DISCUSSION PAPER SERIES

IZA

IZA DP No. 7978

Market vs. Residence Principle: Experimental Evidence on the Effects of a Financial Transaction Tax

Jürgen Huber
Michael Kirchler
Daniel Kleinlercher
Matthias Sutter

February 2014

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Market vs. Residence Principle: Experimental Evidence on the Effects of a Financial Transaction Tax

Jürgen Huber
University of Innsbruck

Michael Kirchler
University of Innsbruck and University of Gothenburg

Daniel Kleinlercher
University of Innsbruck

Matthias Sutter
EUI Florence, University of Cologne and IZA

Discussion Paper No. 7978
February 2014

IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

IZA Discussion Paper No. 7978
February 2014

ABSTRACT

Market vs. Residence Principle: Experimental Evidence on the Effects of a Financial Transaction Tax*

While politically attractive in order to generate tax revenues, the effects of a financial transaction tax (FTT) are scientifically disputed, not the least because seemingly small details of its implementation may matter a lot. In this paper, we provide experimental evidence on the different effects of a FTT, depending on whether it is implemented as a tax on markets, on residents, or a combination of both. We find that the effects of a tax on markets are different from a tax on residents, with negative effects of a market tax on volatility and trading volume. The residence principle shows none of these undesired effects. In addition to studying aggregate market outcomes, we investigate how individual traders react to different forms of a FTT and whether their risk attitude is related to these reactions. We find no such relationship, meaning that a FTT affects traders with different risk tolerances similarly.

JEL Classification: C91, G10, E62

Keywords: Financial Transaction Tax, experimental finance, residence principle, market principle

Corresponding author:

Jürgen Huber
University of Innsbruck
Department of Banking and Finance
Universitätsstrasse 15
6020 Innsbruck
Austria
E-mail: juergen.huber@uibk.ac.at

* We are grateful for comments from seminar participants at the Austrian Central Bank. Financial support by the Austrian Science Fund FWF (grant ZFP220400 Kirchler and START-grant Y617-G11 Kirchler), Hypo Tirol-research grant (grant Kleinlercher), Austrian Central Bank (OeNB Jubliaeumsfonds-Grant 14953), the University of Innsbruck (Nachwuchsförderung Kirchler) and the Austrian Academy of Sciences (DOC-fellowship Kleinlercher) is gratefully acknowledged.

1 Introduction

Few other issues stir emotions as easily as "taxes". This also holds for a Financial Transaction Tax (FTT) – dubbed "Robin Hood Tax" by its supporters, but fiercely contested by others as seemingly threatening to destroy the financial sector. Especially since eleven member countries of the European Union have been considering to implement a FTT by 2015, the discussion about the effects of a FTT has gained momentum.[1] Such a tax is politically highly controversial, because it has rarely been implemented in practice. Hence, evidence on its likely effects is still very limited.

The academic debate has missed some important institutional details so far, for which reason it cannot provide unambiguous evidence as a basis for the political debate. In particular, the academic literature on a FTT has practically ignored the exact taxation scenarios, i.e. whether such a tax is implemented on all trades in a given market – which we call the "market principle" – or on all trades by residents in a particular jurisdiction – which we call the "residence principle".

In this paper, we explore the consequences of applying these different taxation principles. We do so in a controlled laboratory experiment, using the lab as a "wind-tunnel" environment to test how the market principle, the residence principle, or a combination of both, affect market outcomes, such as trading volume, tax revenues, volatility, and market efficiency, as well as individual trading behavior. In particular, experimental subjects can trade assets for money in two independent jurisdictions, each with one financial market. We implement either a tax on residents, a market tax, a combination of a market tax and a tax on residents within the same jurisdiction, or a tax on residents for one jurisdiction and a market tax on the other.

We find that applying the residence principle – meaning that all trades of

[1] The eleven countries are Austria, Belgium, Estonia, France, Germany, Greece, Italy, Portugal, Slovakia, Slovenia, and Spain. The level of the FTT is likely to be 0.1% on stock transactions and 0.01% on derivatives transactions. The EU commission, expecting that stock transactions will fall by 15% and derivative transactions by 75%, still forecasts to raise 30 to 35 bn. euros in tax income per year.

residents of one jurisdiction are taxed, irrespective of whether they trade on their home market or on the foreign market (an approach similarly discussed in the European Union) – has no significant effects on trading volume or volatility. Thus, it causes practically no distortions on the markets and tax revenues are substantial. When the market principle is applied – i.e., all transactions in one market are taxed, while the other market is not taxed – we observe a significant shift in trading volume: about three quarters of trading in the taxed market shift to the untaxed alternative. With liquidity in the taxed market evaporating, volatility increases significantly, while it drops in the untaxed market where liquidity increases.

The combination of both principles in one jurisdiction leads to a significant drop in trading volume in the jurisdiction implementing both market and residence principle, and an increase in the other one. By contrast, volatility increases in the jurisdiction applying the market and residence principle and drops in the one without any tax burden. However, the overall market distortion is weaker compared to the sole implementation of the market principle, but clearly higher compared to jurisdictions implementing only the residence principle.

In the last taxation scenario where one jurisdiction applies the market principle and the other one the residence principle, trade shifts from the jurisdiction with a market tax to the one where only the residents are taxed, causing market distortions within the jurisdiction that applies the market principle.

In addition to disentangling the effects of a market or residence principle, another contribution of our paper is to show how individual traders with different attitudes towards risk are influenced by the introduction of a FTT. We find that traders with high risk tolerance trade significantly more than strongly risk-averse traders. However, risk attitude is irrelevant for a subject's reaction to FTTs: Risk seeking and risk averse traders are equally affected by the introduction of a FTT. We consider these insights on an individual level as important for a deeper understanding of how a FTT affects market outcomes. Remarkably, this micro-foundation has been absent in previous experimental work on a FTT.

The remainder of the paper is structured as follows: In Section 2 the most closely related literature is briefly discussed. In Section 3 the experimental design is introduced. In Section 4 we present results on the aggregate market level, while in Section 5 we look at individual level data. Finally, section 6 concludes.

2 Related literature

In 1936, John Maynard Keynes first advocated the introduction of a FTT on stock markets as the best way to mitigate the predominance of destabilizing short-term speculation over stabilizing long-term investment (Keynes, 1936). After the fall of the Bretton-Woods system, a similar line of argument was adopted by James Tobin, when he called for the introduction of a FTT on foreign exchange markets to curb excessive speculation (Tobin, 1978).[2] Notably, neither Keynes nor Tobin supported their proposals with empirical or analytical research.

This fact did not change until the late 1980ies when scientific research on the impact of a FTT of the market principle-type gained momentum.[3] Since then there is broad scientific consensus on the negative effects of a FTT of the market principle-type on trading volume. Other important issues, namely the impact of a FTT on volatility and market efficiency, are still controversially debated, with strong academic supporters for both sides. In one of the earliest empirical contributions Umlauf (1993) reports an increase of price volatility after Sweden introduced a round trip tax on equity transactions in 1984.[4] Aliber et al. (2003) empirically investigate the impact of the size of transaction costs on volatility and show that higher transaction costs are associated with higher volatility. More recently, contributions by Ehrenstein (2002), Westerhoff (2003),

[2]See ul Haq et al. (1996); Spahn (2002); Habermeier and Kirilenko (2003); McCulloch and Pacillo (2011) for various surveys.

[3]See e.g. Stiglitz (1989); Summers and Summers (1989); Schwert and Seguin (1993).

[4]See Kupiec (1995), Jones and Seguin (1997), Baltagi et al. (2006), and Hau (2006) for more empirical research in this tradition.

and Ehrenstein et al. (2005) provide evidence that a FTT drives chartists from the taxed market and hence stabilizes prices.[5] Turning to the effects of a FTT on market efficiency, Cipriani and Guarino (2008) and Bloomfield et al. (2009) study the effects of a FTT in an experimental financial market. The former find an increase in informational efficiency, but hardly any effects on market volatility. The latter investigate the effects of a FTT on market efficiency through informational cascades. They report no effects on market efficiency in their experiments. In contrast, theoretical work by Subrahmanyam (1998) and Dow and Rahi (2000) concludes that a FTT would decreases market efficiency. To sum up, there is no agreement on the consequences of a FTT of the market principle-type on price volatility and market efficiency.

A limitation of many of the papers mentioned so far is that they consider only one market. While such papers are useful to understand how a tax affects aggregate market outcomes, they are obviously limited to cases where a FTT would cover all existing markets – a scenario that fails to match the current real-world situation. For this reason, recent work has started to examine a setting with two or more markets, because that allows for the coexistence of taxed and untaxed markets.

In agent-based simulations with two markets, Westerhoff and Dieci (2006) and Mannaro et al. (2008) analyze the effects of a FTT either implemented as encompassing or as a unilateral tax, i.e. where a tax haven exists. Westerhoff and Dieci (2006) use agents applying technical and fundamental analysis for trading on two different markets. When a FTT is levied on one market they show that volatility decreases in the taxed market and increases in the untaxed one. In contrast, with a different agent-based modelling approach, Mannaro et al. (2008) argue that the higher a FTT, the higher the increase in volatility in the taxed market.

