Can Restricting Participation Improve Market Efficiency? An Experimental Investigation

Duan Liu* Daniel E. Houser†

March 7, 2026

Abstract

Financial regulations sometimes restrict smaller institutional and individual traders from accessing certain higher-risk assets. The reason is to protect individual traders from losses that may incur when trading against larger, more powerful institutional investors. Such regulations limit individual traders' access to these markets by classifying them as potentially unfavorable for disadvantaged trader groups. The theory developed in Anthropelos and Kardaras (2024) indicates that trading restrictions can increase market efficiency when assets are substitutable and trader groups hold heterogeneous beliefs about return covariances, leading to a separation between advantaged and disadvantaged groups. Here, we use an experimental approach to investigate the effects of trading restrictions across different environments. Our results support Anthropelos and Kardaras (2024)'s theory and shed light on the value of trading restrictions and related regulatory policies.

JEL Codes: D47, G12, C90

Keywords: Market design, Restricted participation, Heterogeneous beliefs, Imperfect competition, Laboratory experiment

*Corresponding author. Department of Economics and Interdisciplinary Center for Economic Science, George Mason University. Email: dliu21@gmu.edu

†Department of Economics and Interdisciplinary Center for Economic Science, George Mason University. Email: dhouser@gmu.edu

1 Introduction

Trading restrictions are a common feature of asset markets. Traders often face exogenous constraints, which typically take the form of legislative regulations prohibiting certain types of traders from holding designated classes of assets. One prominent example is the Volcker Rule, see, for example, Whitehead (2011), which prohibits banking institutions like private equity funds and hedge funds from engaging in proprietary trading. Other restrictions include internal investment mandates constraining portfolio managers' investment strategies. Overall, asset traders do not operate freely or on equal footing. Instead, different types of traders are subject to heterogeneous restrictions.

A natural assumption is that, in the absence of such restrictions, large institutional traders would acquire greater market power in asset markets. Asset markets are often characterized as thin markets in the financial literature, see Rostek and Weretka (2015). In thin markets, traders are not price-takers. Rather, they possess market power; they can influence asset prices; and they recognize the non-competitive nature of the market. This characterization aligns with the current state of financial markets. As estimated by Bretscher et al. (2025), 45-50 % of total corporate bonds are held by institutional traders. Moreover, Schwartz and Shapiro (1991) reports that institutional traders in the United States account for 72 % of share volume on the New York Stock Exchange, 73 % on the London Stock Exchange, and 77 % on the Tokyo Stock Exchange. Other related studies document similar findings, for example Medina et al. (2022).

Another important aspect of thin financial markets is heterogeneity in investors' hedging needs, which notably affects traders' strategies. Theoretical studies, including Rostek and Weretka (2015), Malamud and Rostek (2017), and Anthropelos et al. (2020), demonstrate that investor heterogeneity (e.g., differences in risk aversion and payoff expectations), can significantly influence market efficiency. Thus, it remains an important consideration in market mechanism design.

Our experiment extends the model of Anthropelos and Kardaras (2024) by focusing on how heterogeneous beliefs about the second moments of asset payoffs generate heterogeneous hedging needs, interact with trading restrictions, and ultimately affect market efficiency. As predicted by this model, when traders hold heterogeneous beliefs, partially restricting trading participation can improve total market efficiency under appropriate designed regulations. This theoretical setting corresponds closely to real world financial regulation. In practice, existing regulations restrict certain groups of investors from trading specific assets. The underlying presumption is that such restrictions protect market welfare. While these regulations remain a subject of debate, theory suggests that they may enhance market efficiency when properly designed. Understanding how asset trading restrictions affect market efficiency is therefore essential for assessing whether such regulations can improve financial markets. Our experiment aims to advance this understanding and provide results that may be applicable to a wide range of settings in which trading restrictions are imposed through regulation.

To study the joint effects of trading restrictions and heterogeneous hedging needs arising from heterogeneous beliefs about the second moments of asset returns, we conduct laboratory experiments with treatments that vary along both the presence of trading restrictions and the degree of hedging needs. Our design restricts a subset of traders from trading designated types of assets to capture key features of regulatory constraints. We also generate heterogeneous hedging needs by assigning different covariance matrices of asset returns to traders. Subjects submit bids in a virtual asset market. We then measure total market revenue and equilibrium prices. By comparing outcomes across treatments, we examine how trading restrictions can enhance market efficiency in the presence of heterogeneous hedging needs.

We find that trading restrictions increase total market revenue. Notably, this improvement occurs regardless of whether the partially restricted traders belong to the advantaged or the disadvantaged group, which is consistent with the theoretical predictions.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 presents the model, hypotheses, and institutional context. Section 4 describes the experimental design and treatments. Section 5 presents the experimental results. Section 6 discusses the findings and concludes.

2 Literature Review

Our work contributes to the theoretical financial microstructure literature, for example Wilson (1979), Kyle (1989), and Vives (2011), and follows the experimental tradition of Smith (1982) by implementing double auctions in a laboratory setting. Within the financial microstructure literature, we contribute more specifically to the strand focusing on thin markets, such as Vayanos (1999), Vives (2010), and Rostek and Weretka (2015), which departs from the price taking paradigm and minimizes the role of noisy traders. In the literature, thin markets are non-competitive financial markets in which each participant has market power, internalizes their price impact, and acts strategically. Consequently, equilibrium outcomes are described by noncompetitive Bayesian Nash equilibria. A growing body of work studies asset market mechanism design in thin markets from various perspectives. For instance, Malamud and Rostek (2017), Chen and Duffie (2021), Rostek and Yoon (2021), and Wittwer (2021) analyze noncompetitive equilibria in fragmented asset markets. Rostek and Yoon (2024) and Rostek and Yoon (2025) further examine the role of derivative assets in thin markets. Our experimental approach is also grounded in a thin market environment.

