		0.714		0.806	
Public	0.680		0.741		0.780	
No Shock	0.671		0.708		0.758	
Comparison	χ^2	***p*-value**	χ^2	***p*-value**	χ^2	***p*-value**
Private Public	0.46	.50	0.01	.94	0.41	.52
Private No Shock	0.07	.79	0.24	.62	0.83	.36
Public No Shock	0.57	.45	0.90	.34	0.21	.65
	Average PCTX private		**Average PCTX public**		**Average PCTX no shock**	
Comparison	χ^2	***p*-value**	χ^2	***p*-value**	χ^2	***p*-value**
Periods 1–5 Periods 6–10	1.29	.26	0.05	.82	0.21	.65
Periods 1–5 Periods 11–15	3.29	.07	2.18	.14	1.86	.17
Periods 6–10 Periods 11–15	1.38	.24	0.98	.32	0.89	.34

Note: Average PCTX, for Periods 1–5, 6–10, and 11–15 are calculated for Market 2 by treatment. Kruskal–Wallis nonparametric tests are performed to compare the PCTX in the private information treatment with the public information treatment, the private with the no shock, and the public with the no shock treatment. In all cases the null hypothesis is that the magnitude of the PCTX is likely to be the same across the treatments. In all cases, the null hypothesis is that the magnitude of the PCTX is likely to be the same across the periods.

In Panel C, we report tests of whether the average PE is significantly different across treatments using Kruskal–Wallis tests. We observe that Market 1 PEs for traders in the No Shock treatment are lower than either of the two manipulations, both when traders are predicting for their own market or the other market. Significant differences seem to be driven by poor accuracy in the two treatments with shocks (in comparison to the control No Shock treatment) for Market 1 (the shocked market) in periods after the shock. This conclusion holds for Market 1 traders predicting Market 1 trading prices (Table 8) and Market 2 traders predicting Market 1 trading prices (Table 9). These results suggest that the shock, whether it is private or public information, can cause significant confusion among traders as to pricing.

5 | DISCUSSION AND CONCLUDING REMARKS

This article reports the results of experimental asset markets in which market participants trade shares over 15 periods. Each period is a repetition in the sense that cash and shares are reset. Two markets are run simultaneously, but subjects can only trade in the market to which they are assigned. Subjects can observe the bids, asks, and transactions in both markets as they occur.

TABLE 8 Prediction error in Market 1

Panel A: Average prediction error by Market 1 traders

	Prediction error for own market (Market 1)			Prediction error for other market (Market 2)		
Treatment	Periods 1–5	Periods 6–10	Periods 11–15	Periods 1–5	Periods 6–10	Periods 11–15
Private	0.090	0.246	0.122	0.107	0.074	0.053
Public	0.094	0.221	0.159	0.087	0.052	0.046
No Shock	0.082	0.081	0.049	0.094	0.070	0.053

Panel B: Period comparisons

	Prediction error for own market (Market 1)			Prediction error for other market (Market 2)		
Treatment comparison	Periods 6–10 to Periods 1–5	Periods 11–15 to Periods 1–5	Periods 11–15 to Periods 6–10	Periods 6–10 to Periods 1–5	Periods 11–15 to Periods 1–5	Periods 11–15 to Periods 6–10
Private	0.156 (< 0.01)	0.032 (0.43)	−0.124 (0.04)	−0.033 (0.05)	−0.055 (< 0.01)	−0.022 (0.23)
Public	0.127 (< 0.01)	0.065 (0.49)	−0.062 (0.20)	−0.035 (<0.05)	−0.042 (0.02)	−0.006 (1.00)
No Shock	−0.042 (0.06)	−0.074 (< 0.01)	−0.032 (0.01)	−0.024 (0.15)	−0.041 (< 0.01)	−0.017 (0.08)