Hanke et al. (2010) use laboratory markets to investigate the effects of a FTT. They report that a FTT only imposed on one market increases volatility

[5]See Lux (1998); Lux and Marchesi (2000); Hommes (2006) for studies with the chartist and fundamentalist approach.

when the market is small and illiquid, but has no impact on volatility when the market is large and liquid. Thus, Hanke et al. (2010) stress the crucial interplay of liquidity and volatiltiy when a FTT is imposed.[6] This important relationship is also addressed by Pellizzari and Westerhoff (2009) and Kirchler et al. (2011). Both focus on the market microstructure as an important issue regarding the effects of a FTT. Pellizzari and Westerhoff (2009) show – in the framework of a one-market agent-based model, though – that in a dealership market where liquidity is held constant through artificial market makers a FTT has no negative effects on volatility. By contrast, in a taxed double-auction market volatility rises as soon as liquidity drops. Because of a lower orderbook depth, buy- and sell-orders have a greater price impact which makes prices more volatile. Kirchler et al. (2011) tackle this question with laboratory experiments where traders can trade on two simultaneously running financial markets. They conclude that in markets without market makers an unilaterally imposed FTT increases volatility, while in markets with market makers – and therefore constant liquidity – an unilaterally imposed FTT even decreases volatility. Hence, again there is no consensus on the consequences of a FTT of the market principle-type on price volatility and market efficiency in the academic literature.

So far no paper has explored the effects of an implementation of a FTT implemented as residence principle or as mixture of market and residence principle, leaving it an open question how the institutional details of a FTT matter for its effects. We are going to fill this gap with this paper, concentrating not only on aggregate market outcomes in our analysis, but also on how a FTT affects individual trader behavior.

[6]The relationship between market liquidity and the price impact of orders has also been explored by Ehrenstein et al. (2005), Lillo and Farmer (2005), and Mannaro et al. (2008). Ehrenstein et al. (2005) and Mannaro et al. (2008) argue that transaction taxes might have a negative impact on market liquidity, hinting at increasing volatility when the market is illiquid.

3 Design of the Experiment

The fundamental value of the asset traded (expressed in Taler) is modelled as geometric Brownian motion:

$$\mathrm{FV}_k = \mathrm{FV}_{k-1} \cdot e^{\gamma_k}. \tag{1}$$

FV_k denotes the fundamental value in period k and γ_k is a normally distributed random variable with a mean of zero and a standard deviation of 10 percent. The FV_0 is set to 40. We draw one fundamental value path randomly (path I) and then create a counterpart by mirroring path I at the unconditional expected value of the FV.[7] In half of the sessions for each treatment we use path I, in the other half path II. Furthermore, we introduce a symmetric information structure. In each period each subject receives a private signal on the fundamental value of the asset. This signal is calculated as the current FV plus a noise term with a mean of zero and a standard deviation of 5 percent. Estimation errors cancel out across subjects to make sure that each market has an unbiased estimation of the FV.[8]

The treatments are designed to test the effects of a financial transaction tax (FTT), either implemented as a tax on each transaction conducted in a given market (market principle), or a tax on each transaction by a person hailing from a given jurisdiction (residence principle), or a combination of both.

Subjects can trade units of one asset on two different markets (denoted LEFT and RIGHT). Subjects are assigned to one market as their home market, i.e., half of the subjects are residents of market LEFT (home market LEFT) and the other half are residents of market RIGHT (home market RIGHT). This enables us to tax transactions on a particular market or the residents of a given market (or jurisdiction), respectively, within various taxation scenarios.

[7] In particular,

$$\mathrm{FV}_k(pathII) = 80 - \mathrm{FV}_k(pathI).$$

[8] This was implemented by drawing positive estimation errors for half of the subjects and using the respective negative error terms for the other half of subjects.

As a preliminary before presenting design details, we provide the following definitions: A *session* consists of two markets (LEFT and RIGHT) where ten subjects can trade simultaneously for a sequence of 8 periods. These are divided into two *phases* of 4 consecutive trading periods where a certain taxation scenario is levied. A *taxation scenario (treatment)* specifies how a FTT of 0.1 percent is collected, i.e. either as a tax on transactions in a given market, as a tax on residents of a given market (jurisdiction), or a combination of both.

Each session is populated by 10 subjects and has 8 periods of 4 minutes trading.[9] Subjects trade units of the asset on two continuous double auction markets simultaneously. Both markets (LEFT and RIGHT) are displayed on the trading screen at the same time. It is possible to buy assets on the right market and to sell them on the left market, or vice versa, as it is possible to buy or sell assets on the same market.

3.1 Treatments

We implement four treatments which only differ with respect to the taxation scenarios.

Treatment M**: market principle**. This taxation scenario follows the proposal of Tobin (1978) to introduce a FTT on financial markets as a market tax. This means that each trade on the taxed market is taxed, irrespective of the residencies of the involved traders. For the sake of simplicity we only tax market LEFT, while market RIGHT serves as tax haven.

Treatment R**: residence principle**. This taxation scenario follows the idea of imposing a FTT on residents of a given market (jurisdiction). Every market participant who is resident in the jurisdiction that levies a FTT is taxed for all his trading activities, no matter whether these are conducted on the domestic or a foreign market. In particular, subjects who are residents of the

[9]Before trading started subjects had 15 minutes to read written instructions. Questions were answered privately. Then the trading screen was explained and two trial periods (not relevant for payment) were conducted to allow subjects to become familiar with the trading screen and the trading procedure (see Appendix C for the trading screen and the experimental instructions).

left market (home market LEFT) are taxed for each trade they make, no matter whether it happens on the left or right market. Subjects with residence on the right market (home market RIGHT) can trade on the left and right market without being taxed.

Treatment $\mathrm{MR}_{\mathrm{SAME}}$**: market and residence principle on the same market**. Treatment $\mathrm{MR}_{\mathrm{SAME}}$ is a combination of treatments M and R and comes close to the plans of eleven members of the European Union for the implementation of a FTT. We implement the FTT on market LEFT where the market and residence principles are applied at the same time: subjects with home market LEFT are taxed irrespective whether they trade on the left or right market (residence principle). In addition, subjects with home market RIGHT who trade on the LEFT market are taxed as well (market principle). Only trading on the right market remains untaxed for subject with home market RIGHT.

Treatment $\mathrm{MR}_{\mathrm{DIFF}}$**: market and residence principle on different markets**. This treatment stands for the possible scenario that one country imposes a FTT according to the residence principle and another country imposes a FTT following the market principle. A FTT for subjects with home market LEFT is applied according to the residence principle. In addition, the market principle is applied on the right market. Thus, subjects with home market LEFT are taxed by their home jurisdiction whenever they trade and additionally face a tax of 0.1 percent when trading on the right market. In contrast, subjects with home market RIGHT are only taxed for trading on their home market, as market LEFT remains untaxed for them.

Table 1 shows the taxation scenarios depending on residence and trading activity, i.e. trading on the left or right market.

Insert Table 1 about here

3.2 The Order of Implementing the FTT

In all treatments we use a specific taxation scenario either in the first phase (periods 1-4) or in the second phase (periods 5-8). For instance, when we introduce a FTT in the first phase, we abolish the FTT in the second phase. To control for possible learning effects in each treatment, we impose a FTT in half of the sessions in the first phase, and in the second phase in the other half of the sessions. Before the beginning of each phase subjects are informed about the imposition/abolition of a FTT with an announcement screen. This screen is shown for one minute and outlines in detail how the FTT is levied. It also provides a calculation example for taxation. Subjects do not get any information about the possible implementation of a FTT before the main experiment starts and they are not informed in advance whether and when the taxation is changed again, i.e., the taxation changes come as a surprise. Once a FTT has been introduced, the tax rate is also displayed on the trading screen.

3.3 Market Architecture and Implementation

In each session half of the subjects are initially endowed with 75 units of the asset and 3000 in Taler (experimental currency). The other half starts with 25 units of the asset and 5000 in Taler. Given an initial fundamental value FV_0 of 40, each subject's initial wealth is 6000 in Taler. Holdings of assets and Taler are carried over from one period to the next. Furthermore, subjects are able to go short up to 100 units of the asset and 6000 in Taler.[10] Before the beginning of a new period, all order books are emptied and there are no interest payments on holdings in assets or cash. To avoid end-of-experiment effects, subjects are told that the experiment will end between period 6 and 12.

In this experiment all units of the asset are bought back at the fundamental value of the last period. Thus, final wealth is the sum of the portfolio value of the asset (units of the asset held multiplied by the fundamental value of the last

[10]The maximum levels of shorting assets and cash add up to double their initial average endowments.

period) and cash holdings. This sum is converted into Euros at an exchange rate of 1 EUR = 400 Taler.

In total, we conducted 12 sessions for each of the four treatments, resulting in 48 sessions and a total of 480 subjects participating in the experiments. All subjects were economics and business students at the University of Innsbruck, recruited with ORSEE (Greiner, 2004). Sessions were computerized using zTree 3.2.8 (Fischbacher, 2007) and lasted about 90 minutes. Average payment to subjects was EUR 20.4.

3.4 Elicitation of Risk Attitude and Loss Aversion

In this experiment, we also conducted two tasks to elicit subjects' risk attitudes and loss aversion. To test for subjects' risk attitudes we employ a mechanism based on Gneezy and Potters (1997). We endow subjects with EUR 2, out of which they can invest an amount X in a 50/50 coin flip lottery. If the subject wins in the lottery she earns EUR 2+1.5X, and if she loses she earns EUR 2-X. The more risk averse, the less a subject would invest in the lottery, and thus the lower is X.