The literature discussed above addresses heterogeneous hedging needs arising from differences in traders' risk aversion, demand conditions, and expectations about asset returns. By contrast, most thin market models assume that all traders share the same beliefs about the covariance matrix of asset returns. This assumption differs from the framework of Anthropelos and Kardaras (2024), which is directly related to our study. Related discussions also appear in Duchin and Levy (2010). Our experiment follows the model of Anthropelos and Kardaras (2024) and examines the efficiency effects of restricted participation in asset markets, relaxing the assumption that all traders agree on the covariance matrix of asset returns.

Our work further contributes to the literature on restricted participation in financial markets, including Duffie (1987), Polemarchakis and Siconolfi (1997), Basak and Cuoco (1998), Cass (2006), Hens et al. (2006), and Aouani and Cornet (2009), which study markets with constrained anticipation sets. However, while these papers typically assume that market participants are price-takers, our study considers traders with market power who can strategically influence prices. In our restricted participation framework, prices are endogenously determined through traders' conscious price impact.

As an experimental investigation, our paper is among the few studies that examine thin financial microstructure models using laboratory experiments. For example, Bayona et al. (2020) investigates how private cost signals affect Bayesian supply function equilibria when experimental participants compete by submitting supply functions. To the best of our knowledge, our study is the first experimental analysis of the interaction between trading restriction and thin asset markets. It is also the first experimental setting in which subjects engage in supply function competition while a subset of participants is restricted from trading.

3 Model

We consider a uniform-price double auction market model with Gaussian payoffs on multiple risky assets, following Kyle (1989) and Anthropelos and Kardaras (2024). The market is with I $\geq$ 3 traders who trade K risky assets. Traders are identified by i, while assets are identified by k. Each trader i has access to a specified set of assets $K^i \subseteq K$.

The market is represented as a uniform-price double auction in which traders submit supply schedules. Traders could be restricted from trading certain assets. Thus, each trader i submits K supply functions $q_k^i(p) = q_k^i \in \mathbb{R}; |; q_j^i = 0; \forall; j \in K; \setminus; K^i$, specifying the quantity of asset k supplied for any price p. As is the universal rule of the double auction, asset trades are established when the seller's asking price is less than or equal to the opposing buyer's bidding price.

Risky assets have jointly Gaussian payoffs $R \sim N(\delta, \Sigma^i)$, where δ represents the vector of expected payoff rates and Σ^i represents the covariance matrix. Each trader i takes actions to maximize their own utility, assumed to exhibit Constant Absolute Risk Aversion:

$$U^i(q^i) = exp(-\alpha^i(R(q^i + q_0^i) - pq^i)) \tag{1}$$

where α^i is risk aversion, p is the price vector, q^i represents the vector of realized trades, and q_0^i is the vector of initial endowment. Since the asset payoff R is normally distributed, the expected utility function can be expressed as:

$$EU = exp(-\alpha^i(\delta(q^i + q_0^i) - \frac{\alpha^i}{2}(q^i + q_0^i)\Sigma^i(q^i + q_0^i) - pq^i)) \tag{2}$$

Thus, to maximize expected utility, trader i maximizes the quadratic utility function:

$$u^i(q^i) = \delta(q^i + q_0^i) - \frac{\alpha^i}{2}(q^i + q_0^i)\Sigma^i(q^i + q_0^i) - pq^i \tag{3}$$

Taking the derivative with respect to q^i, the first-order condition for each asset indexed by k is:

$$\begin{aligned} \delta_k - \alpha^i(\Sigma_{kk}^i(q_k^i + q_{0,k}^i) + \sum_{l \neq k} \Sigma_{kl}^i(q_l^i + q_{0,l}^i) \\ = p_k + \frac{dp_k}{dq_k^i} q_k^i p + \frac{dp_l}{dq_k^i} q_l^i \end{aligned} \tag{4}$$

In matrix form, the condition for all assets becomes:

$$\delta - \alpha^i \Sigma^i (q^i + q_0^i) = p + \Lambda^i q^i \tag{5}$$

where the price impact matrix Λ^i is:

$$\Lambda^i = \frac{dp}{dq^i} = \begin{bmatrix} \frac{dp_1}{dq_1^i} & \dots & \frac{dp_k}{dq_1^i} \\ \vdots & \ddots & \vdots \\ \frac{dp_1}{dq_k^i} & \dots & \frac{dp_k}{dq_k^i} \end{bmatrix} = \begin{bmatrix} \lambda_{11}^i & \dots & \lambda_{1k}^i \\ \vdots & \ddots & \vdots \\ \lambda_{k1}^i & \dots & \lambda_{kk}^i \end{bmatrix} \tag{6}$$

where λ_{kk}^i is the price impact of trader i on asset k. The term λ_{kk}^i is proportional to the covariance matrix Σ^i due to the jointly-clearing nature of the market.