Panel C: Treatment comparisons

	Prediction error for own market (Market 1)			Prediction error for other market (Market 2)		
Treatment comparison	Periods 1–5	Periods 6–10	Periods 11–15	Periods 1–5	Periods 6–10	Periods 11–15
Private Public	0.143 (0.71)	0.366 (0.55)	0.00 (1.00)	0.571 (0.45)	1.12 (0.29)	0.006 (0.94)
Private No Shock	2.176 (0.14)	8.258 (0.00)	6.228 (0.01)	0.092 (0.76)	0.006 (0.94)	0.006 (0.94)
Public No Shock	2.522 (0.11)	11.071 (0.00)	5.147 (0.02)	0.092 (0.76)	1.043 (0.31)	0.280 (0.60)

Note: Panel A of the table reports average prediction errors for Periods 1–5, 6–10, and 11–15 by treatment for traders in Market 1. Panel B compares prediction errors across these segments. The average difference in prediction errors is shown in the top row of Panel B. The bottom row contains the p-value from a two-tailed Wilcoxon signed-rank nonparametric test that the difference in prediction errors across the specified segments equals zero. Panel C compares prediction errors across treatments. Panel C reports the results of Kruskal–Wallis nonparametric tests of the null hypothesis of no difference across paired treatment comparisons. p-values appear in parentheses below each χ^2 statistic.

TABLE 9 Prediction error in Market 2

Panel A: Average prediction error by Market 2 traders

Treatment	Prediction error for own market: Periods 1–5	Periods 6–10	Periods 11–15	Prediction error for other market: Periods 1–5	Periods 6–10	Periods 11–15
Private	0.095	0.046	0.048	0.091	0.320	0.167
Public	0.082	0.051	0.041	0.085	0.233	0.103
No Shock	0.082	0.065	0.049	0.114	0.076	0.041

Panel B: Period comparisons

Treatment Comparison	Prediction error for own market (Market 2): Periods 6–10 to Periods 1–5	Periods 11–15 to Periods 1–5	Periods 11–15 to Periods 6–10	Prediction error for other market (Market 1): Periods 6–10 to Periods 1–5	Periods 11–15 to Periods 1–5	Periods 11–15 to Periods 6–10
Private	−0.049 (< 0.01)	−0.047 (< 0.01)	0.002 (0.92)	0.229 (<0.01)	0.077 (0.23)	−0.153 (0.05)
Public	−0.031 (< 0.01)	−0.040 (< 0.01)	−0.010 (0.56)	0.148 (<0.01)	0.018 (0.38)	−0.130 (0.03)
No Shock	−0.017 (0.42)	−0.033 (0.03)	−0.016 (0.16)	−0.037 (0.08)	−0.073 (<0.01)	−0.036 (<0.01)

Panel C: Treatment comparisons

Treatment Comparison	Prediction error for own market (Market 2): Periods 1–5	Periods 6–10	Periods 11–15	Prediction error for other market (Market 1): Periods 1–5	Periods 6–10	Periods 11–15
Private Public	0.280 (0.60)	0.280 (0.60)	0.366 (0.55)	0.463 (0.50)	1.286 (0.26)	0.516 (0.47)
Private No Shock	0.572 (0.45)	0.572 (0.45)	0.070 (0.79)	1.2867 (0.26)	7.8287 (0.01)	3.8658 (0.05)
Public No Shock	0.366 (0.55)	0.280 (0.60)	0.692 (0.41)	2.2874 (0.13)	11.071 (0.00)	8.2576 (0.00)

Note: Panel A of the table reports average prediction errors for Periods 1–5, 6–10, and 11–15 by treatment for traders in Market 2. Panel B compares prediction errors across these segments. The average difference in prediction errors is shown in the top row of Panel B. the bottom row contains the *p*-value from a two-tailed Wilcoxon signed-rank nonparametric test that the difference in prediction errors across the specified segments equals zero. Panel C compares prediction errors across treatments. Panel C reports the results of Kruskal–Wallis nonparametric tests of the null hypothesis of no difference across paired treatment comparisons. *p*-values appear in parentheses below each χ^2 statistic.

In two of our treatments, an interest rate shock is administered in one market (Market 1) after the fifth period. The interest rate in the other market (Market 2) is not shocked. In the Public Information treatment, the interest rate change is announced to participants in both markets, but in the Private Information treatment Market 2 subjects are not informed. Our main research question concerns whether the shock in Market 1 affects behavior in Market 2. This information is irrelevant to Market 2 in the sense that the fundamental value of the asset is unaffected.