For the elicitation of loss aversion we employ a method developed by Gächter et al. (2007). Subjects are asked to either accept or reject a series of coin flip lotteries. One of the lotteries is later chosen randomly to determine a subject's earnings. In case the randomly chosen lottery is rejected, the subject earns EUR 0, regardless of the outcome of the coin flip. In case the lottery is accepted the subject either earns EUR 5 or loses an amount X. The amount X varies across lotteries, ranging from a minimum loss of EUR 2 to a maximum loss of EUR 6. Assuming a simple piecewise linear loss aversion specification, the row in which a subject switches from accepting the lottery to rejecting it defines the loss aversion parameter. It ranges from "larger than 2.5" in case of rejecting all lotteries to "lower than 0.83" in case of accepting all lotteries.[11]

[11] If losses were incurred in one part of the experiment they were deducted from profits in other parts. No subject came close to an overall loss.

4 The Effects of FTT on Aggregate Market Outcomes

We use the following panel regression model to investigate the consequences of a FTT on the market variables trading volume, price volatility, and market efficiency:

$$y_{m,p} = \alpha + \beta_1 \text{LEFT}_p + \beta_2 \text{RIGHT}_p + \epsilon_{m,p}. \tag{2}$$

Here, $y_{m,p}$ is a generic placeholder for the dependent variables explained below, m indicates cross-section (either the LEFT or RIGHT market in a specific session) and p phase (i.e., four periods in which a certain taxation scenario is applied). LEFT is a binary dummy for the left market and RIGHT is a binary dummy for the right market when a taxation scenario is applied. Consequently, intercept α represents the state in which both markets are untaxed, i.e. no taxation scenario is imposed. We apply clustered standard errors on a session level to allow for correlation within sessions and independence of observations between sessions. In addition, we run pairwise Wald-tests to test for differences between the left and the right market when a taxation scenario is applied.

Insert Table 2 about here

Table 2 provides formulae for the dependent variables on a macro level. Following Kirchler et al. (2011) we normalize trading volume (VOL) by the mean and standard deviation of trading volume in each session s to control for idiosyncratic effects of individual sessions. As one can see from Table 2 the means and standard deviations are calculated from period data. To arrive at the normalized volume of phase p of market m (either LEFT or RIGHT) the average of the respective four period values is calculated.

A similar approach as for normalized trading volume is applied for the volatility measure – the standard deviation of normalized returns ($SDRET$). Logreturns between consecutive trades i, $ret_{s,m,i}$, are normalized by the mean and the standard deviation in each session.[12] The standard deviation of these normalized returns in each market phase serves as dependent variable. With this approach sessions with idiosyncratic effects in the absolute level of volatility become comparable.

As a proxy for mispricing, relative absolute deviation (RAD) is calculated as the absolute difference between mean prices per period and the respective FVs, benchmarked at the average FV in the market (see Stöckl et al. (2010)). Hence, a high level of RAD indicates strong mispricing and therefore a low level of market efficiency.

Additionally, we measure the level of tax revenues (TAX) prior to and after the imposition of a FTT. We calculate both, naive hypothetical tax revenues of untaxed markets by multiplying the trading volume with the tax rate and actual realized tax revenues after the imposition of the tax. We further normalize tax revenues (either naive or realized) by the mean and standard deviation in each market. We do not normalize on a session level as we want to measure the impact of a tax on the tax revenues of each individual jurisdiction. Thus, we use a different regression model which is outlined in Section 4.4.

For the variables VOL, RAD and TAX period values are calculated first and the mean per phase p and market m is used in the regression.

4.1 Trading Volume

Figure 1 shows descriptive statistics for normalized trading volume (VOL) and Table 3 provides the results of the regressions according to equation (2).

Insert Figure 1 about here

In treatment M trading volume drops significantly on the left market (taxed market) and increases significantly on the right market (untaxed market) after a FTT is imposed. This is straightforward, as avoiding the tax is easy for

[12] See the discussion in Plerou et al. (1999) on the importance of normalizing returns from different observations.

everybody by trading on the untaxed RIGHT market. In contrast, treatment R shows almost no differences in trading volume after a tax is levied on subjects with home market LEFT (residence principle). Thus, we observe no major distorting effects of a FTT when it is implemented according to the residence principle.

Insert Table 3 about here

Treatment $\mathrm{MR}_{\mathrm{SAME}}$ shows similar patterns as treatment M, though the effects are somewhat weaker. Again, trading volume is significantly reduced on the left market where a FTT is imposed on residents and as a market tax for foreigners. Trading volume increases significantly on the right market. This pattern is driven by residents of market RIGHT who leave the left market and trade on the right market without any tax burden. However, traders with home market LEFT still provide liquidity to the left market, making the effects less pronounced compared to treatment M. In treatment $\mathrm{MR}_{\mathrm{DIFF}}$ one can observe the opposite effects: a strong and significant increase in trading volume in the left market and a significant decrease of trading volume in the right market. Subjects with home market LEFT avoid possible double taxation on the right market and subjects with home market RIGHT also shift their trading activity to the left market to avoid taxation on their home market.

4.2 Volatility

One of the most controversially discussed issues surrounding the implementation of a FTT is how price volatility is affected. Descriptive results are outlined in Figure 2 and econometric estimations are shown in Table 4. We find that the development of volatility varies markedly across treatments. After the imposition of the FTT in treatment M, the level of volatility increases in the taxed market (LEFT), whereas it remains almost unchanged in the untaxed market (RIGHT). Most importantly, we report a significant difference between the left market and the right market when a tax is levied (see pairwise Wald-tests in

Table 4). However, in treatment R no differences between market LEFT and market RIGHT are visible. Thus, imposing a residence principle on subjects with home market LEFT causes no changes in volatility. Similarly to treatment M, we report an increase of volatility in the left market in treatment $\mathrm{MR_{SAME}}$ and a slight decrease in volatility in the right market. Again, we find a significant difference between the left and the right market when a tax is imposed. In treatment $\mathrm{MR_{DIFF}}$ we find the opposite pattern: volatility decreases in market LEFT and increases in market RIGHT when a residence tax (LEFT) and a market tax (RIGHT) are applied. Volatility in both markets is significantly different from each other. Hence, volatility in our markets is mostly volume-driven: whenever volume is high, volatility is low, and vice versa.

Insert Figure 2 and Table 4 about here

4.3 Market Efficiency

The values of *RAD* in the different treatments are shown in Figure 3. Econometric tests are provided in Table 5. They show that the implementation of a FTT has no significant effect on market efficiency in any of treatments M, $\mathrm{MR_{SAME}}$ and $\mathrm{MR_{DIFF}}$. Only when a residence tax is levied in treatment R, mispricing is significantly reduced in the left market. This is mainly driven by one outlier in a market that was untaxed. Therefore inefficiency was highest in this treatment. However, the inefficiency observed in this treatment when LEFT is taxed, is at the same level as in the other three treatments. Thus, the reduced inefficiency is a result of a less efficient benchmark, rather when indeed lower inefficiency, when compared to other treatments.

Insert Figure 3 and Table 5 about here

4.4 Tax Revenues

In the political debate on the implementation of a FTT tax revenues are a core argument of the proponents of the tax. Therefore, we calculate a naive estimate of hypothetical tax revenues – i.e., tax revenue if trading volume would not change after the introduction of a tax – and compare it to the actually realized tax revenues in each treatment. Figure 4 gives descriptive results on naive and realized tax revenues.

Insert Figure 4 about here

Since we measure level of tax revenues prior to and after the imposition of a FTT for each market (jurisdiction) separately, a different regression model is used:

$$y_{m,p} \quad = \quad \alpha + \beta_1 FTT_p + \epsilon_{m,p}. \tag{3}$$

Here, $y_{m,p}$ is a generic placeholder for the tax revenues in the phase prior to and after the introduction of a FTT on each market, m indicates cross-section (either the LEFT or RIGHT market in a specific session) and p phase (i.e., four periods in which a certain taxation scenario is applied). FTT is a binary dummy for the left or right market when a tax is levied and the intercept α represents the state in which the market is untaxed.

Table 6 provides econometric estimations. We see that in treatment M realized tax revenues are significantly lower than naively estimated hypothetical tax revenues. This result is driven by the strong shift in trading volume out of the taxed market LEFT. In contrast, we find no significant changes in tax revenues prior and after the introduction of a FTT in treatments R and MR_{SAME}. The latter effect can be explained by a lower shift in trading volume after the imposition of a FTT as traders taxed according to the residence principle cannot avoid the tax, except by not trading. In treatment MR_{DIFF} market LEFT as well as market RIGHT impose a FTT. Both market places show a significantly lower amount of tax revenues once a FTT is implemented, compared to the naive tax revenues. The extremely low tax revenues in the right market are due to its market tax, which traders avoid by trading on the left market. The significantly lower tax revenues on the left market are triggered by the residence tax of traders with home market LEFT, who trade less. This effect is not compensated by traders with home market RIGHT, although they trade without tax burden on the left market.

Insert Table 6 about here

4.5 Discussion of Market Outcomes

To sum up, the results on a macro level show a very clear picture. The implementation of a FTT as a market tax (treatment M) or as a combination of a market and a residence tax (treatment MR_{SAME} and treatment MR_{DIFF}) has negative effects on the marketplace which imposes the FTT as a market tax. In particular, subjects avoid a market tax and shift most of their trading volume to the tax haven. Due to the loss of liquidity, volatility is significantly higher in markets with a market tax compared to the ones without market tax. This result is in line with earlier evidence in Hanke et al. (2010) and Kirchler et al. (2011).