The ex-post Bayesian Nash equilibrium is then given by:

$$q^i = (\alpha^i \Sigma^i + \Lambda^i)^{-1}(\delta - p - \alpha^i \Sigma^i q_0^i) \tag{7}$$

At equilibrium, the market clearing condition satisfies:

$$\sum_{i \in I} q^i = \sum_{i \in I} (\alpha^i \Sigma^i + \Lambda^i)^{-1}(\delta - p - \alpha^i \Sigma^i q_0^i) = 0 \tag{8}$$

Rearranging, the market-clearing price vector is:

$$p = (\sum_{i \in I} (\alpha^i \Sigma^i + \Lambda^i)^{-1})^{-1} \sum_{i \in I} (\alpha^i \Sigma^i + \Lambda^i)^{-1}(\delta - \alpha^i \Sigma^i q_0^i) \tag{9}$$

Defining $X^i = (\alpha^i \Sigma^i + \Lambda^i)^{-1}$, we can rewrite the equilibrium conditions as:

$$p = (\sum_{i \in I} X^i)^{-1} \sum_{i \in I} (X^i)^{-1}(\delta - \alpha^i \Sigma^i q_0^i) \tag{10}$$

$$q^i = X^i(\delta - p - \alpha^i \Sigma^i q_0^i) \tag{11}$$

Finally, to satisfy the correct price impact condition at equilibrium, the price impact of trader i equals the Jacobian of their inverse residual supply function:

$$\Lambda^i = (\sum_{j\neq i}(\alpha^j\Sigma^j + \Lambda^j)^{-1})^{-1} \tag{12}$$

Rearranging gives:

$$(X^i)^{-1} = \alpha^i\Sigma^i + \sum_{j\neq i}(X^j)^{-1} \tag{13}$$

For simplicity, we restrict our experiment to the environment where $K = 2$. At the same time, we assign no value to the initial endowment; in other words, we set $q_0^i = 0$. The equilibrium conditions thus become:

$$p = (\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta \tag{14}$$

$$q^i = X^i(\delta - p) \tag{15}$$

where the individual quadratic utility function is simplified to:

$$u^i(q^i) = \delta q^i - \frac{\alpha^i}{2} q^i\Sigma^i q^i - pq^i \tag{16}$$

The aggregate utility of the market, with the equilibrium conditions substituted, is thus:

$$\begin{aligned}\sum_{i\in I} u^i = \sum_{i\in I}(\delta X^i(\delta - (\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta)\\ -\frac{\alpha^i}{2} X^i(\delta - (\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta)\Sigma^i X^i(\delta - (\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta)\\ -(\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta X^i(\delta - (\sum_{i\in I} X^i)^{-1} \sum_{i\in I} (X^i)^{-1}\delta))\end{aligned} \tag{17}$$

The core takeaway from the aggregate utility equation above is that the aggregate welfare of the market is solely determined by factors contributing to traders' hedging needs, including each trader's risk aversion, covariance matrix, and price impact. Hence, by restricting some traders from accessing certain assets, the aggregate utility can be altered, as the price impact is also impacted by the restrictions. In the experimental design section, we provide an example where the aggregate utility of the market increases due to imposed exogenous restrictions.

4 Experimental Design

Our experiment applies a double auction method. In each trading session, four subjects act as sellers, selling virtual assets (Circle Widgets and Square Widgets) to a computerized buyer. Both types of Widgets are solely for sale revenue and provide no payoff for the sellers. Each subject initially receives 100 units of Circle Widgets and 25 units of Square Widgets, and submits a linear supply schedule $P = C^iQ$ for both types of Widgets simultaneously by selecting a constant slope C^i_k. The computerized buyer observes all units offered by the sellers and purchases the cheapest 100 units of Circle Widgets and the cheapest 25 units of Square Widgets. In other words, the computerized buyer has an inelastic demand of 100 units for Circle Widgets and 25 units for Square Widgets. The market prices of assets are determined by the intersection of the market supply schedule and the inelastic demand schedule. All assets are purchased at market prices.

When the main session concludes, participants are asked to complete the Holt and Laury (2002) risk preference task and a demographics survey. The experiment then ends. The 2000 experimental cash have an equal value of one US dollar. A random draw decides which round will determine payment to each participant. Participants are privately paid in US dollars at the end of the experiment based on the experimental cash they accumulated in the randomly drawn round.

Due to the small number of suppliers, the environment is imperfectly competitive. Thus, we expect traders to have a considerable price impact and to act strategically, as emphasized in the tradition of Kyle (1989). The market power and its influence on market efficiency is observable by measuring the asks and trading volumes.

Using the previously mentioned endowed assets, in all treatments, subjects participate in four training rounds and sixteen rounds with payment, for a total of twenty rounds. Each subject faces a trading cost function. Each round lasts for two minutes, or until all four subjects in the round have made their asking decisions. Following each round, subjects receive their payoff, calculated as their selling revenue minus the trading cost.

To represent an environment mimicking real financial markets with regulations restricting trading, we use a 2×2 treatment model. In this experiment, we focus on two main factors of interest: Asset Payoff Correlation (which creates heterogeneous hedging needs) and Trading Restriction.

In the Trading Restriction treatment, among the four subjects, the subject with index 1 receives 100 units of Circle Widgets, and thus cannot ask for any Square Widgets. All other subjects receive 100 units each of Circle Widgets and 25 units of Square Widgets. Subjects can submit asks for both types of Widgets. In the No Trading Restriction treatment, all subjects receive 100 units of Circle Widgets and 25 units of Square Widgets and can ask for both types of Widgets.

To create heterogeneous hedging needs, subjects have different asset payoff correlations, represented by heterogeneous trading cost functions based on their subject index in a round and the treatment variable.