The evidence presented in this paper suggests that trade in synchronous markets is connected. Because behavior across segmented markets is significantly correlated when the drivers of fundamental value are identical, we conclude that traders in one market refer to information about the other market when trying to achieve efficient pricing.

We find no evidence of contagion. The shock in Market 1 is not mistakenly transmitted to Market 2. We also examine whether the shock in Market 1 interferes with the speed to which prices move to fundamentals in Market 2. In Periods 6–10 and 11–15, RAD is lowest in the No Shock treatment, but the difference is not significant at standard significance levels.

Prior experimental research suggests that contagion of irrelevant information across markets can lead to poor outcomes (Camerer & Weigelt, 1991). In contrast, our evidence suggests that traders learn through observation. We do not observe contagion. Furthermore, while much archival research suggests that traders overreact to information, recent experimental work indicates that this is not a universal phenomenon. Marquardt et al. (2019) report that traders do not overreact to a shock in their experimental asset markets. In fact, Fink et al. (2020) find that market prices *underreact* to fundamental information. Future research is encouraged to probe into the impact of context and design on outcomes. Camerer and Weigelt (1991) posit that pricing improves with a shared dividend structure across traders, trading experience, or sequential information distribution in the case of private information.

An important caveat of our study is that traders are restricted to trade in one market. As we discussed in this paper, restrictions in naturally occurring markets have eased in recent years, yet pricing differences across markets have persisted. Future research to provide additional insight into information use across contemporaneous markets that are not fully segmented is encouraged.

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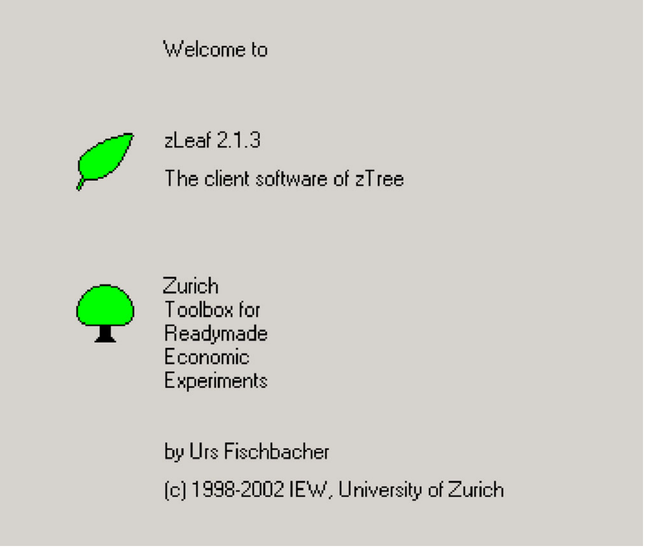
APPENDIX: EXPERIMENTAL INSTRUCTIONS

The computerized double asset markets were conducted using Z-tree. Participants were given the following written instructions and asked to follow along with recorded instructions. Instructions for the No Shock treatment follow. At the end of the instructions, the information sheets provided to traders regarding the treatments with interest rate shocks are provided.

A.1. | Instructions

We are about to begin an asset market experiment where you can trade a stock using experimental currency. The experiment is conducted in a computerized electronic market. We will describe to you how this market works and your interface with it.Please raise your hand and let the experimenter know if you do not see the following screen on your computer:



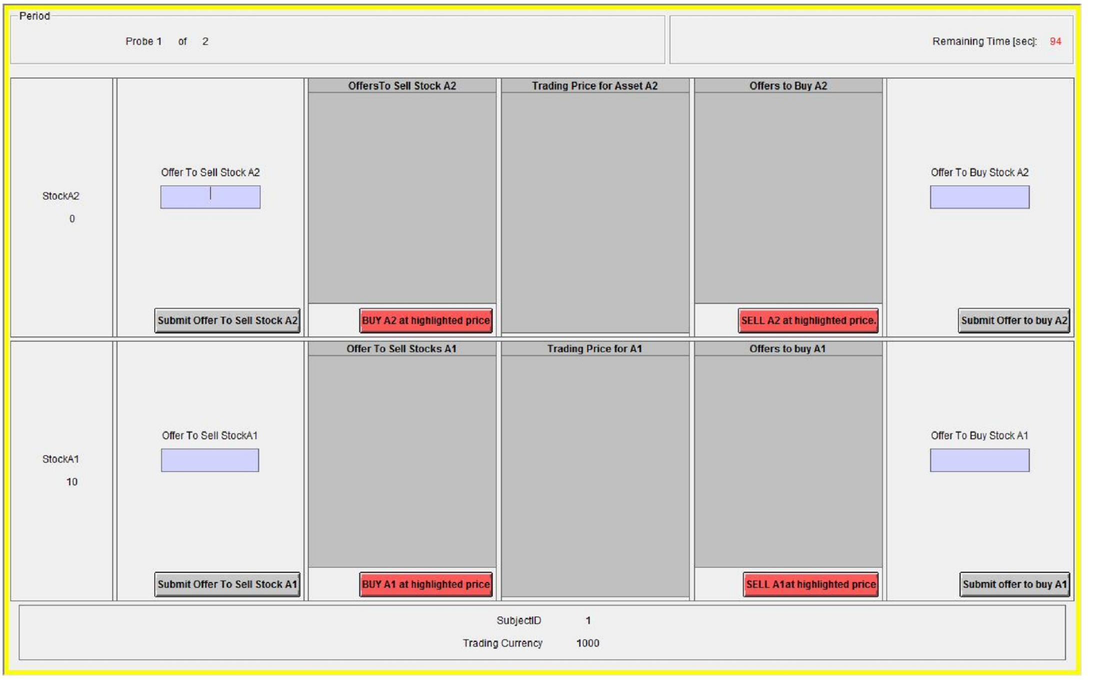
Please follow along the recorded instructions. Feel free to ask questions at any time. We will practice trading on the computer before the actual market begins.

A.1.1. | Trading screen

The left upper corner of the screen shows you the current trading period and the total number of trading periods we are going to play today. The right upper corner shows the remaining *seconds* of the *current* trading period. In today's experiment, each trading period is 2 min.

There is one asset (Stock A) in today's experiment. Stock A is traded in two areas: Area A1 and Area A2. Each trader is permitted to transact in only one area throughout the entire experiment. Later you will learn which area you can trade in but now we will review the information provided on the trading screen. Though you will trade in only one area, trading activity in both areas will be visible to all.

The bottom of the screen displays your participant ID and the money you have in your portfolio. We will call the experimental currency francs.The rest of the screen is divided into two horizontal boxes, one for each area (A2 and A1).



On the left of each horizontal box, you will see the number of units of the stock in your portfolio. The above window indicates that you have 10 units of Stock A in your portfolio right now and you can trade in Area A1. The next column is where traders in the area can submit offers to sell Stock A; right next to it is the column of existing offers submitted to the area to sell Stock A. The middle column is the trading price for Stock A. The next column on the right shows existing offers submitted in to buy Stock A. The last column on the very right of the screen is where offers to buy Stock A in this area are submitted.

A.1.2. | To sell or buy a stock

You **will not be able to delete or change an offer** to sell or buy after you submit it, so make sure the price you type is correct before you hit the "Submit Offer" button. In addition, remember that you can only trade *one unit at a time*, therefore there is no need to specify the quantity you wish to trade.

To place an offer to sell a stock, type the price you want to sell it for in the cell under the label "Offer to Sell Stock *A*." Click the button "Submit Offer to Sell Stock *A*" to send your offer. Your offer will be posted in the column of "Offers to Sell Stock *A*," which is to the right of the column where you submitted your offer. Once you submit an offer either to buy or sell, *you are committed to that offer until someone accepts the offer, or, if no one accepts your offer, until the end of the current trading period.*

Follow the same steps to place an offer to buy a stock. The column to submit buying offers and the column showing the current submitted buying offers are laid symmetrically to the right of the box for each area. The offers are displayed in descending order using submitted prices. **Accepting an offer results in a trade.** If you would like to accept any of the offers (either to buy or sell a stock) submitted to the area, click the red "accept" button.

Note that accepting an offer from the column of "Offers to Sell Stock *A*" means that you are buying that stock from the participant who submitted the offer, while accepting an offer from the column of "Offers to Buy Stock *A*" means that you are selling that stock to the participant who submitted the offer at the specified price. After the transaction, the corresponding units of the stock you traded and the francs left in your portfolio will be updated and the trading price will be posted in the middle column of "Trading Price for *A*." Meanwhile, the offer will be eliminated from the column of existing offers.

Notice that there are two ways to sell a stock. First, an offer to sell that you have submitted may be accepted by another trader. Second, you can accept another trader's offer to buy.

Similarly, there are two ways to buy a stock. First, an offer to buy that you have submitted may be accepted by another trader. Second, you can accept another trader's offer to sell.

There are a few restrictions regarding submitting and accepting offers when trading.

They are summarized as follows:

In today's experiment, half of the participants will trade Stock A in Area A1 and the other half will trade Stock A in Area A2. You will not know exactly which participants trade in each area but, ***you can view information on the offers and transactions of both areas*** on your screen regardless of the area you trade in. You will know which area you can trade in because you will be endowed with shares of Stock A in only one area. You will not be permitted to enter offers to buy or sell or accept offers in the other area.

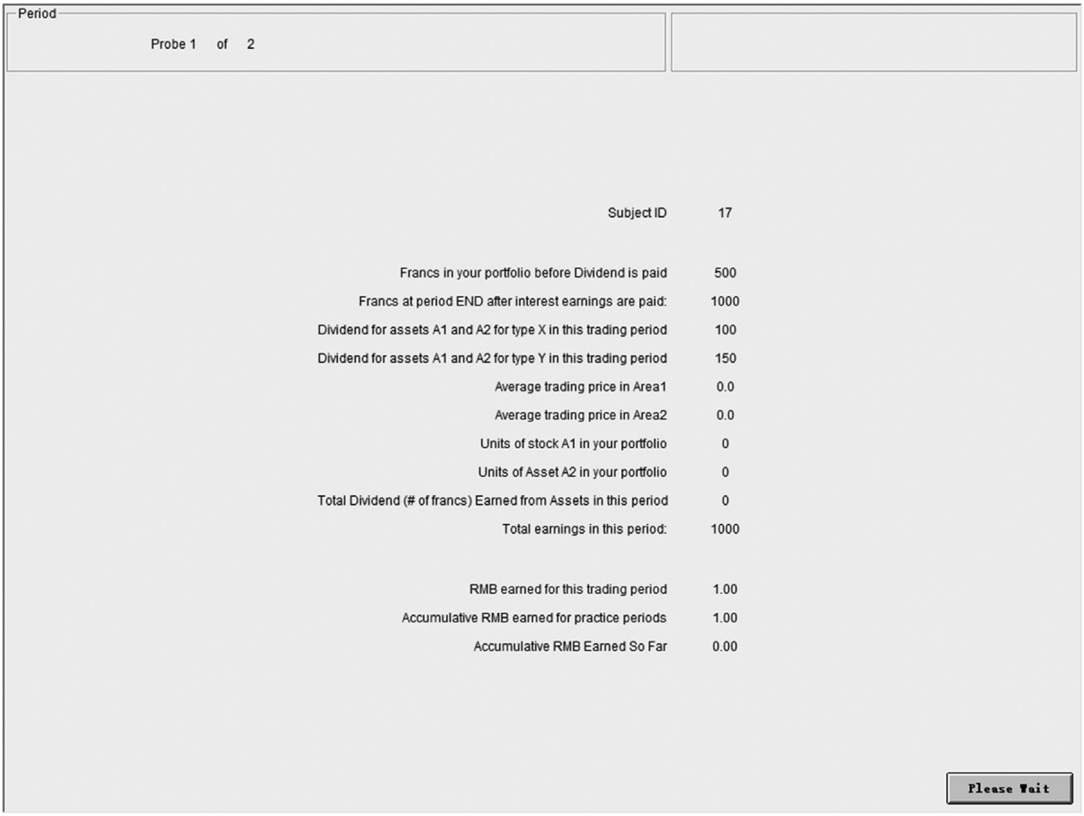
Second, you are also not allowed to trade with yourself, meaning that you cannot accept offers that you submitted. If you do so, an error message will appear.

Third, no short selling is allowed, which means that if you do not have a unit of a stock, you cannot send out an offer to sell that stock. Similarly, you cannot place a buy order if you do not have enough money left in your account. An error message will inform you of the situation.

Let us start a practice trading period.

A.1.3. | Summary screen

At the end of each trading period, a summary screen will pop up.



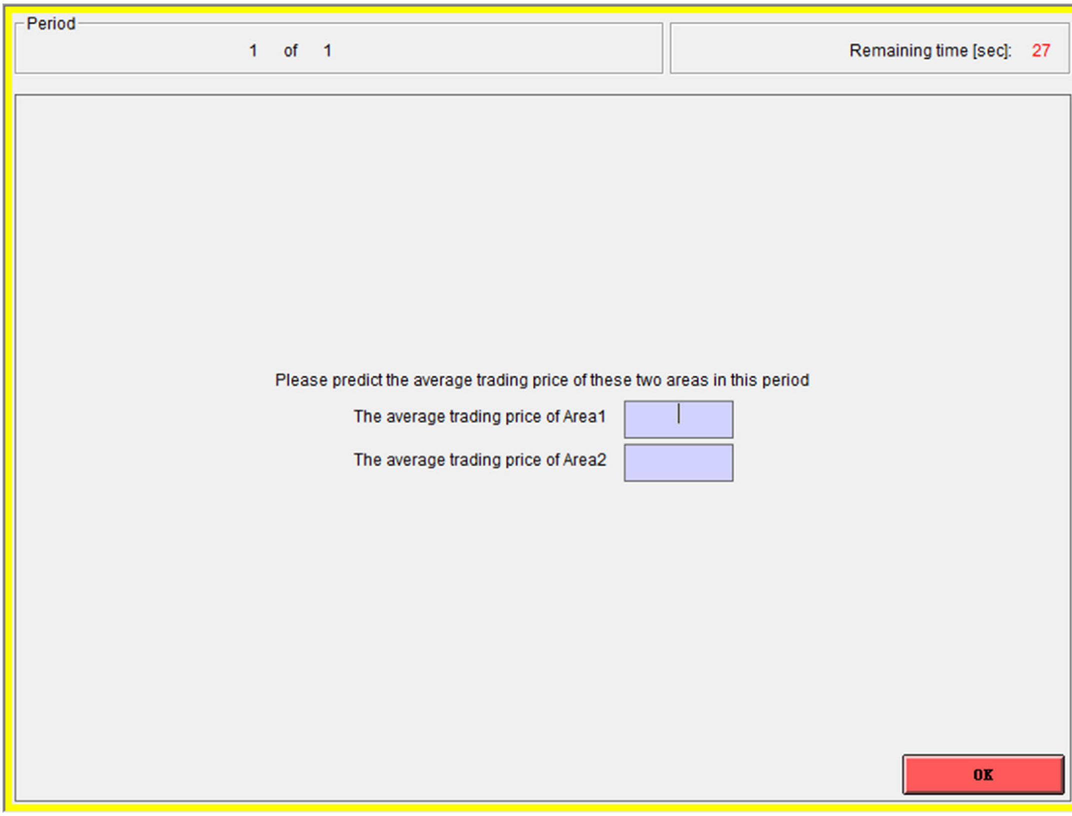
On this screen, you will see the following information:

1. Trading currency at the end of the current trading period.
2. Dividends for Stock A and the number of units of stock held in your portfolio for the current period.
3. Total dividends you earned in the current trading period.
4. Total income in francs for the current trading period.
5. RMB earned for the current trading period.
6. Cumulative RMB earned thus far in the experiment (excluding the 15 Yuan show-up fee and earnings from the prediction task).
7. Current period's average trading prices for both markets.

You will be asked to record some of the above information on a record sheet included in the folder with these instructions. After you are ready, click the “Please Wait” button to wait for all the other participants to be ready to continue to the next trading period.

Now let us talk about the experiment in which you will participate in a few minutes!

Today's experiment will include 15 trading periods. Each period lasts 2 min. There is one stock in our experiment, Stock A, which generates dividends at the end of each trading period. The trading currency is francs.At the start of each period, you will be asked to record predictions of the average trading price in both areas for the period. You will receive 50 cents RMB each period for recording predictions on your Prediction Sheet.



At the **end** of each trading period, a dividend is paid on each unit of the stock you have in your portfolio. In each area, there are two types of traders: Type X and Type Y. There are four Type X and four Type Y traders in each area. The dividend you earn on the stock is determined by which state occurs at the end of the 2-min trading period **and** your trader type. There are two possible states, State I and II. A random draw determines the state. There is one random draw per period, which determines the state for Area A1 and Area A2. The probability distributions of the realization of each state in the experiment and the dividend payoff corresponding to each state are described in the following table:

	Dividend of A trader type X (in francs)	Dividend of A trader type Y (in francs)
State I ($p = .50$)	300	50
State II ($p = .50$)	100	150

Notice that the expected payoff for the stock is 200 francs for Type X traders because half the time they earn 300 francs and the other half of the time they earn 100 francs. The expected payoff for the stock is 100 francs for Type Y traders because

half the time they earn 50 francs and the other half of the time they earn 150 francs. Remember that the stock lasts only one period so that at the beginning of each trading period your holdings begin again at your initial endowment.

A.1.4. | How do you earn your payoff?

Remember that your cash payoff is determined by the dividends you earn on stocks ***and*** *the francs in your portfolio at the end of each trading period.*

In addition to dividend earnings on the stock, you hold at the end of a period, the cash you hold in francs earns interest during each period. In fact, each franc you have in cash *before dividends are paid* will be worth **two** francs at the end of a period.

For example, if you hold two shares and the dividend is 100, your dividend earnings are 200 francs. If you have 1000 in trading currency, your total earnings are 200 + 1000*2 = 2200 francs.

To convert your earnings into RMB Yuan, multiply the total francs you have earned at period end (including interest) by 0.00075.

A.1.5. | Summary of important points

Before we start our practice trading game, let me remind you of a few important points:

1. At the beginning of each period you will record predictions of the average price in Areas A1 and A2
2. On your Record Sheet, you will see your initial endowments, trader type (X or Y), and the area you trade in (A1 or A2). You can always view information about both areas. Your trader type will be the same for the entirety of the experiment. Likewise, you will trade in only one area for the entirety of the experiment.
3. Recall the dividend information on the stock for the two trader types

	Dividend of A trader type X (in francs)	Dividend of A trader type Y (in francs)
State I ($p = .50$)	300	50
State II ($p = .50$)	100	150

4. Each franc you have in cash *before dividends are paid* is worth **two** francs at the end of a period.
5. Earnings in RMB are computed by multiplying total francs at period end (dividends plus cash with interest) by the conversion rate of 0.00075.
6. At the end of each 2-min trading period, record your francs, shares held, and the earnings in RMB on the record sheet given to you.
7. At the beginning of each period, your starting endowment of francs and Stock A will appear at the bottom of your trading screen. Units of stock **do not** carry forward across periods. Your endowment will be the same at the beginning of each trading period.

Now let us practice trading.

Traders in the private information treatment were given the following written instructions, the first for Area 1 and the second for Area 2.

A.2. | Information for traders in Area A1

For the remainder of the trading periods, the interest earned on francs held at the end of the trading period is increased for traders in Area A1. Now, each franc you have in cash *before dividends are paid* will be worth **four** francs at the end of a period. Nothing else is changed for traders in Area A1: that is, all other procedures and parameters are exactly the same as in Periods 1–5.

A.3. | Information for traders in Area A2

Nothing is changed in Area A2: that is, all procedures and parameters are exactly the same as in Periods 1–5.

All traders in Public Information Treatment were given the following written instructions.

A.4. | Information for traders

For the remainder of the trading periods, the interest earned on francs held at the end of the trading period is increased for traders in Area A1. Now, each franc held in cash *before dividends are paid* will be worth **four** francs at the end of a period. Nothing else is changed for traders in Area A1: that is, all other procedures and parameters are exactly the same as in Periods 1–5.

Nothing is changed in Area A2: that is, all procedures and parameters are exactly the same as in Periods 1–5.