When the residence principle is applied – an institutional form of a FTT not discussed in the literature so far – the affected traders cannot avoid the tax and therefore they provide higher liquidity to the market compared to a scenario with a market tax that is easily avoided. This is also confirmed by running regression equation (2) with limit orders as dependent variable. The number of posted limit orders decreases significantly in the taxed market after the imposition of a FTT in treatments with a market tax (M and MR_{SAME}: z-values of -7.872 and -4.196, respectively). In contrast, liquidity, measured by the number of limit orders, stays constant (R, z-value of 0.407) or even increases (MR_{DIFF}, z-value of 6.823) in treatments where a residence tax is imposed without a corresponding market tax. As a consequence, the implementation of a FTT according to the residence principle has no negative effects on volume and volatility in its plain-vanilla form in treatment R. This non-negative effect of a residence-based tax is reinforced and even leads to a significantly lower volatility of this market as soon as the other market imposes a market-based tax. This pattern is evident in treatment $\mathrm{MR_{DIFF}}$ as volatility decreases in the left market because of an inflow of liquidity from the right market.

5 Analysis of Individual-Level Data

Our experimental approach allows to examine individual level data on trading behavior in detail. Here, we investigate whether a FTT has different effects on traders with different levels of risk tolerance. To do so, we first establish whether risk attitudes are related to trading behavior in general. Then we proceed and check whether a FTT has different effects on traders with different risk attitudes.[13]

5.1 Risk Aversion and Individual Trading

To explore differences in the trading behavior of subjects conditional on their risk attitudes, we run the following regression model:

$$\begin{aligned} y_i &= \alpha + \beta_1 \mathrm{M} * RISK_i + \beta_2 \mathrm{R} * RISK_i + \\ &\quad \beta_3 \mathrm{MR_{SAME}} * RISK_i + \beta_4 \mathrm{MR_{DIFF}} * RISK_i + \epsilon_i. \end{aligned} \tag{4}$$

y_s is a generic placeholder for the dependent variables explained below, i identifies a particular subject. The interacted binary dummy variables for each treatment – e.g., M*$RISK$ – measure the impact of subject's risk preferences in each treatment. $RISK$ stands for the amount X invested in the risky lottery in the risk aversion task (Gneezy and Potters, 1997). The higher a subject's

[13]Since not only risk attitudes might be important for trading on markets, we also consider loss aversion as a potentially important trader characteristic in order to explain trading behavior. However, in our analysis we do not observe any significant impact of subjects' level of loss aversion (parameter λ) on their trading behavior, as shown in Appendix A and B. In fact, adding loss aversion as an explanatory variable makes the model fit worse (as measured by BIC or AIC). For this reason, and for the sake of brevity and readability, we therefore relegate the analysis including loss aversion to the Appendix.

amount X is, the less risk-averse she is considered. The intercept α represents the average of all treatments.[14] Table 7 presents the dependent variables: normalized trading volume per subject, normalized limit orders per subject, and normalized standard deviation of stock holdings per subject.[15] It is important to mention that as all dependent variables are normalized the interacted binary dummies only measure the impact of the risk coefficient.

Insert Table 7 about here

Table 8 outlines the results. We find that subjects with high risk tolerance coefficients show a significantly higher trading activity. Subjects who are less risk-averse trade significantly more and post significantly more limit orders compared to their more risk-averse counterparts. These results are robust across all treatments. As a consequence, subjects with high risk coefficients show a significantly higher standard deviation of stock holdings and therefore hold more volatile and extreme portfolio positions over time.

Insert Table 8 about here

Additionally, we analyze the use of short selling and borrowing cash with regards to subjects' risk attitudes. As outlined above, short selling and borrowing was allowed up to 100 percent of the initial endowments in assets and cash. We find that only 64 out of 480 subjects (13.3 percent) have short positions in assets and 41 subjects (8.5 percent) have negative cash holdings at the end of at least one period. Approximately 60 percent of the subjects who go at least once short in assets or cash have the highest risk coefficient of 2, while only 34 percent of the subjects who do not use short-selling or borrowing have the highest risk coefficient. To test whether there is a significant difference in the distribution of risk coefficients between these two groups, we run a Kolmogorov-Smirnov equality-of-distributions test. Indeed, we find a significant difference

[14] We apply clustered standard errors on a session level to allow for correlation within sessions and independence between sessions.

[15] Again, we normalize trading volume, limit orders and standard deviation of stock holdings per subject to control for idiosyncratic effects of individual sessions as argued in Section 4.

between the distribution of both groups (D-value for short-selling: 0.2462, p-value: 0.002, N=480; D-value for borrowing: 0.2492, p-value: 0.019; N=480). Thus, the more risk tolerant subjects are, the more they use short selling and borrowing.

We summarize this subsection by noting that subjects' trading behavior strongly depends on their risk tolerance. More specifically, subjects with more risk tolerance – i.e. with lower degrees of risk aversion – trade more, post more limit orders, show a higher volatility in their asset holdings and use short selling opportunities more frequently. These effects hold across all treatments. Based on these findings, we can now proceed to answer our final question, whether the imposition of a FTT has different effects on traders with different levels of risk aversion.

5.2 Interaction of FTT with Risk Aversion

We apply the following regression model to explore whether subjects with different risk attitudes react differently to the imposition of a FTT:

$$y_{m,p} = \alpha + \beta_1 RISK_i + \epsilon_i. \tag{5}$$

Here, $y_{m,p}$ is a generic placeholder for the dependent variables and $RISK_i$ stands for the risk coefficient of subject i.[16]

Insert Table 9 about here

We use the following dependent variables: First, we calculate the normalized sum of all tax payments per subject i ($SUMTAX_i$). This allows to test whether subjects with different risk attitudes show a different proneness for paying the tax. Second, we calculate subject i's ratio between the trading volume on the left market and on the right market when a tax is levied ($MARKETSHARE_i$).

[16]Again, we apply clustered standard errors on a session level.

Here, we examine whether less risk averse subjects avoid more taxes resulting in a smaller market share on the taxed market compared to more risk averse subjects. Third, we compare each subject's change in trading volume prior and after a FTT is applied on both markets ($\Delta VOLLEFT$ and $\Delta VOLRIGHT$). This enables us to investigate whether risk attitude determines behavioral changes after the imposition of a FTT on each market place. Table 9 shows the variables, and Table 10 presents the econometric results. Except for one single case (which lies well in the limits of chance), we find no differences in behavior of subjects with different risk attitudes when a FTT is applied.

Insert Table 10 about here

In sum, this final subsection has provided strong evidence that traders with different risk attitudes do *not* react differently to the imposition of a FTT. This means that risk tolerant and risk averse traders adapt their trading behavior in the same way when a FTT is levied. As a consequence, the macro results of our paper are not primarily driven by the tax avoiding behavior of traders with low levels of risk aversion. Instead, results on a macro level are driven by adaptive behavior of all traders, which is independent of their risk attitudes (and also independent of their level of loss aversion, as shown in the Appendix).

6 Conclusion

The possible introduction of a FTT in eleven member states of the European Union in 2015 constitutes a very large-scale policy experiment, with unclear consequences for financial markets all over Europe (and most likely elsewhere). We consider laboratory experiments as ideal, cheap, and practically riskfree testbeds to explore likely consequences of a legislative change before this change is actually implemented.[17] For this reason, we conducted experiments to explore

[17]Several researchers have advocated the potential usefulness of experiments for addressing policy-relevant questions. For instance, Roth (2002) discusses the role of (experimental) economists as institutional engineers. However, it is clear that experiments are by necessity always a simplification and can thus not give a perfect and fully comprehensive picture of

the effects of a FTT on market outcomes and individual traders. We compared the "market principle" and the "residence principle" as basis of a FTT, examining both principles separately, but also jointly. We found that applying only the residence principle as basis for a FTT had no significant effects on trading volume or volatility. The market principle, however, resulted in large and significant shifts in trading volume from the taxed market to the untaxed alternative. With liquidity in the taxed market evaporating, volatility increased significantly, while it dropped in the untaxed alternative.

The combined implementation of market and residence principle within one jurisdiction showed the following effects: a significant drop in trading volume in the jurisdiction implementing both principles and a respective increase in the other one. By contrast, volatility increased in the jurisdiction with a tax on residents and market tax for foreigners, whereas it dropped in the one without any tax burdens. However, both effects were considerably weaker than when only the market principle was applied. This means that adding the residence principle dampened (rather than exacerbated) the negative repercussions from applying a market principle. We consider the latter a particularly interesting, and novel, finding of our experiment. Our results highlight that details of the implementation are of paramount importance and economists should get their hands dirty with these details.

the real-world situation under consideration (see e.g. List (2011) for limitations of laboratory experiments).

References

Aliber, Robert C., Chowdhry Bhagwan, Yan Shu. 2003. Some evidence that a tobin tax on foreign exchange transactions might increase volatility. *European Finance Review* **7**(3) 481–510.

Baltagi, Badi H., Dong Li, Qi Li. 2006. Transaction tax and stock market behavior: evidence from an emerging market. *Empirical Economics* **31** 393–408.

Bloomfield, Robert, Maureen O'hara, Gideon Saar. 2009. How noise trading affects markets: an experimental analysis. *The Review of Financial Studies* **22**(6) 2275–2301.

Cipriani, M., A. Guarino. 2008. Transaction costs and informational cascades in financial markets. *Journal of Economic Behavior and Organization* **68** 581–592.

Dow, J., R. Rahi. 2000. Should sepculators be taxed? *Journal of Business* **73** 89–107.

Ehrenstein, G., F. Westerhoff, D. Stauffer. 2005. Tobin tax and market depth. *Quantitative Finance* **5**(2) 213–218.