In the Negative Asset Correlation (Substitute) treatment, if the subject index is 1 or 2 in a round, the trading cost function is:

$$\begin{aligned} Cost = 5 * ((units\ of\ Circle\ sold)^2 + (units\ of\ Square\ sold)^2) \\ +3 * (units\ of\ Circle\ sold) * (units\ of\ Square\ sold) \end{aligned} \tag{18}$$

In the Positive Asset Correlation (Complement) treatment, if the subject index is 1 or 2 in a round, the trading cost function is:

$$Cost = 5 * ((units\, of\, Circle\, sold)^2 + (units\, of\, Square\, sold)^2) \\ -3 * (units\, of\, Circle\, sold) * (units\, of\, Square\, sold) \tag{19}$$

In both the Complement and Substitute treatments, if the subject index is 3 or 4 in a round, the trading cost function is:

$$Cost = 5 * ((units\, of\, Circle\, sold)^2 + (units\, of\, Square\, sold)^2) \tag{20}$$

Therefore, subjects have different asset payoff correlations, leading to heterogeneous hedging needs. For example, in the Negative Asset Correlation (Substitute) treatment, the final payoff function of subjects 1 and 2 is thus:

$$Price\, of\, Circle * units\, of\, Circle\, sold + Price\, of\, Square * units\, of\, Square\, sold \\ -5 * ((units\, of\, Circle\, sold)^2 + (units\, of\, Square\, sold)^2) \\ +3 * (units\, of\, Circle\, sold) * (units\, of\, Square\, sold) \tag{21}$$

While the final payoff function of subjects 3 and 4 is:

$$Price\, of\, Circle * units\, of\, Circle\, sold + Price\, of\, Square * units\, of\, Square\, sold \\ -5 * ((units\, of\, Circle\, sold)^2 + (units\, of\, Square\, sold)^2) \tag{22}$$

Note that the payoff functions of all subjects are direct translations of the quadratic utility function (16) in the model. By this method, we affirm that the experiment adheres to the model, and we are able to establish the hypotheses based on the model.

As illustrated by the model, at the Bayesian Nash Equilibrium of the four subjects, the correct price impact condition (13) must be met. Here, we use the parameters from the

Substitute treatment as an example. For simplicity of calculation, assuming traders are risk neutral, when no trading restriction exists and asset payoffs are negatively correlated, for the four subjects, X^i are respectively:

$$X^1 = X^2 = \begin{bmatrix} 0.0897 & -0.0444 \\ -0.0444 & 0.0897 \end{bmatrix} \qquad X^3 = X^4 = \begin{bmatrix} 0.0689 & -0.0087 \\ -0.0087 & 0.0689 \end{bmatrix} \tag{23}$$

When trading restrictions do exist, as in the treatment, X^i for the four subjects become:

$$X^1 = \begin{bmatrix} 0.0318 & 0 \\ 0 & 0 \end{bmatrix} \qquad X^2 = \begin{bmatrix} 0.0630 & -0.0160 \\ -0.0160 & 0.0630 \end{bmatrix} \tag{24}$$

$$X^3 = X^4 = \begin{bmatrix} 0.0606 & 0.0029 \\ 0.0029 & 0.0606 \end{bmatrix} \tag{25}$$

Note that X^i is a negatively-sloped function of the price impact. In the example above, when no trading restriction exists, X^i is more imbalanced compared to the situation where the restriction exists. The imbalanced market power comes from the heterogeneous hedging needs of traders. Thus, by imposing trading restrictions on the market, we expect traders to have more balanced market power, as in this example.

We expect the market to be more efficient as well. Recalling the aggregate utility function at the market level (17), given that the risk aversion level, the covariance matrix, and the payoff vector are assigned, X^i is a sufficient statistic for the aggregate utility. Therefore, plugging the induced X^i back into the aggregate utility function, we find that the aggregate utility is expected to rise at the market level when the previously mentioned trading restriction is imposed. We thus hypothesize that market revenue, as a direct translation of the aggregate utility, would rise under the Trading Restriction treatments, as compared to the No Trading Restriction treatments. Moreover, based on the model predictions, we hypothesize that greater market revenue would be achieved regardless of whether the treatment includes Negative Asset Correlation or Positive Asset Correlation, provided the treatment is shifted from No Trading Restriction to Trading Restriction.

Through the above parametric analysis and definition of measurement, we obtain the following four hypotheses based on the theoretical predictions:

Hypothesis 1: A higher market price will be achieved under the Trading Restriction/Substitute treatment, compared to the No Trading Restriction/Substitute treatment.

Hypothesis 2: A higher market price will be achieved under the Trading Restriction/Complement treatment, compared to the No Trading Restriction/Complement treatment.

Hypothesis 3: A higher market revenue will be achieved under the Trading Restriction/Substitute treatment, compared to the No Trading Restriction/Substitute treatment.

Hypothesis 4: A higher market revenue will be achieved under the Trading Restriction/Complement treatment, compared to the No Trading Restriction/Complement treatment.

The hypotheses focus on the efficiency-increasing effect of trading restrictions under an imperfectly competitive environment with initially imbalanced market power.

5 Results

The experiments were programmed in Otree (Chen et al. (2016)). We conducted all experiments at George Mason University from June 2025 to October 2025. A total of 192 students participated in our experiments (48 subjects in each treatment). We ran 12 sessions for each treatment, totaling 48 sessions. The experiments lasted about an hour and a half. Subjects could earn $18 on average (including the $10 show-up fee). We report the demographics summary in the table below:

	UnRes Substitute	Res Substitute	UnRes Complement	Res Complement
Age	24.04	23.94	21.85	22.26
Male	62.5%	60.42%	58.33%	54.17%
Risk Aversion	5.17	4.73	4.67	4.52
Sessions	240	240	240	240
Subjects	48	48	48	48

Table 1: Summary Statistics

We first test Hypotheses 1 and 2, which relate to trading prices. Given that trading restrictions are imposed on the Square Widgets under treatments with restrictions, only the market prices of the Circle Widgets are reasonable to compare. The results are shown in the following figures:

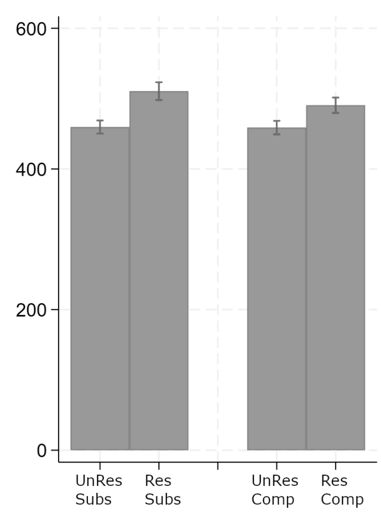


Figure 1: Prices of Circle Widgets under all treatments

We find a significant difference in trading prices between the Trading Restriction/Substitute treatment and the No Trading Restriction/Substitute treatment (trading price of Circle Widgets, Wilcoxon Ranksum test, p-value < 0.0001). Similarly, we find a significant difference in trading prices between the Trading Restriction/Complement treatment and the No Trading Restriction/Complement treatment (trading price of Circle Widgets, Wilcoxon Ranksum test, p-value < 0.0001). Thus, we qualitatively fail to reject both Hypothesis 1 and Hypothesis 2 and conclude our results as follows:

Result 1: Comparing the Trading Restriction/Substitute treatment to the No Trading Restriction/Substitute treatment, assets have higher prices when trading restrictions are imposed on the markets.

Result 2: Comparing the Trading Restriction/Complement treatment to the No Trading Restriction/Complement treatment, assets have higher prices when trading restrictions are imposed on the markets.

The results are consistent with the theoretical predictions. As predicted by the theoretical model, imposing trading restrictions brings more balanced market power, increasing trading aggressiveness and the trading prices of assets.

We also observe positive results for Hypotheses 3 and 4, which are shown in the following figures:

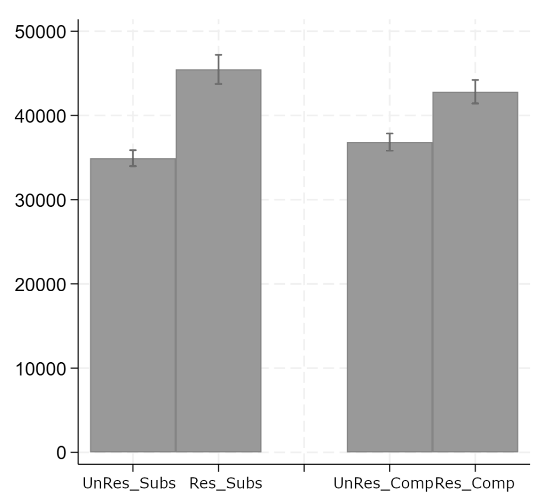


Figure 2: Total market revenues under all treatments

We observe a significant difference in total market revenue (Wilcoxon Ranksum test, p-value < 0.0001) when comparing the markets in the Trading Restriction/Substitute treatment with their counterparts in the No Trading Restriction/Substitute treatment. We also find a significant increase in total market revenue (Wilcoxon Ranksum test, p-value < 0.0001) when comparing the Trading Restriction/Complement treatment to the No Trading Restriction/Complement treatment, indicating a revenue-increasing effect. Therefore, we fail to reject both Hypothesis 3 and Hypothesis 4 and obtain the following results:

Result 3: Comparing the Trading Restriction/Substitute market treatment to the No Trading Restriction/Substitute treatment, we observe an increase in total market revenue when trading restrictions are imposed on the market.

Result 4: Comparing the Trading Restriction/Complement market treatment to the No Trading Restriction/Complement treatment, we observe an increase in total market revenue when trading restrictions are imposed on the market.

To conclude, in the table below, we summarize the trading prices and total market revenue from all treatments.

	UnRes Substitute	Res Substitute	UnRes Complement	Res Complement
Market	4.60	5.11	4.59	4.91
Price of A	(0.05)	(0.06)	(0.05)	(0.06)
Market	1.77	3.96	1.75	3.18
Price of B	(0.04)	(0.17)	(0.05)	(0.14)
Market	349.17	454.69	368.39	429.17
Revenue	(4.83)	(8.76)	(5.18)	(7.09)

Table 2: Summary of Results

6 Conclusion

Currently, regulations restrict certain groups of investors from trading certain "unfavorable" assets flagged by regulators. An open debate remains as to whether such restrictions may indeed help improve market efficiency. Empirical evidence suggests that the current asset market is a thin market, dominated by a small group of strategic institutional players with heterogeneous hedging needs. Larger institutional traders often hold different beliefs about the covariance of returns compared to smaller institutional traders. This disagreement leads to varying hedging demands among traders, giving larger traders a comparative advantage and significantly greater market power. To address issues arising from this imbalanced market power, some regulations restrict disadvantageous institutions, such as banks, from trading high-risk assets.

Given this background, theoretical work supports the idea that these regulations can increase market efficiency. Theories suggest that participation restrictions may enhance efficiency in thin markets when traders have different hedging needs, such as heterogeneous beliefs about the covariance matrix of returns. The reason is that restrictions may help re-balance the initially imbalanced market power caused by these heterogeneous needs. This corresponds to real-world settings, where large institutional traders, including regional banks and pension funds, may face regulatory restrictions limited them from trading certain types of assets, including proprietary trading.

Understanding how regulations on asset trading affect market efficiency can help determine who benefits from these regulations and whether they improve financial markets. Our experiment aims to shed light on this question, providing results with potential implications for many situations in which trading restrictions are imposed via regulations. To this end, we conducted experiments comparing the performance of unrestricted asset markets with markets subject to trading restrictions.

We implemented two experimental market conditions: (i) unrestricted markets with full participation; and (ii) markets with restricted participation. We assigned traders initial endowments and trading cost functions to ensure the experiment closely follows the theoretical model and that traders exhibit heterogeneous hedging needs. We observed market trading prices and total market revenue from the realized trades to examine changes in market efficiency and trading aggressiveness. Additionally, we tested the influence of relative trading advantages by imposing restrictions on traders with either positively correlated asset payoffs (Substitute treatment) or negatively correlated asset payoffs (Complement treatment).

Consistent with our hypotheses, subjects in the Trading Restriction/Substitute treatment trade assets at significantly higher prices than those in the No Trading Restriction/Substitute treatment. We observe a similarly significant increase in trading prices in the Trading Restriction/Complement treatment compared to the No Trading Restriction/Complement treatment. Likewise, total market revenue increases when comparing the Trading Restriction/Substitute treatment to the No Trading Restriction/Substitute treatment. Total revenue is also greater in the Trading Restriction/Complement treatment than in the No Trading Restriction/Complement treatment. Overall, we provide statistical evidence that well-designed trading restriction regulations do increase market revenue, and that the efficiency-promoting effect can be achieved by restricting either the advantageous group of traders or the disadvantageous group of traders.

Our results align with the theoretical predictions about the efficiency-improving effect of trading restrictions in thin markets. An unrestricted market that allows full participation by strategic traders can create imbalanced market power, or price impact, which in turn limits market efficiency. By re-balancing market power, imposing trading restrictions may lead to increased market revenue. Overall, our study highlights the fact that well-designed trading restrictions can positively impact market efficiency.

Our research focuses on how market efficiency improves under imposed trading restrictions, which can be considered a type of asset market innovation. Nevertheless, there are various other methods of asset market innovation beyond our approach. While we focus on well-designed trading restrictions, one avenue for future experimental research could focus on how other types of asset market innovations, e.g., well-designed derivative assets, may affect market efficiency.

References

Anthropelos, Michail and Constantinos Kardaras (2024), "Price impact under heterogeneous beliefs and restricted participation." *Journal of Economic Theory*, 215, 105774.

Anthropelos, Michail, Constantinos Kardaras, and Georgios Vichos (2020), "Effective risk aversion in thin risk-sharing markets." *Mathematical Finance*, 30, 1565–1590.

Aouani, Zaier and Bernard Cornet (2009), "Existence of financial equilibria with restricted participation." *Journal of Mathematical Economics*, 45, 772–786.

Basak, Suleyman and Domenico Cuoco (1998), "An equilibrium model with restricted stock market participation." *The Review of Financial Studies*, 11, 309–341.

Bayona, Anna, Jordi Brandts, and Xavier Vives (2020), "Information frictions and market power: A laboratory study." *Games and Economic Behavior*, 122, 354–369.

Bretscher, Lorenzo, Lukas Schmid, Ishita Sen, and Varun Sharma (2025), "Institutional corporate bond pricing." *The Review of Financial Studies*, hhaf067.

Cass, David (2006), "Competitive equilibrium with incomplete financial markets." *Journal of Mathematical Economics*, 42, 384–405.

Chen, Daniel and Darrell Duffie (2021), "Market fragmentation." *American Economic Review*, 111, 2247–2274.

Chen, Daniel L, Martin Schonger, and Chris Wickens (2016), "otree—an open-source platform for laboratory, online, and field experiments." *Journal of Behavioral and Experimental Finance*, 9, 88–97.

Duchin, Ran and Moshe Levy (2010), "Disagreement, portfolio optimization, and excess volatility." *Journal of Financial and Quantitative Analysis*, 45, 623–640.

Duffie, Darrell (1987), "Stochastic equilibria with incomplete financial markets." *Journal of Economic Theory*, 41, 405–416.

Hens, Thorsten, P Jean-Jacques Herings, and Arkadi Predtetchinskii (2006), "Limits to arbitrage when market participation is restricted." *Journal of Mathematical Economics*, 42, 556–564.

Holt, Charles A and Susan K Laury (2002), "Risk aversion and incentive effects." *American economic review*, 92, 1644–1655.

Kyle, Albert S (1989), "Informed speculation with imperfect competition." *The Review of Economic Studies*, 56, 317–355.

Malamud, Semyon and Marzena Rostek (2017), "Decentralized exchange." *American Economic Review*, 107, 3320–3362.

Medina, Alejandra, Adriana de la Cruz, and Yun Tang (2022), "Corporate ownership and concentration."

Polemarchakis, Heraklis M and Paolo Siconolfi (1997), "Generic existence of competitive equilibria with restricted participation." *Journal of Mathematical Economics*, 28, 289–311.

Rostek, Marzena and Marek Weretka (2015), "Dynamic thin markets." *The Review of Financial Studies*, 28, 2946–2992.

Rostek, Marzena and Ji Hee Yoon (2021), "Exchange design and efficiency." *Econometrica*, 89, 2887–2928.

Rostek, Marzena and Ji Hee Yoon (2024), "Innovation in decentralized markets: technology versus synthetic products." *American Economic Journal: Microeconomics*, 16, 63–109.

Rostek, Marzena and Ji Hee Yoon (2025), "Financial product design in decentralized markets." *Journal of Political Economy*, 133, 888–934.

Schwartz, Robert Alan and James E Shapiro (1991), *The challenge of institutionalization for the equity markets*. Salomon Bros. Center for the Study of Financial Institutions, Leonard N . . . .

Smith, Vernon L (1982), "Microeconomic systems as an experimental science." *The American economic review*, 72, 923–955.

Vayanos, Dimitri (1999), "Strategic trading and welfare in a dynamic market." *The Review of Economic Studies*, 66, 219–254.

Vives, Xavier (2010), *Information and learning in markets: the impact of market microstructure*. Princeton University Press.

Vives, Xavier (2011), "Strategic supply function competition with private information." *Econometrica*, 79, 1919–1966.

Whitehead, Charles K (2011), "The volcker rule and evolving financial markets." *Harv. Bus. L. Rev.*, 1, 39.

Wilson, Robert (1979), "Auctions of shares." *The Quarterly Journal of Economics*, 93, 675–689.

Wittwer, Milena (2021), "Connecting disconnected financial markets?" *American Economic Journal: Microeconomics*, 13, 252–282.

A Appendix A: Instructions, comprehension test, experimental screenshots and post-experiment survey

These instructions, comprehension test, and experimental screenshots apply to the treatment without trading restriction and with positively correlated costs. The instructions, comprehension test, and experimental screenshots for the other three treatments follow an analogous structure.

A.1 Instructions

Welcome

Thank you for participating in today's experiment. You will earn $10 upon completion for your participation. If you read these instructions carefully, you could potentially earn much more.

You will remain on each section of the instructions for a few minutes. You can only move on to the next section once that time has passed. Please note that this is not a countdown. Feel free to stay on the current section and continue reading until you fully understand the instructions.

In this experiment, you will be trading with other participants. During the experiment, you are not allowed to speak to other participants or use your cell phone. If you have any questions, please raise your hand, and an experimenter will assist you.

Rounds

The experiment consists of 4 unpaid practice rounds and 16 paid rounds. Each round will last 120 seconds. The practice rounds are for learning purposes only.

The 4 practice rounds will be discarded. Out of the remaining 16 rounds, the computer will randomly select ONE round to calculate your final payment.

At the end of the 20th round, the experiment will end, and the computer will determine your final payment.

Experimental settings

In each round, you participate in virtual trade and earn Experimental Dollars (E$). E$ will be converted into Dollars at the end. For every E$2000 you have at the end of the experiment, you will be paid $1 in cash.

Before starting the experiment, we will explain how to trade. Throughout the instructions, you will answer questions to make sure you understand the experiment. If your answer is wrong, you can answer again. You will do so until your answer is correct.

If you answer all questions correctly without any retry, you get $1 as bonus.

You are a seller, selling Widgets to a computerized buyer in an experimental market. Each market will have 4 sellers.

In each round, there are two types of ”Widgets”, • (CIRCLES) and ■ (SQUARES) , available on the experimental market. You and other three sellers each receive 100 • and 25 ■ at the beginning of each round.

The Experiment

You are required to offer all your 100 units of • and 25 units of ■ to the market at the same time. Other sellers are required to offer all their Widgets as well.

The asks of • and ■ you are willing to accept are determined as follows:

You choose an ask for the 1st unit of • and another ask for the 1st unit of ■ . If your ask for the 1st unit is 15, then the price you ask for the 2nd will be 30, and the price you ask for the 3rd will be 45 and so on.

Tips: By this, the ask for every unit of • or ■ will be unique, just as what you see above.

Trading

There will always be 4 sellers, and each seller is required to offer all Widgets to the market. 4 sellers will offer a total of 400 • and 100 ■ . The computer will rank from lowest to highest the asks of the 400 units of • and 100 units of ■ , and buy 100 units of • and 25 units of ■ .

Market Price: The 100th lowest ask for • becomes the Market Price for •. The 25th lowest ask for ■ becomes the Market Price for ■. The computer buy the 100 units of • and 25 units of ■ all at the market price.

If multiple sellers have offered units at an ask equal to the Market Price, these units would be bought and the E$ would split among these sellers.

Trading Cost

Your payoff = Revenue - Trading Cost

Your revenue = (Market price of • * Units of • sold by you) + (Market price of ■ * Units of ■ sold by you)

Your trading cost = 5 * (Units of • sold by you)^2 + 5 * (Units of ■ sold by you)^2 + (3 * Units of • sold by you * Units of ■ sold by you)

Units not sold will not create any trading cost. Please note, if you have no trading earnings in the round, you will still earn the 10 dollars (for your participation) mentioned in previous pages.

Simulator

You have a simulator for better understanding about your payoff.

You can simulate the Market Prices to see your simulated trading cost and final payoff, based on your asks and the simulated Market Prices.

Before the final submission, you can always change your asks and see its impact on the simulated payoff.

New Rounds

After the round ends, you observe the round payoff and move to the rest of the rounds.

Each round is independent: you will never be able to use the payoff from previous rounds.

This is the end of the instructions. If you have any questions, please raise your hand and an experimenter will assist you privately.

A.2 Comprehension Test

Q1: True or False: By choosing the asks for the 1st unit of the Widgets, the ask for every unit of • or ■ will be unique.

1. True 2. False

Q2: True or False: You choose an ask for the 1st unit of • and another ask for the 1st unit of ■ . If your chosen ask for the 1st unit of • is 15, and the chosen ask for the 1st unit of ■ is 15, Then, the asks for the 100 units of • would be 15, 30, 45...1500 , and the selling prices for the 25 units of ■ would be 15, 30, 45...375 .

1. True   2. False

Q3: True or False: The 100th lowest ask for • is the Market Price for •. The 25th lowest ask for ■ is the Market Price for ■.

1. True   2. False

Q4: Suppose the Market Price of • is E$500 and the Market Price of ■ is E$200 , In your offered Widgets, there are 30 units of • offered at asks lower than E$500 and 10 units of ■ offered at asks lower than E$200 , Will the computer buy these Widgets by each unit's own ask, or all at the Market Prices?

1. By each units own ask   2. All at the Market Prices

Q5: Suppose the Market Price of • is E$500 and the Market Price of ■ is E$200 , In your offered Widgets, there are 30 units of • offered at asks lower than E$500 and 10 units of ■ offered at asks lower than E$200 , How many units of Widgets will you sell out?

1. 30 CIRCLE Widgets and 10 SQUARE Widgets

2. 70 CIRCLE Widgets and 15 SQUARE Widgets

Q6: Your trading cost = 5 * (Units of • sold by you)^2 + 5 * (Units of ■ sold by you)^2 + (3 * Units of • sold by you * Units of ■ sold by you) Suppose you sell 30 units of • and 10 units of ■ , How much would be your trading cost?

1. 5000   2. 5900

Q7: Suppose the Market Price of • is E$500 and the Market Price of ■ is E$200 , You sell 30 units of • and 10 units of■ . Your trading cost is E$5900. How much would be your payoff?

1. 11100   2. 12000

Answers: Q1. 1 Q2. 1 Q3. 1 Q4. 2 Q5. 1 Q6. 2 Q7. 1

Notes: These instructions were displayed when a participant selected a wrong answer for any of the preceding questions.

Q1: That's incorrect. Let's review the instructions. By choosing the asks, the ask for every unit of CIRCLE Widgets or SQUARE Widgets will be unique.

Q2: That's incorrect. Let's review the instructions. You choose an ask for the 1st unit of CIRCLE Widgets and another an ask for the 1st unit of SQUARE Widgets. If your chosen ask for the 1st unit of CIRCLE Widgets is 15, and the chosen ask for the 1st unit of SQUARE Widgets is 15, Then, the asks for the 100 units of CIRCLE Widgets would be 15, 30, 45...1500, and the asks for the 25 units of SQUARE Widgets would be 15, 30, 45...375.

Q3: That's incorrect. Let's review the instructions. The computer will rank from lowest to highest the asks of the 400 units of CIRCLE Widgets and 100 units of SQUARE Widgets. The 100th lowest ask for CIRCLE Widgets is the Market Price for CIRCLE Widgets. The 25th lowest ask for SQUARE Widgets is the Market Price for SQUARE Widgets.

Q4: That's incorrect. Let's review the instructions. The computer buy the 100 units of CIRCLE Widgets and 25 units of SQUARE Widgets, all at the Market Prices.

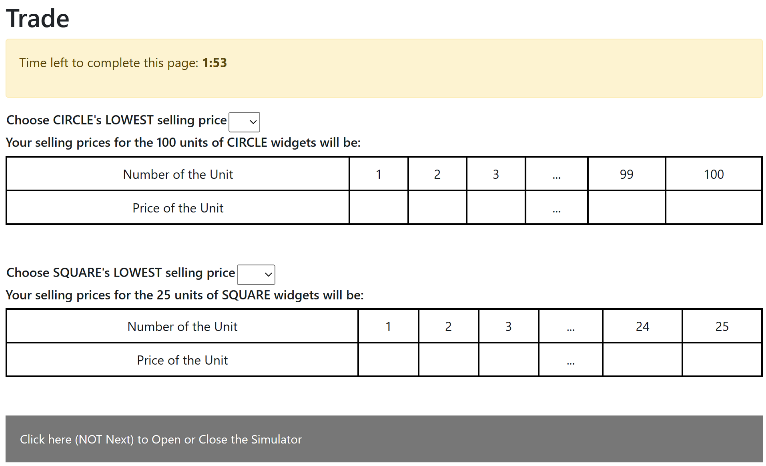
Q5: That's incorrect. Let's review the instructions. Suppose the market price of CIRCLE Widgets is E$500 and the market price of SQUARE Widgets is E$200. If in your offered Widgets, there are 30 units of CIRCLE Widgets offered at asks lower than E$500 and 10 units of SQUARE Widgets offered at asks lower than E$200. Then the computer will buy all the 30 units of CIRCLE Widgets at E$500 and buy all the 10 units of SQUARE Widgets at E$200.

Q6: That's incorrect. Let's review the instructions. Your trading cost = (5 * Units of CIRCLE Widgets sold by you * Units of CIRCLE Widgets sold by you) + (5 * Units of SQUARE Widgets sold by you * Units of SQUARE Widgets sold by you) + (3 * Units of CIRCLE Widgets sold by you * Units of SQUARE Widgets sold by you) You sell 30 units of CIRCLE Widgets and 10 units of SQUARE Widgets, Your trading cost = 5 * (30 * 30) + 5 * (10 * 10) + 3 * (30 * 10) = E$5900

Q7: That's incorrect. Let's review the instructions. Your payoff = Market price of CIRCLE * Units of CIRCLE sold by you + Market price of SQUARE * Units of SQUARE sold by you - Trading cost Your payoff = (E$500 * 30) + (E$200 * 10) - E$5900 = E$11100

A.3 Screenshots from Trading Stage

bf Screen: Trading


Trade

Time left to complete this page: **1:53**

Choose CIRCLE's LOWEST selling price
Your selling prices for the 100 units of CIRCLE widgets will be:

Number of the Unit	1	2	3	...	99	100
Price of the Unit				...		

Choose SQUARE's LOWEST selling price
Your selling prices for the 25 units of SQUARE widgets will be:

Number of the Unit	1	2	3	...	24	25
Price of the Unit				...		

Click here (NOT Next) to Open or Close the Simulator

A.4 post-experiment survey

1.What is your age ?

2.What is your gender?

(a) Female

(b) Male

3.How many siblings do you have?

4.What is your major at George Mason University?

5.Are you a graduate or undergraduate student?

(a) Undergraduate

(b) Graduate

6. Which year are you in the program?

7. Have you ever participated in any economics or psychology experimental studies before?

(a) Yes

(b) No

8. What do you consider your racial or ethnic background to be?

(a) White

(b) Black

(c) Hispanic

(d) Asian

(e) Other, please specify