Ehrenstein, Gudrun. 2002. Cont-bouchaud percolation model including tobin tax. *International Journal of Modern Physics C* **13**(10) 1323–1331.

Fischbacher, Urs. 2007. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics* **10**(2) 171–178.

Gächter, Simon, E. J. Johnson, A. Hermann. 2007. Individual-level loss aversion in riskless and risky choices. CeDEx Discussion Paper No. 2007-02.

Gneezy, Uri, Jan Potters. 1997. An experiment on risk taking and evaluation periods. *Quarterly Journal of Economics* **112** 631–645.

Greiner, Ben. 2004. *Forschung und wissenschaftliches Rechnen 2003, An Online Recruitment System for Economic Experiments*. GWDG Bericht 63. Gesellschaft fuer Wissenschaftliche Datenverarbeitung, Goettingen, 79–93.

Habermeier, K., A. Kirilenko. 2003. Securities transaction taxes and financial markets. J. Weaver, R. Dodd, J. Baker, eds., *Debating the Tobin Tax*. New Rules for Global Finance Coalition, Washington D.C.

Hanke, Michael, Jürgen Huber, Michael Kirchler, Matthias Sutter. 2010. The economic consequences of a tobin tax - an experimental analysis. *Journal of Economic Behavior and Organization* **74** 58–71.

Hau, Harald. 2006. The role of transaction costs for financial volatility: Evidence from the paris bourse. *Journal of the European Economic Association* **4**(4) 862–890.

Hommes, Cars. 2006. Heterogeneous agent models in economics and finance. Leigh Tesfatsion, Kenneth L. Judd, eds., *Handbook of Computational Economics, Edition 1, Volume 2*. 1109–1186.

Jones, Charles M., Paul J. Seguin. 1997. Transaction costs and price volatility: Evidence from commission deregulation. *The American Economic Review* **87**(4) 728–737.

Keynes, J.M. 1936. *The General Theory of Employment, Interest and Money*. London: MacMillan.

Kirchler, Michael, Jürgen Huber, Daniel Kleinlercher. 2011. Market microstructure matters when imposing a tobin tax - evidence from laboratory experiments. *Journal of Economic Behavior & Organisation* **80(3)** 586–602.

Kupiec, Paul H. 1995. A securities transactions tax and capital market efficiency. *Contemporary Economic Policy* 101–112.

Lillo, Fabrizio, J. Doyne Farmer. 2005. The key role of liquidity fluctuations in determining large price changes. *Fluctuation and Noise Letters* **5**(2) L209–L216.

List, John. 2011. Why economists should conduct field experiments and 14 tips for pulling one off. *Journal of Economic Perspectives* **25**(3) 3–16.

Lux, Thomas. 1998. The socio-economic dynamics of speculative markets, interacting agents, chaos, and the fat tails of return distributions. *Journal of Economic Behavior and Organization* **33** 143–165.

Lux, Thomas, Michele Marchesi. 2000. Volatility clustering in financial markets, a microsimulation of interacting agents. *International Journal of Theoretical and Applied Finance* **3** 675–702.

Mannaro, Katiuscia, Michele Marchesi, Alessio Setzu. 2008. Using an artificial financial market for assessing the impact of tobin-like transaction taxes. *Journal of Economic Behavior and Organization* **67** 445–462.

McCulloch, Neil, Grazia Pacillo. 2011. The tobin tax: A review of the evidence. *IDS Research Report* **68** 1–79.

Pellizzari, Paolo, Frank Westerhoff. 2009. Some effects of transaction taxes under different microstructures. *Journal of Economic Behavior and Organization* **72** 850–863.

Plerou, Vasiliki, Parameswaran Gopikrishnan, Luís A. Nunes Amaral, Martin Meyer, Eugene H. Stanley. 1999. Scaling of the distribution of price fluctuations of individual companies. *Physical Review E* **60** 6519–6529.

Roth, Alvin E. 2002. The economist as engineer: Game theory, experimentation, and computation as tools fo design economics. *Econometrica* **70**(4) 1341–1378.

Schwert, William G., Paul J. Seguin. 1993. Securities transaction taxes: An overview of costs, benefits, and unresolved questions. *Financial Analysts Journal* 27–35.

Spahn, Paul Bernd. 2002. On the feasibility of a tax on foreign exchange transactions. *Report to the Federal Ministry for Economic Cooperation and Development* .

Stiglitz, Joseph E. 1989. Using tax policy to curb speculative short-term trading. *Journal of Financial Services Research* **3** 101–115.

Stöckl, Thomas, Jürgen Huber, Michael Kirchler. 2010. Bubble measures in experimental asset markets. *Experimental Economics* **13** 284–298.

Subrahmanyam, Avanidhar. 1998. Transaction taxes and financial market equilibrium. *Journal of Business* **71**(1) 81–118.

Summers, L., V.P. Summers. 1989. When financial markets work too well: A cautious case for a securities transaction tax. *Journal of Financial Services Research* **3** 261–286.

Tobin, James. 1978. A proposal for international monetary reform. *Eastern Economic Journal* **4** 153–159.

ul Haq, Mahbub, Inge Kaul, Isabelle Grunberg. 1996. *The Tobin Tax. Coping with Financial Volatility*. Oxford University Press.

Umlauf, Steven R. 1993. Transaction taxes and the behaviour of the swedish stock market. *Journal of Financial Economics* **33** 227–240.

Westerhoff, Frank H. 2003. Heterogeneous traders and the tobin tax. *Journal of Evolutionary Economics* **13** 53–70.

Westerhoff, Frank H., Roberto Dieci. 2006. The effectiveness of keynes-tobin transaction taxes when heterogenous agents can trade in different markets: A behavioral finance approach. *Journal of Economic Dynamics & Control* **30**(2) 293–322.

Tables and Figures

Table 1: Taxation Scenarios for the various treatments depending on subjects' home market and trading place (LEFT or RIGHT).

	Tax when trading on market...	
Treatment M	LEFT	RIGHT
Home Market LEFT	0.1%	-
Home Market RIGHT	0.1%	-
Treatment R	LEFT	RIGHT
Home Market LEFT	0.1%	0.1%
Home Market RIGHT	-	-
Treatment MR_{SAME}	LEFT	RIGHT
Home Market LEFT	0.1%	0.1%
Home Market RIGHT	0.1%	-
Treatment MR_{DIFF}	LEFT	RIGHT
Home Market LEFT	0.1%	0.2%
Home Market RIGHT	-	0.1%

In case of taxation, entries show the tax rate conditional on the residence of the subjects for each market.

Table 2: Formulae for the calculation of variables on the market level.

Measure	**Calculation**
Normalized trading volume	$VOL_{s,m,k} = (vol_{s,m,k} - \overline{vol_s})/\sigma_s^{vol}$
Normalized returns (tick data)	$RET_{s,m,i} = (ret_{s,m,i} - \overline{ret_s})/\sigma_s^{ret}$
SD of normalized returns	$SDRET = SD(RET_{s,m,i})$
Relative absolute deviation	$RAD_{s,m,k} = \lvert\overline{P_{s,m,k}} - FV_{s,m,k}\rvert/\lvert\overline{FV_s}\rvert$
Normalized tax revenues	$TAX_{m,k} = (tax_{m,k} - \overline{tax_m})/\sigma_m^{tax}$

s...session, m...market (either LEFT or RIGHT), k...period, i...trades. $vol_{s,m,k}$ = units of the asset traded in period k; $\overline{vol_s}$ = average trading volume per period of the asset in session s; σ_s^{vol} = standard deviation of all trading volumes per period of the asset in session s;
$ret_{s,m,i} = \ln(P_{s,m,i}) - \ln(P_{s,m,i-1})$; $P_{s,m,i}$ = trading price of trade i; $\overline{ret_s}$ = average of all returns (ret) in session s; σ_s^{ret} = standard deviation of all returns (ret) in session s; $\overline{P_{s,m,k}}$ = (volume-weighted) mean price; $FV_{s,m,k}$ = fundamental value in session s and period k (identical in both markets); $\overline{FV_s}$ = average fundamental value of the session; $tax_{m,k}$ = tax revenues in Taler in market m and period k; $\overline{tax_m}$ = average tax revenues per period in Taler in market m; σ_m^{tax} = standard deviation of all tax revenues per period in Taler in market m;

Table 3: Trading volume (VOL) across treatments.

VOL	M	R	$\mathrm{MR_{SAME}}$	$\mathrm{MR_{DIFF}}$
Intercept	-0.023	-0.060	0.014	0.083
	(-0.571)	(-0.592)	(0.136)	(1.186)
LEFT	-0.997***	0.150	-0.688***	0.685***
	(-10.420)	(0.704)	(-2.962)	(3.543)
RIGHT	1.091***	0.090	0.633***	-1.016***
	(13.518)	(0.282)	(2.926)	(-9.338)
Pairwise Wald-tests:				
LEFT vs.				
RIGHT	976.00***	0.03	43.68***	137.90***
N	48	48	48	48

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. $\mathrm{MR_{SAME}}$: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. $\mathrm{MR_{DIFF}}$: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: Intercept: phase in which both markets are untaxed. LEFT: market LEFT, either taxed or untaxed. RIGHT: market RIGHT, either taxed or untaxed.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Top: Coefficient values with corresponding z-values (in parentheses) are provided. Bottom: t-statistics of pairwise Wald-tests are shown.

Table 4: Volatility ($SDRET$) across treatments.

$SDRET$	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.935***	0.974***	0.924***	1.049***
	(9.748)	(11.433)	(13.020)	(13.905)
LEFT	0.294	-0.058	0.240	-0.175
	(1.188)	(-0.280)	(1.073)	(-1.137)
RIGHT	-0.031	0.012	-0.121	0.164
	(-0.176)	(0.072)	(-0.883)	(1.060)
Pairwise Wald-tests:				
LEFT vs.				
RIGHT	3.93**	0.68	7.14***	4.81**
N	47	48	48	45

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: Intercept: phase in which both markets are untaxed. LEFT: market LEFT, either taxed or untaxed. RIGHT: market RIGHT, either taxed or untaxed.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Top: Coefficient values with corresponding z-values (in parentheses) are provided. Bottom: t-statistics of pairwise Wald-tests are shown.

Table 5: Market efficiency (RAD) across treatments.

RAD	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.082***	0.098***	0.082***	0.137**
	(5.915)	(7.313)	(7.478)	(2.585)
LEFT	0.029	-0.030***	0.002	-0.053
	(0.876)	(-3.021)	(0.114)	(-1.078)
RIGHT	-0.003	-0.018	-0.001	-0.047
	(-0.200)	(-1.413)	(-0.079)	(-0.871)
Pairwise Wald-tests:				
LEFT vs.				
RIGHT	1.35	4.64**	0.46	0.17
N	48	48	48	46

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: Intercept: phase in which both markets are untaxed. LEFT: market LEFT, either taxed or untaxed. RIGHT: market RIGHT, either taxed or untaxed.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Top: Coefficient values with corresponding z-values (in parentheses) are provided. Bottom: t-statistics of pairwise Wald-tests are shown.

Table 6: Normalized tax revenues (TAX) for market LEFT and market RIGHT across the various taxation scenarios.

TAX	M	R	$\mathrm{MR}_{\mathrm{SAME}}$	$\mathrm{MR}_{\mathrm{DIFF}}$	
	LEFT	LEFT	LEFT	LEFT	RIGHT
Intercept	0.625***	0.116	-0.113	0.377***	0.758***
	(7.080)	(0.713)	(-0.729)	(5.721)	(31.506)
FTT	-1.249***	-0.232	0.206	-0.755***	-1.516***
	(-7.080)	(-0.713)	(0.688)	(-5.721)	(-31.506)
N	24	24	24	24	24

Treatments: M: market tax on market LEFT. R: tax for residents of market LEFT. $\mathrm{MR}_{\mathrm{SAME}}$: tax for residents of market LEFT and corresponding market tax on market LEFT. $\mathrm{MR}_{\mathrm{DIFF}}$: tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: Intercept: phase in which a market is untaxed. FTT: phase in which a market is taxed.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Table 7: Formulae for the calculation of variables on an individual level.

Measure	Calculation
Normalized trading volume	$VOL_i = (vol_i - \overline{vol_s})/\sigma_s^{vol}$
Normalized limit orders	$LO_i = (lo_i - \overline{lo_s})/\sigma_s^{lo}$
Normalized SD of stock holdings	$SDSTOCK_i = (sd\_stock_i - \overline{sd\_stock_s})/\sigma_s^{sd\_stock}$

s...session, i...trader.

vol_i = average number of traded assets per period for trader i; $\overline{vol_s}$ = average trading volume per period in session s among all subjects; σ_s^{vol} = standard deviation of all trading volumes among all subjects in session s; lo_i = average number of limit orders per period for trader i; $\overline{lo_s}$ = average number of of all limit orders (lo) among all subjects in session s; σ_s^{lo} = standard deviation of the number of all limit orders (lo) in session s among all subjects; sd_stock_t = standard deviation of stock holdings per trader i; $\overline{sd\_stock_s}$ = average standard deviation of stock holdings in session s; $\sigma_s^{sd\_stock}$ = standard deviation of all standard deviations of stock holdings in session s;

Table 8: Regression for differences in behavior conditional on subjects' risk attitudes.

	VOL	*LO*	*SDSTOCK*
Intercept	-0.230***	-0.294***	-0.230**
	(-3.499)	(-3.536)	(-2.422)
M**RISK*	0.159***	0.196***	0.120
	(3.128)	(2.943)	(1.630)
R**RISK*	0.180***	0.240***	0.207***
	(3.430)	(3.208)	(2.735)
MR_{SAME}**RISK*	0.199***	0.267***	0.178*
	(2.983)	(3.790)	(1.907)
MR_{DIFF}**RISK*	0.166***	0.201***	0.199***
	(3.648)	(3.405)	(3.165)
N	480	480	480

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: *VOL*: normalized trading volume. *LO*: normalized limit orders. *SDSTOCK*: normalized standard deviation of stock holdings. Intercept: average across all treatments. *RISK*: amount X invested in the risky lottery in the risk aversion task (Gneezy and Potters, 1997). *, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Table 9: Formulae for the calculation of variables for trading behavior prior to and after the imposition of a FTT.

Measure	Calculation
Normalized Tax Payments	$SUMTAX_{i,k} = (sumtax_{i,k} - \overline{sumtax_s})/\sigma_s^{sumtax}$
Market Share	$MARKETSHARE_i = vol\_\mathrm{LEFT}_i/(vol\_\mathrm{LEFT}_i + vol\_\mathrm{RIGHT}_i)$
Change in volume on market LEFT	$\Delta VOLLEFT_i = vol\_\mathrm{LEFT}_i/\overline{vol\_noTax_i} - 1$
Change in volume on market RIGHT	$\Delta VOLRIGHT_i = vol\_\mathrm{RIGHT}_i/\overline{vol\_noTax_i} - 1$

s...session, i...trader, k...period.

vol_LEFT_i = trading volume of trader i on the left market in case of taxation; vol_RIGHT_i = trading volume of trader i on the right market in case of taxation; $\overline{vol\_noTax_i}$ = average trading volume of trader i in market LEFT and RIGHT in case of no taxation;

Table 10: Regression for $SUMTAX$, $MARKETSHARE$, $\Delta VOLLEFT$ and $\Delta VOLRIGHT$.

$SUMTAX$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	-0.068	-0.032	-0.147	0.018	-0.126
	(-0.833)	(-0.156)	(-0.912)	(0.109)	(-0.805)
$RISK$	0.052	0.023	0.115	-0.015	0.091
	(0.834)	(0.157)	(0.918)	(-0.109)	(0.804)
N	480	120	120	120	120
$MARKETSHARE$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.445***	0.087**	0.579***	0.308***	0.901***
	(7.281)	(2.786)	(7.086)	(7.005)	(13.404)
$RISK$	0.009	0.041	-0.008	-0.005	-0.019
	(0.323)	(1.765)	(-0.141)	(-0.206)	(-0.435)
N	408	119	58	115	116
$\Delta VOLLEFT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.450	-0.853***	0.159	0.987	1.396***
	(1.225)	(-10.379)	(0.720)	(0.821)	(4.927)
$RISK$	-0.223	0.142**	0.019	-0.799	-0.236
	(-1.031)	(2.305)	(0.118)	(-1.098)	(-1.448)
N	472	118	119	116	119
$\Delta VOLRIGHT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	1.048	1.039**	0.172	3.222	-0.804***
	(1.480)	(2.984)	(0.411)	(1.379)	(-5.852)
$RISK$	-0.452	-0.094	0.058	-1.505	0.062
	(-1.074)	(-0.537)	(0.171)	(-1.026)	(0.714)
N	472	118	119	116	119

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: $SUMTAX$: normalized sum of all tax payments per subject. $MARKETSHARE$: subject i's ratio between the trading volume on the left market and on the right market when a tax is levied. $\Delta VOLLEFT$ and $\Delta VOLRIGHT$: subject i's change in trading volume (on market LEFT or RIGHT) between phases with and without the tax. $RISK$: amount X invested in the risky lottery in the risk aversion task (Gneezy and Potters, 1997).
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

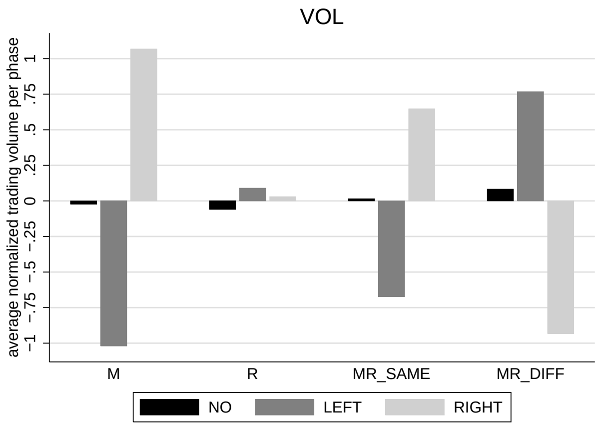


Figure 1: Descriptive statistics for VOL (normalized trading volume) averaged per phase and conditional on treatment and taxation scenario. NO stands for periods without any tax, $LEFT$ for the left market and $RIGHT$ for the right market when a tax is applied (on any market).

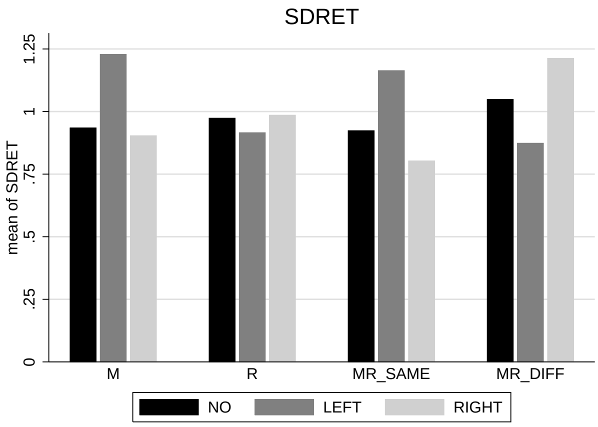


Figure 2: Descriptive statistics for $SDRET$ (standard deviation of normalized returns) averaged per phase and conditional on treatment and taxation scenario. NO stands for periods without any tax, $LEFT$ for the left market and $RIGHT$ for the right market when a taxation scenario is applied.

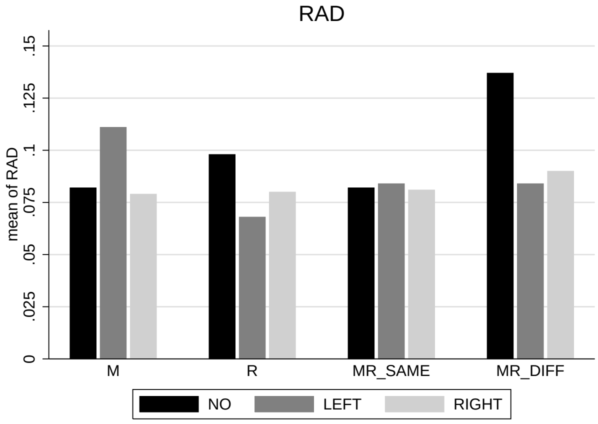


Figure 3: Descriptive statistics for RAD (relative absolute deviation of prices compared to fundamentals) averaged per phase and conditional on treatment and taxation scenario. NO stands for periods without any tax, $LEFT$ for the left market and $RIGHT$ for the right market when a taxation scenario is applied.

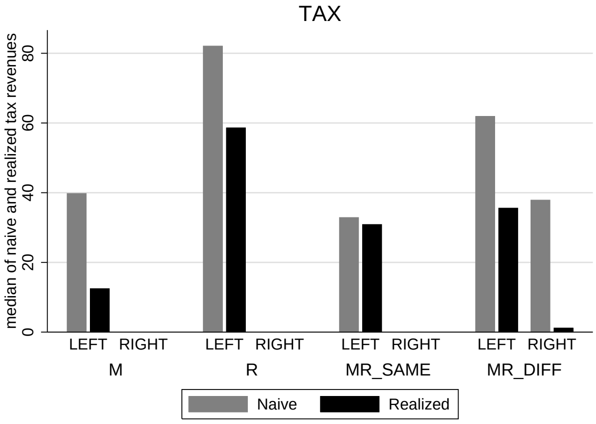


Figure 4: Descriptive statistics for naive and hypothetical tax revenues. Median of hypothetical and realized tax revenues (in Taler) for market LEFT across the various taxation scenarios and market RIGHT in $\mathrm{MR}_{\mathrm{DIFF}}$.

Appendix

Appendix A: Loss Aversion and Individual Trading

To explore whether we observe differences in the trading behavior of subjects conditional on their level of loss aversion, we run the following regression model:

$$\begin{aligned} y_i &= \alpha + \beta_1 \mathrm{M} * LOSS_i + \beta_2 \mathrm{R} * LOSS_i + \\ &\quad \beta_3 \mathrm{MR}_{\mathrm{SAME}} * LOSS_i + \beta_4 \mathrm{MR}_{\mathrm{DIFF}} * LOSS_i + \epsilon_i. \end{aligned} \tag{6}$$

y_s is a generic placeholder for the dependent variables explained below, i stands for subject. The interacted binary dummy variables for each treatment – e.g., M*$LOSS$ – measure the impact of subjects' loss aversion in each treatment. $LOSS$ stands for the individual loss aversion parameter λ (Gächter et al., 2007) ranging from larger than 2.5 in case of rejecting all lotteries to smaller than 0.83 in case of accepting all lotteries. The higher the individual loss parameter λ, the more loss averse a subject is. The intercept α represents the average of all treatments. Again, we apply clustered standard errors on a session level to allow for correlation within sessions and independence between sessions. It is important to mention that as all dependent variables are normalized the interacted binary dummies only measure the impact of the loss aversion coefficient.

Table A1 shows that loss aversion has an effect on trading volume in the expected direction. More loss averse subjects trade less. Adding the coefficient of $RISK$ to the specification in Table A1, we see from Table A2 that the significance of loss aversion gets weaker, and partly insignificant, when we control for $RISK$. In fact, the best model fit (according to BIC and AIC) is given when we only control for $RISK$, as has been done in the main text in Table 8.

Table A1: Regression for differences in behavior conditional on subjects' loss aversion.

	VOL	*LO*	*SDSTOCK*
Intercept	0.321**	0.131	-0.050
	(2.013)	(1.067)	(-0.348)
M*$LOSS$	-0.185**	-0.064	0.017
	(-2.272)	(-0.996)	(0.214)
R*$LOSS$	-0.171**	-0.064	0.016
	(-2.150)	(-1.087)	(0.211)
$\mathrm{MR}_{\mathrm{SAME}}$*$LOSS$	-0.137	-0.055	0.062
	(-1.539)	(-0.824)	(0.820)
$\mathrm{MR}_{\mathrm{DIFF}}$*$LOSS$	-0.184**	-0.078	0.017
	(-2.227)	(-1.147)	(0.219)
N	458	458	458

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. $\mathrm{MR}_{\mathrm{SAME}}$: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. $\mathrm{MR}_{\mathrm{DIFF}}$: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: VOL: normalized trading volume. LO: normalized limit orders. $SDSTOCK$: normalized standard deviation of stock holdings. Intercept: average across all treatments. $LOSS$: individual loss aversion parameter λ.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Table A2: Regression for differences in behavior conditional on subjects' risk and loss aversion.

	VOL	LO	$SDSTOCK$
Intecept	0.090	-0.237	-0.342*
	(0.404)	(-1.311)	(-1.885)
M*$RISK$	0.097	0.158	0.007
	(1.151)	(1.323)	(0.057)
R*$RISK$	0.162**	0.225*	0.259**
	(2.212)	(1.821)	(2.317)
MR_{SAME}*$RISK$	0.099	0.265***	0.094
	(0.885)	(3.120)	(0.676)
MR_{DIFF}*$RISK$	0.168**	0.199**	0.296***
	(2.262)	(2.069)	(4.624)
M*$LOSS$	-0.137	0.011	0.152
	(-1.547)	(0.126)	(1.338)
R*$LOSS$	-0.157*	-0.022	0.004
	(-1.764)	(-0.291)	(0.040)
MR_{SAME}*$LOSS$	-0.081	-0.024	0.150
	(-0.723)	(-0.302)	(1.558)
MR_{DIFF}*$LOSS$	-0.183*	-0.032	-0.034
	(-1.804)	(-0.326)	(-0.392)
N	458	458	458

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: VOL: normalized trading volume. LO: normalized limit orders. $SDSTOCK$: standard deviation of stock holdings. Intercept: average across all treatments. $RISK$: amount X invested in the risky lottery in the risk aversion task (Gneezy and Potters, 1997). $LOSS$: individual loss aversion parameter λ.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Appendix B: Interaction of FTT with Loss Aversion

We apply the following regression model to explore whether subjects with different levels of loss aversion react differently to the imposition of a FTT:

$$y_{m,p} \quad = \quad \alpha + \beta_1 LOSS_i + \epsilon_i. \tag{7}$$

Here, $y_{m,p}$ is a generic placeholder for the dependent variables and $LOSS_i$ stands for the loss aversion coefficient of subject i.[18] Table B1 shows that loss aversion is never significant. This remains true if one adds $RISK$ to the specification. Table B2 shows that loss aversion remains insignificant when risk aversion is controlled for. Again, the best model fit (according to BIC and AIC) is given when we only control for $RISK$, as has been done in the main text in Table 10.

[18]Again, we apply clustered standard errors on a session level.

Table B1: Regression for $SUMTAX$, $MARKETSHARE$, $\Delta VOLLEFT$ and $\Delta VOLRIGHT$.

$SUMTAX$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.008	-0.197	0.167	0.025	0.012
	(0.052)	(-0.816)	(0.599)	(0.078)	(0.035)
$LOSS$	-0.008	0.093	-0.080	-0.005	-0.026
	(-0.103)	(0.731)	(-0.557)	(-0.029)	(-0.141)
N	458	113	115	114	116
$MARKETSHARE$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.391***	0.182**	0.461***	0.279***	0.780***
	(6.137)	(2.688)	(4.463)	(3.453)	(9.996)
$LOSS$	0.035	-0.024	0.050	0.017	0.049
	(1.418)	(-0.968)	(1.215)	(0.456)	(1.525)
N	389	112	56	109	112
$\Delta VOLLEFT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	-0.019	-0.494**	0.312	-0.893	1.053**
	(-0.072)	(-2.482)	(1.018)	(-1.105)	(2.324)
$LOSS$	0.087	-0.090	-0.065	0.506	-0.039
	(0.592)	(-1.135)	(-0.506)	(0.899)	(-0.195)
N	450	111	114	110	115
$\Delta VOLRIGHT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.140	0.944*	0.697	-0.961	-0.502**
	(0.312)	(2.068)	(0.873)	(-0.543)	(-2.329)
$LOSS$	0.164	-0.002	-0.219	1.251	-0.119
	(0.566)	(-0.011)	(-0.672)	(1.017)	(-1.127)
N	450	111	114	110	115

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: $SUMTAX$: normalized sum of all tax payments per subject. $MARKETSHARE$: subject i's ratio between the trading volume on the left market and on the right market when a tax is levied. $\Delta VOLLEFT$ and $\Delta VOLRIGHT$: subject i's change in trading volume prior and after a FTT is applied on both markets. $LOSS$: individual loss aversion parameter λ.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Table B2: Regression for $SUMTAX$, $MARKETSHARE$, $\Delta VOLLEFT$ and $\Delta VOLRIGHT$.

$SUMTAX$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	-0.048	-0.158	-0.036	0.077	-0.131
	(-0.238)	(-0.439)	(-0.092)	(0.153)	(-0.308)
$RISK$	0.032	-0.022	0.121	-0.030	0.080
	(0.477)	(-0.145)	(0.885)	(-0.197)	(0.644)
$LOSS$	-0.001	0.088	-0.055	-0.013	-0.009
	(-0.010)	(0.667)	(-0.364)	(-0.067)	(-0.051)
N	458	113	115	114	116
$MARKETSHARE$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.355***	0.138*	0.446***	0.274**	0.802***
	(4.516)	(2.054)	(3.948)	(2.854)	(7.258)
$RISK$	0.021	0.025	0.008	0.003	-0.012
	(0.743)	(1.100)	(0.140)	(0.113)	(-0.266)
$LOSS$	0.040	-0.019	0.053	0.017	0.047
	(1.551)	(-0.749)	(1.478)	(0.455)	(1.390)
N	389	112	56	109	112
$\Delta VOLLEFT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.287	-0.688***	0.284	0.388	1.271**
	(0.862)	(-4.281)	(1.011)	(0.424)	(2.652)
$RISK$	-0.178	0.114*	0.017	-0.738	-0.122
	(-0.847)	(1.862)	(0.107)	(-1.093)	(-0.674)
$LOSS$	0.049	-0.071	-0.061	0.293	-0.063
	(0.418)	(-0.890)	(-0.549)	(0.757)	(-0.351)
N	450	111	114	110	115
$\Delta VOLRIGHT$	Overall	M	R	MR_{SAME}	MR_{DIFF}
Intercept	0.916**	1.060	0.680	1.347	-0.623*
	(2.088)	(1.481)	(1.240)	(1.399)	(-1.857)
$RISK$	-0.451	-0.068	0.010	-1.329	0.068
	(-1.127)	(-0.344)	(0.033)	(-1.031)	(0.742)
$LOSS$	0.067	-0.014	-0.217	0.868	-0.105
	(0.319)	(-0.060)	(-0.770)	(1.086)	(-0.874)
N	450	111	114	110	115

Treatments: M: Market tax on market LEFT. R: Residence tax for residents of market LEFT. MR_{SAME}: Residence tax for residents of market LEFT and corresponding market tax on market LEFT. MR_{DIFF}: Residence tax for residents of market LEFT and corresponding market tax on market RIGHT.
Variables: $SUMTAX$: normalized sum of all tax payments per subject. $MARKETSHARE$: subject i's ratio between the trading volume on the left market and on the right market when a tax is levied. $\Delta VOLLEFT$ and $\Delta VOLRIGHT$: subject i's change in trading volume prior and after a FTT is applied on both markets. $RISK$: amount X invested in the risky lottery in the risk aversion task (Gneezy and Potters, 1997). $LOSS$: individual loss aversion parameter λ.
*, ** and *** represent the 10%, 5% and the 1% significance levels of a double-sided test. Coefficient values with corresponding z-values (in parentheses) are provided.

Appendix C: Instructions for the Experiments

Background of the Experiment

This experiment is concerned with replicating an asset market where 10 traders can trade one asset on two different marketplace (Market LEFT and market RIGHT) simultaneously. Thereby one half of the subjects is a resident of market LEFT and the other half of market RIGHT. You are a resident of market XY - this will be displayed on the trading screen as well.

Market Properties

- Initial endowment: Half of the traders start with 75 units of the asset and 3000 cash, while the other half of the traders start with 25 units of the asset and 5000 cash.
- There are two markets where the asset can be traded - markets LEFT and RIGHT.
- No interests are paid.
- The prices in the two markets can deviate.

Fundamental value of the asset

The fundamentally justified value - fundamental value need not equal the price - of the asset (expressed in cash) is the value that would result from a full and fair analysis of the asset. In reality it depends on micro- and macroeconomic variables. In our market the fundamental the asset (expressed in cash) is modelled as a stochastic process:

$$\mathrm{FV}_k = \mathrm{FV}_{k-1} \cdot e^{\gamma_k}.$$

where FV_k stands for the fundamental value in period k and γ_k is a normally distributed random variable with a mean of zero and a standard deviation of 10 percent. The fundamental value in the current period (increased by 0.5funda-mental value in the next period.

Information on the fundamental value of the asset

Each period each subject receives a private signal (SIGNAL) on the fundamental value of the asset (expressed in cash). This signal can be above or below the actual fundamental value with equal probability. Most signals are close to the true fundamental value, as only an error term with an expected value of zero and a standard deviation of 5 percent is added to the fundamental value.

Trading

- All subjects can buy and sell units of the asset at any time. This can be done on the LEFT or RIGHT market - switching between markets is free and causes no extra costs. Short selling (negative holdings) is possible up to an amount of -100 units of the asset and -6.000 in cash. The volume of each transaction is limited to 20 units of the asset, but trading volume within a period is unlimited.
- Each period subjects can enter as many BIDs and ASKs (between 1 and 999) as they want - again without restrictions on the LEFT and RIGHT market.
- IMPORTANT: The price of the asset is set exclusively by you and the other subjects in the market by supply and demand.

Calculating wealth during the experiment

Your wealth (expressed in cash) during the experiment is comprised of the value of your holdings in the asset (units of the asset multiplied by the last price) plus the holdings in cash. For valuing the asset the last price is used.

$$\text{Wealth} = (\text{units of the asset} * \text{price of the asset}) + \text{cash}$$

If prices in the two markets deviate, the current price with the higher trading volume is used.

Payout in EUR in the end of the experiment

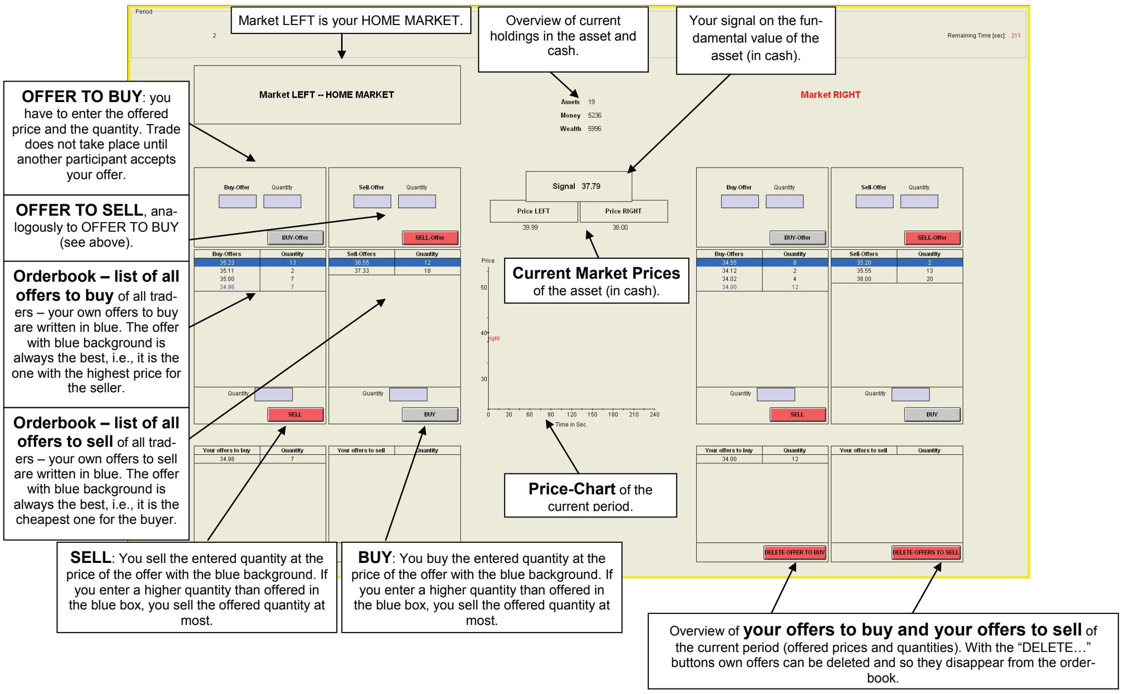
Your payment in Euro depends on your total wealth at the end of the experiment. Your holdings of the asset will be valued at their fundamental value (not price!) of the last period. The final payment is calculated as follows:

$$\text{Final wealth} = (\text{units of the asset} * \text{fundamental value}) + \text{cash},$$
$$\text{Payout in EUR} = \text{Final wealth} \ / \ 400$$

Example: assets: 30, fundamental value of the asset: 45, cash: 5050.

$$\text{Final wealth} = (30 * 45) + 5050 = 6400$$
$$\text{Payout in EUR} = 6400 \ / \ 400 = 16 \text{ Euro}$$

The trading screen looks as follows:[19]



Important Details

- Each trading period lasts 240 seconds, i.e. 4 minutes.
- The experiment lasts between 6 and 12 periods.

[19]Please note that we have chosen the left market to be the HOME MARKET in this example screenshot.

After each trading period a history screen is shown for 10 seconds to provide you with information on what happened in the market: