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Josef Fink, Stefan Palan, Erik Theissen

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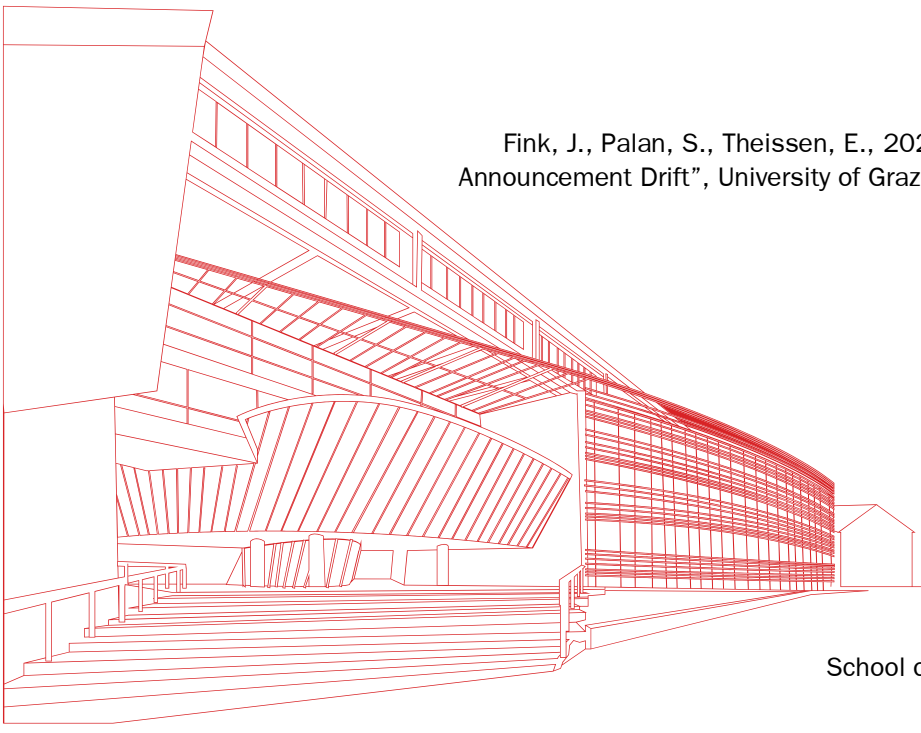

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JEL: G12, G14, G40, M41

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Trading Frictions and the Post-Earnings-Announcement Drift*

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1. Introduction

The *post earnings announcement drift* (PEAD), first documented by Ball and Brown (1968), is a well documented but poorly understood phenomenon. It describes the stylized fact that share prices do not adjust fully and instantaneously to the news contained in earnings announcements. Rather, an initial price change in the direction of the announcement (i.e., a price increase [decrease] after positive [negative] announcements) is followed by a subsequent drift of prices in the same direction, lasting up to a year. Such a predictable price change is difficult to reconcile with the efficient markets hypothesis (Fama, 1970). Consequently, a large number of papers both in accounting and in finance (most recently surveyed in Fink, 2021) have proposed and tested explanations for the PEAD. The available evidence is inconsistent with risk-based explanations of the PEAD and rather favors explanations related to mispricing or frictions.

Empirical analyses are complicated by the fact that important variables are unobservable. Researchers have to estimate the news component of an earnings announcement using a time-series model, or by comparing actual earnings to analyst forecasts. Furthermore, the effect of the earnings news on the fundamental value of a stock is unclear. Consequently, there is no benchmark against which to judge the actual price change. In a recent contribution, Fink et al. (2020) propose to analyze causes of the PEAD using financial market experiments. The focus of their paper is on earnings autocorrelation, a factor that is variably considered to cause or to strengthen the post earnings announcement drift (e.g., Bernard and Thomas (1989)). Fink et al. design two experimental treatments, one with and one without earnings autocorrelation. They report observing PEAD in both, but find that it is stronger in the treatment with correlated earnings.

The present paper extends this line of research. Where Fink et al. (2020) vary earnings autocorrelation but keep the amount of frictions in their experimental markets constant, we do the opposite. We keep earnings autocorrelation constant (at the level of the correlated

earnings treatment of Fink et al.) but vary the amount of frictions in our markets. We impose no transaction costs beyond the bid-ask spread that arises endogenously in the experimental markets in our *no frictions* treatment. Furthermore, traders are free to engage in margin buying and short selling (up to pre-defined limits). Conversely, we impose a transaction fee, levied on both the buyer and the seller in each transaction, in our *frictions* treatment. Traders are also barred from short selling and margin buying. Together, the two treatments allows us to study the extent to which trading frictions affect the strength of the PEAD.

The prior literature on the PEAD has addressed the issue of frictions in two different contexts: their effect on the strength of the PEAD and their effect on the profitability of trading strategies aimed at exploiting the PEAD. With respect to the first aspect, several papers find that the PEAD is more pronounced for stocks with higher direct (Bhushan, 1994; Doyle et al., 2006; Ng et al., 2008a; Zhang et al., 2013) and indirect (Chordia et al., 2009; Chung and Hrazdil, 2011) transaction costs. Boehmer and Wu (2013) find that greater short selling activity reduces the PEAD after negative earnings surprises, a result that implies more pronounced drift in the presence of short selling constraints.

With respect to the second aspect, the effect of frictions on the profitability of trading strategies, the available evidence is ambiguous. While Ng et al. (2008b), Chordia et al. (2009), Pavlova and Parhizgari (2011) and Zhang and Zhang (2013) find that abnormal returns essentially disappear after accounting for transaction costs, Ke and Ramalingegowda (2005), Battalio and Mendenhall (2011) and Li (2016) report evidence of significant excess returns even after transaction costs. The findings of Ali et al. (2020) partly reconcile these opposing views. They show that competition moderates the profitability of PEAD-based investment strategies.

As noted previously, there have been no prior experimental studies of the PEAD except for Fink et al. (2020). However, the experimental finance literature has addressed the issue of trading frictions in other contexts. Palan (2013) surveys the literature of experiments

using the Smith et al. (1988) design, concluding that there "is no clear evidence that taxes and transaction costs mitigate bubbles" (Palan, 2013, 579). Among the studies he surveys, Lei et al. (2002) find that transaction taxes do not decrease bubbles or asset turnover, and Chan et al. (2013) also find no significant effect of transaction taxes on turnover. In a different design, Hanke et al. (2010) and Huber et al. (2012) find that a transaction tax, when consistently levied on all available markets, reduces turnover, but otherwise has little effect on market efficiency and on what they term prices' 'stylized facts', i.e., fat tails and volatility clustering.

Our results can be summarized as follows. Trading activity is significantly lower in the presence of frictions. We observe slightly higher prices in the frictions treatment, a finding that is consistent with the notion that short selling constraints result in overvaluation. Imposing frictions has little effect on the PEAD. While the immediate price reaction to an earnings announcement tends to be weaker in the presence of frictions, the strength of the subsequent drift and the total price adjustment (i.e., the sum of the initial price reaction and the subsequent drift) are not significantly different between the two treatments. Cum-fee bid-ask spreads are not larger in the frictions treatment than the spreads in the no frictions treatment, implying that the trading fee is eventually borne by the suppliers of liquidity. Trading strategies designed to exploit the PEAD are less profitable in the presence of frictions. Overall our results suggest that trading frictions are not a main driver of PEAD.

The remainder of the paper is organized as follows. Section 2 provides a brief summary of the relevant literature and develops our hypotheses. Section 3 describes the experimental design. Section 4 presents the results and section 5 concludes.

2. Hypotheses

The existence of a transaction fee makes trading more expensive. Importantly, the cost is not just a redistribution of wealth among traders (as is the bid-ask spread, which is paid

by market order traders and earned by limit order traders) but is a deadweight loss to the trader population. We therefore expect that traders will engage in fewer transactions in the presence of the transaction fee. Furthermore, short selling and margin buying constraints prevent traders from engaging in transactions that, without the constraints, would have taken place. Thus, both types of frictions we consider give rise to the following hypothesis.

Hypothesis 1. *Trading frictions lead to reduced trading activity in the market.*

Miller (1977) argues that short selling constraints result in overvaluation because they prevent pessimistic traders who are not currently owning an asset from selling it, thus slowing down the incorporation of negative information into prices. Several papers find evidence of overvaluation in experimental assets markets with short-selling constraints (Ackert et al. (2006), Haruvy and Noussair (2006), Fellner and Theissen (2014), **?**).[1] We note that, in principle, margin buying restrictions could have an opposing effect because they may prevent some optimistic traders from buying an asset. Indeed, Füllbrunn and Neugebauer (2020) find that allowing margin purchases increases prices in experimental markets. However, the fraction of traders running out of investible funds in the presence of margin buying restrictions will typically be (and certainly is in our experimental markets[2]) lower than the fraction of traders running out of shares to sell in the presence of short selling constraints. We therefore test the following hypothesis.

Hypothesis 2. *Short-selling restrictions result in higher asset prices.*

An earnings announcement in our experimental markets causes a change in the fundamental value of the asset that is independent of the existence of frictions. If, in the presence of

[1] There is also a substantial empirical literature on the issue, partly surveyed in Fellner and Theissen (2014).

[2] As will be explained in detail in section 3, all traders in our experimental markets are endowed with money, but only half are endowed with shares of company A while the other half are endowed with shares of company B. Consequently, short selling restrictions affect traders immediately, while margin buying restrictions do not.

trading fees, short selling and margin buying constraints, traders trade less aggressively on the news, the immediate price reaction following the announcement will be lower. As a result, the difference between the post-announcement price and the post-announcement fundamental value will be larger, increasing the potential for a post-announcement drift. We therefore test the following hypothesis.

Hypothesis 3. *Trading frictions lead to a lower immediate price response to an earnings announcement and a greater subsequent PEAD.*

The existence of a trading fee which is levied on both parties in every transaction reduces the revenue that suppliers of liquidity earn from the bid-ask spread. Consequently, they should attempt to widen the spread in order to recover the opportunity losses. At the same time, however, the fee increases the cost of transacting for market order traders beyond the bid-ask spread. Therefore, total execution costs for market order traders are higher in the presence of trading fess as long as the spread does not decrease (at least) by the amount of the fee. While the exact level of the bid-ask spread should depend on the price elasticities of the suppliers and demanders of liquidity, it is plausible to expect the total cum-fee execution costs to be higher in the presence of frictions. Furthermore, several papers (e.g., Boehmer et al. (2013) and Beber (2013)) analyze the short sale bans imposed during the financial crisis in many countries and conclude that short sale bans are associated with higher bid-ask spreads. We therefore formulate the following hypothesis.

Hypothesis 4. *Effective bid-ask spreads (i.e., spreads including trading fees) are larger in the presence of trading frictions.*

Fink et al. (2020) have shown that in experimental markets without frictions, trading strategies based on limit orders can profitably exploit the PEAD. The introduction of frictions may affect the profitability of these strategies in two different ways. First, as argued in hypothesis 3 above, the PEAD may be more pronounced in the presence of frictions, implying

that strategies aimed at exploiting the drift would be more profitable. Second, the existence of trading fess makes trading more expensive, and the existence of short selling and margin buying constraints may prevent traders from implementing strategies that would be profitable absent these constraints. Given this ambiguity, we formulate and test two alternative hypotheses.

Hypothesis 5. *(A) The profitability of trading strategies aimed at exploiting the PEAD is higher in the presence of trading fees.*
(B) The profitability of trading strategies aimed at exploiting the PEAD is lower in the presence of trading fees.

Both the immediate price reaction to an earnings announcement and the subsequent PEAD move prices closer to the fundamental value. While in the absence of frictions the price changes should equal the changes in fundamental values, they may fall short of doing so in the presence of frictions. We therefore test the following hypothesis.

Hypothesis 6. *Price adjustment following announcements is less complete in the presence of trading frictions.*

3. Experimental design

As noted above our experiments consist of two treatments. The no frictions treatment is identical to the correlated earnings treatment ("Corr") of Fink et al. (2020), and we use the data generated in their experiments. Our frictions treatment also builds on this precursor work, but adds a trading fee, bans short selling and bans margin purchases. We use a between subjects design, implying that subjects in one experimental session only encounter one of the two treatments. We present the two treatments in detail later.

We report on a total of 21 sessions (10 with the no frictions treatment and 11 with the frictions treatment), conducted between May 2019 and July 2020 in the experimental research laboratories of three large research and teaching universities. Our participants

are bachelor, master and PhD students of Economics, Business and related programs.[3] Each experimental session has ten to twelve participants who interact over four independent periods.[4] After having been welcomed by the experimenter and assigned to workstations, all participants in a session receive the same, two-part instructions (written and read aloud by the experimenter).[5] In the first part, the participants are acquainted with the trading screen. Following the instructions, they train their newly acquired knowledge in a training period. The second part of the instructions, which follows after the training period, describes the fundamental value of the stocks, the earnings announcements, and how participants' payoffs are calculated. All participants then have to correctly answer a set of control questions before trading starts with the first period. After trading has concluded, participants answer a post-experiment questionnaire and receive their cash payment (in private).

3.1. Trading environment

There are two (fictitious) companies in the experiment, company A and company B. Participants trade shares of these companies in a continuous double auction with open order books. We use a software based on GIMS v7.4.11 to conduct our markets (Palan, 2015, running on z-Tree v4.1.7 by Fischbacher, 2007). We provide a screenshot of the trading screen in Figure A.1 in the appendix. Participants in the no frictions [frictions] treatment begin the experiment with a starting balance of 900 [925] talers in experimental currency and 9 shares of either company A or company B stock. No participant initially has shares of both companies' stocks.[6] The participants received more cash in the frictions treatment than in the no frictions treatment to offset the effect of the trading fee on the cash-to-assets

[3]Since we used only students of economics, business and related programs (financial mathematics, information technology for business, business education) and required many sessions with 10-12 participants each, we had to resort to using more than one experimental lab.

[4]In four out of eleven frictions sessions, more registered participants than expected did not come to the experiment. These sessions therefore had only 10 instead of the targeted 12 participants.

[5]Find a copy of the instructions in section B in the online appendix.

[6]The markets with only 10 participants used the same individual-level endowments. These markets thus had lower aggregate cash and asset balances, yet an unchanged cash-to-assets ratio.

ratio in the market.[7]

Participants trade using single-share limit and market orders in the markets for the shares of both companies. We reset the order book after every period, but not during periods (e.g., after announcements). Trading is anonymous, in that traders cannot identify the originators of orders other than their own. Orders are executed by price and time priority, using the same algorithm as applied at NASDAQ (2019). Orders that rest in the book can be cancelled by their originators for free and at any time. We do not pay interest on taler holdings.

Traders in the no frictions treatment face no transaction costs beyond the bid-ask spread that emerges endogenously, while in the frictions treatment they face a fee of 2 talers per transaction, payable by both the buyer and the seller. Furthermore, traders in the no frictions treatment are allowed to short sell up to 9 A and 9 B shares, and to buy on margin up to a negative cash balance of 900 talers.[8]

3.2. Earnings announcements

Each period is 900s long. We inform all participants about the earnings per share of both companies (5 talers) at the beginning of each period. We also inform them that the shares will be bought back by the experimenter after the end of the period for the fundamental value (FV) of 20 times earnings after the fifth announcement (this corresponds to perpetual

[7]Each transaction reduces the market balance of cash by 4 talers (2 for the buyer and 2 for the seller). In the no frictions treatment we observe an average of 170 transactions per market. We expect this number to be lower in the frictions treatment, at 150 transactions per period, which would imply a market-wide cash reduction of 600 talers. We add half of this value (300 talers) to the market-wide cash endowment. Assuming a linear decrease in market-wide cash, and 150 transactions per period, the cash-to-asset ratio thus decreases from 1.03 to 0.97 over the course of the period, yielding a cash-to-asset ratio of close to 1 on average and around the middle of the period. Validating our design, participants' actual trading decisions in the experiment led to a cash-to-asset ratio that averaged 1.0056 over time, see Figure A.2.

[8]The maximum number of short sales and the maximum margin amount in the no frictions treatment is rarely binding. On average, there were 1.70 incidences per period where any trader hit the short sale limit and 2.08 where any trader hit the margin purchasing limit. In other words, when we check the asset and cash balances of every trader after every action (by any trader) in the market, only in 3.78 cases per period was any one of the entire group of traders unable to sell or purchase (at the prevailing best ask) another share in any one of the two markets.

discounting at a rate of 5%). Since the initial earnings are an unbiased estimator of final earnings, the fundamental value of each share is 100 talers initially.

Over the course of the trading period, participants then receive updated earnings information. Specifically, the companies simultaneously publish earnings updates after 180s, 360s, 540s and 720s have elapsed in a period. We refer to the time between earnings announcements as 'phases'. Furthermore, the companies publish a final earnings update at the close of the period, i.e., 900s after markets open. It is this final earnings value which is used to calculate the buyback value of a share. Participants thus trade continuously throughout five phases of equal length (180s each) in each period. Phase 0 ranges from the opening of the market until the first earnings announcement, Phase 1 from the first to the second earnings announcement, and so on. We illustrate this period structure in Figure 1.

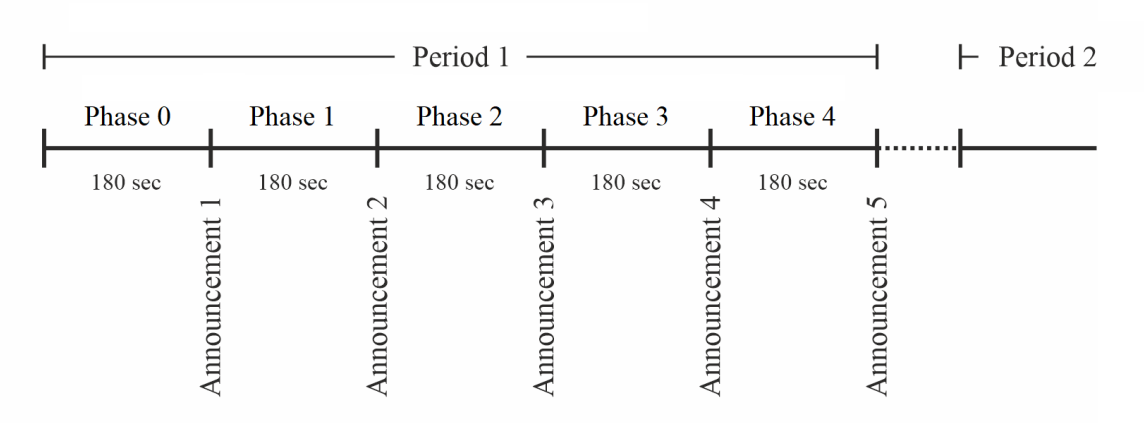


Figure 1: Structure of a trading period. Each of the four 900s trading periods in a session is structured into five 180s phases, separated by four inter-phase earnings announcements, and concluded by one earnings announcement at period close.

Participants see a countdown to the next earnings announcement on their trading screens (see Figure A.1 in the appendix). When the time of the announcement has arrived, the two companies' updated earnings are shown on screen (and highlighted by a flashing red box). In each announcement, the earnings for a company can either increase or decrease by the fixed amount of 0.5 talers. The earnings-generating process is characterized by positive

autocorrelation of order 1. Earnings news of a given sign are followed, in the subsequent announcement, by earnings news of the same sign, with a probability of .75, and by earnings news of the opposite sign with a probability of .25. Both earnings and FV hence follow a non-recombining binomial tree, which is illustrated in Figure 2.

Each announcement in the experiment thus conveys information about the current earnings, but also about the likelihood of future earnings changes. Surprising announcements (characterized by carrying the opposite sign as did the preceding announcement) affect the fundamental value more strongly than unsurprising announcements because—in addition to what they mean for the current earnings—they make future earnings changes carrying the same sign more likely and future earnings changes carrying the opposite sign less likely.

To rule out aggregate market risk as a potential driver for PEAD in our treatments, we draw the earnings change for one of the companies as described above and then set the earnings change for the other company to the opposing sign. Company A's and company B's earnings thus follow the same theoretical earnings-generating process, yet are perfectly negatively correlated. So are the changes in the companies' fundamental values (FV). This implies that a portfolio made up of equal numbers of A and B shares is risk-free and worth 200 talers times the number of share pairs, a fact that is clearly communicated to the participants in the instructions. Since all traders start the experiment with extreme positions of *either* 9 A shares *or* 9 B shares, every risk-averse participant has an incentive to trade to equalize his or her positions in the two companies. Furthermore, due to the (at the cohort level) balanced number of A and B shares, the aggregate risk in the market is zero. Consequently, the risk premium is zero and prices should equal fundamental value in equilibrium.

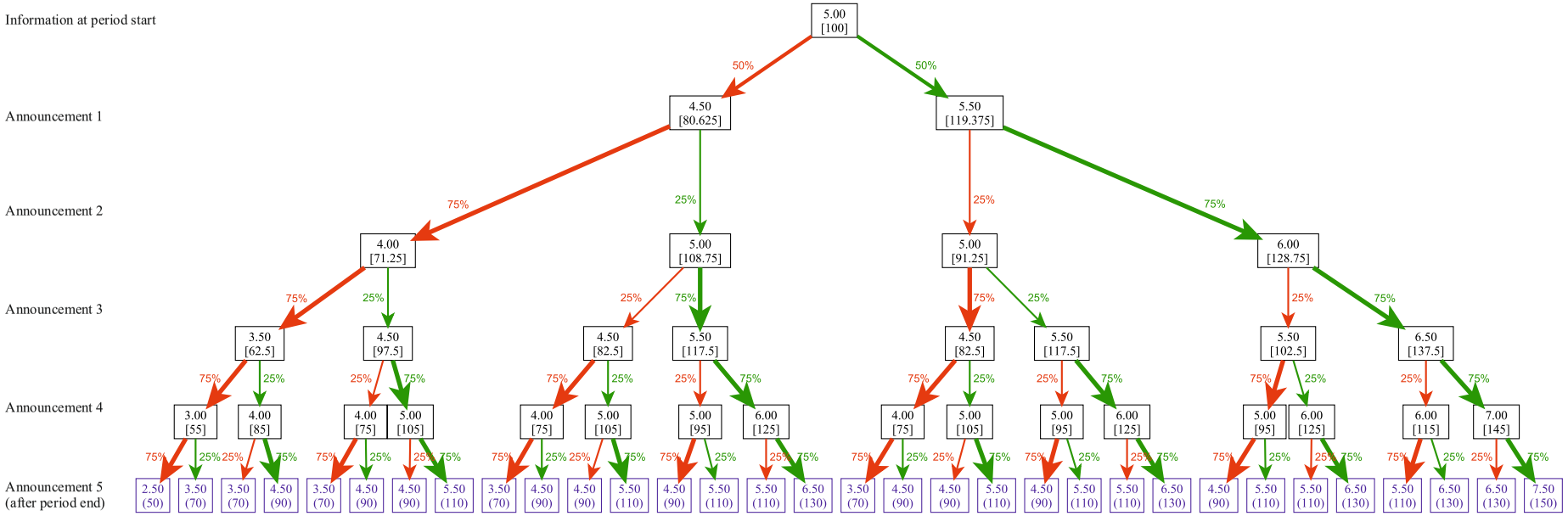


Figure 2: Illustration of the possible earnings trajectories within a period. The first number in each box are the current earnings. The amounts in parentheses and square brackets are the respective fundamental values, i.e., the expected future payoffs per share corresponding to the current earnings (figures in parentheses were communicated to participants, figures in square brackets were not). Red (Green) arrows lead to boxes following decreases (increases) in earnings. Bold arrows indicate a high probability of events unfolding along this path (noted next to the arrows in the same color). The blue boxes (bottom row) are only reached after trading for that period has concluded.

3.3. Participant payment

At the end of an experimental session, one of the four trading periods is randomly chosen for payment. Participants are paid the sum of their holdings in cash and shares, with the latter being valued at the buyback value of 20 times earnings (as set in the final announcement) and the total being converted to euros at the rate of 100 talers = 1 euro. Participants further receive a base compensation of 5 to 8 euros depending on which lab's participant pool they belong to.[9] Table 1 presents summary statistics of participant payments in our experiment. The average participant earns around €25 for an experiment lasting around 2h.

Table 1: Overview of participant payoff in euros. Information about participant payoffs by treatment, including mean payoff, payoff standard deviation (SD, within-session average), minimum (Min) and maximum (Max) payoff.

Treatment	Mean	SD	Min	Max
No frictions	25.0	5.0	9.1	47.1
Frictions	25.3	2.7	18.0	33.1

4. Results

4.1. Trading activity

We start with an analysis of the trading activity in our experimental markets.[10] Table 2 reports the average number of trades and of actions (submission of a new limit order, acceptance of an order submitted by another trader, or cancellation of a standing order) per period in both treatments. Both are significantly smaller in the frictions treatment than in the no frictions treatment. The average trader in the frictions [no frictions] treatment engages in 39.6 [48.2] actions over the course of a period and is involved in 17.9 [28.3] transactions per period. The differences are statistically significant in both cases (Welch two-sample

[9] Average experimental payments are typically designed to equal the wage of a student job in the city the lab is located in.

[10] We conduct our analysis using *R* (R Core Team, 2017). We import the raw data using package *ztree* (Kirchkamp, 2019) and generate regression tables with *stargazer* (Hlavac, 2018) and *texreg* (Leifeld, 2013). We also use *kableExtra* (Zhu, 2019) for other tables and *ggplot2* (Wickham, 2016) for figures.

Table 2: Overview of trading activity. 'Actions' include order submissions, order cancellations, and the acceptance of outstanding orders. 'Trades' are the transactions per period. 'Short trades' are the transactions where the seller sold short (either the submitter of a sell order had assets of 0 or less at the time of order submission, or the accepter of a buy order had a negative asset balance upon conclusion of the transaction). 'Margin trades' are transactions where the buyer bought on margin (either the submitter of a buy order had a cash balance of less than the buy offer price at the time of order submission, or the accepter of a sell order had a negative cash balance upon conclusion of the transaction).

Treatment	Mean	SD	Min	Max
Actions per period				
No frictions	578	148	352	870
Frictions	449	139	276	741
Limit order submissions per period				
No frictions	304	75	186	455
Frictions	240	73	148	399
Transactions per period				
No frictions	170	57	86	318
Frictions	101	35	50	182
Order cancellations per period				
No frictions	105	37	33	205
Frictions	108	52	25	268
Short trades per period				
No frictions	27	18	0	97
Frictions	-	-	-	-
Margin trades per period				
No frictions	14	12	0	62
Frictions	-	-	-	-

$t(76.859) = -3.4288$, $p = 0.0010$ for the number of actions and $t(62.921) = -5.9515$, $p = 1.288e-07$ for the number of transactions). We can therefore confirm Hypothesis 1 and state the following result.

Result 1. *The presence of trading fees significantly reduces trading activity in the market.*

One potentially important difference between the two treatments is that short sales and margin purchases are allowed in the no frictions treatment but prohibited in the frictions treatment. This difference, however, is only likely to materially affect market outcomes when traders actually engage in short sales and/or margin purchases when permitted to do so. Table 2 therefore also shows the number of short sales and margin purchases in the no frictions treatment. There are on average 27 short sales and 14 margin purchases per

period, implying that approximately 16% of all trades involve a short sale and 8.2% involve a margin purchase. We conclude that there is substantial short selling and margin buying activity, and that the restrictions imposed in the frictions treatment are a relevant constraint on traders' action space.

4.2. Asset values and short selling constraints

As noted before, both empirical and experimental evidence shows that price levels are higher in the presence of short selling constraints. We test whether we observe the same phenomenon in our experimental markets. However, we can go a step further. Our experiments are designed such that there is no aggregate risk, implying that equilibrium prices are equal to expected (fundamental) values. We can therefore not only compare asset prices across treatments but can actually compare them to their known equilibrium values. To do so we follow the approach of Powell (2016) and define two measures of mispricing as follows.

$$GD \equiv 100 \cdot \left(exp\left(\frac{1}{N} \sum_{t=0}^{N-1} ln\left(\frac{P_{k,t}}{FV_k} \right) \right) - 1 \right) \tag{1}$$

and

$$GAD \equiv 100 \cdot \left(exp\left(\frac{1}{N} \sum_{t=0}^{N-1} \left| ln\left(\frac{P_{k,t}}{FV_k} \right) \right| \right) - 1 \right) \tag{2}$$

GD is a measure of signed mispricing. It is the geometric mean of the deviations of prices from fundamental values. The GAD measure is unsigned, such that positive and negative deviations do not cancel out. Table 3 presents average values for both measures and both treatments. It shows separate values for the starting phase of each period, for the phase after the first announcement,[11] for phases after positive and negative announcements, and

[11]Note that the first announcement is special because (only) in the first announcement earnings are equally likely to increase or to decrease. In all subsequent announcements, continuations (announcements with the same sign as the previous announcement) are more likely than reversals.

for phases after surprising and non-surprising announcements.

Aggregated over all phases, prices are above fundamental values in both treatments, by 2.44% in the no frictions treatment and by 4.64% in the frictions treatment. The difference between the treatments is significant at $p = 0.013$. The second line of the table reveals that no such difference is observable in the starting phase of a period but that it rather only emerges after the first earnings announcement. Thus, the implications for asset prices of trading frictions materialize only when new information arrives and has to be incorporated into prices.

Considering positive and negative earnings announcements separately, we make two observations. First, prices are always below [above] fundamental values following positive [negative] announcements, implying that prices only partially adjust to the news content of the announcement. Second, prices are significantly higher in the frictions than in the no frictions treatment following both types of announcements. This tendency is more pronounced after negative announcements, a finding that is consistent with short sale constraints slowing the incorporation of negative news into prices. When we further disaggregate the data and consider first announcements, surprising announcements and non-surprising announcements separately, we confirm the previous observation that prices are higher in the frictions treatment than in the no frictions treatment. However, the differences are not always significant, partly because of lower numbers of observations in the disaggregated data.

We confirm the univariate results in a regression analysis. The dependent variables are the GD and GAD measures for consecutive 10s windows. Table 4 reports the results. We include several independent variables to capture the pricing dynamics during the session. Specifically, we include count variables for the period within a session and the phase within a period. Their coefficients are negative throughout, implying that mispricing is lower in later phases and periods of a session. This finding is consistent with learning. We further include a count variable for the window within a phase. The negative coefficient implies that prices

Table 3: Mispricing. Measures of relative (GD) and absolute (GAD) mispricing relative to FV. The columns '$t(p)$' are the t-statistics and the p-value (in parentheses) of a Welch two-sample t-test between the two treatments. 'Starting phase' is Phase 0, the phase prior to the first earnings announcement. 'First announcement' is Phase 1, the phase following the first announcement. 'Surprise' ['No surprise'] denotes phases in which the earnings did [did not] change direction, and excludes the first announcement.

	GD			**GAD**			**Observations**	
Phases	**No frictions**	**Frictions**	***t*-stat. (*p*)**	**No frictions**	**Frictions**	***t*-stat. (*p*)**	**No frictions**	**Frictions**
All	2.44	4.64	2.49 (0.013)	10.88	10.88	-0.01 (0.989)	400	440
Starting phase	6.18	5.26	-0.43 (0.669)	12.78	10.86	-0.95 (0.346)	80	88
First announcement	4.75	8.83	2.14 (0.034)	11.05	12.53	1.06 (0.293)	80	88
Positive earnings change	-4.49	-2.62	2.30 (0.022)	7.86	7.01	-1.17 (0.244)	160	176
First announcement	-2.09	-0.25	0.87 (0.389)	8.15	6.44	-0.97 (0.339)	40	44
Surprise	-4.29	-4.28	0.01 (0.994)	8.33	8.44	0.06 (0.949)	29	31
No Surprise	-5.61	-3.15	2.81 (0.006)	7.58	6.83	-0.88 (0.380)	91	101
Negative earnings change	7.50	11.59	2.89 (0.004)	12.96	14.74	1.62 (0.105)	160	176
First announcement	11.58	17.91	3.16 (0.002)	13.94	18.62	2.85 (0.006)	40	44
Surprise	8.02	13.19	1.95 (0.056)	11.56	14.99	1.49 (0.142)	29	31
No Surprise	5.54	8.34	1.35 (0.180)	12.98	12.98	0.00 (1.000)	91	101

move closer to the fundamental value as time passes, which is consistent with initial underreaction to the news contained in an earnings announcement, followed by PEAD. The positive coefficient of the squared window variable indicates that, while prices move closer to the fundamental value, they do so at a decreasing rate. Besides these count variables we include a dummy variable identifying positive earnings announcements. Its negative coefficient is consistent with the asymmetry already described above. Prices exceed fundamental values following negative announcements but fall short of them following positive announcements. The most important independent variable is a dummy that identifies sessions conducted under the frictions treatment.[12] The coefficient is positive, implying that prices are higher in the frictions treatment. It marginally misses the hurdle of significance at the 5% level, with a t-statistic of 1.957.

Taken together, the results are in line with Hypothesis 2. We thus have

Result 2. *Prices in the frictions treatment are higher than those in the no frictions treatment, consistent with the hypothesis that short selling restrictions result in overpricing.*

Interestingly, even though prices are, on average, higher in the frictions treatment, they are not—in absolute terms—farther away from fundamental values than those in the no frictions treatment. Columns 5–8 of Table 3 and column 2 in Table 4 reveal that there are no significant differences in the GAD measure across treatments.

[12]We also estimated a specification where we included an interaction term between the dummy for the frictions treatment and the dummy for positive earnings announcements. This specification allowed for asymmetric effects following positive and following negative announcements in the frictions treatment, possibly caused by the existence of short selling constraints. However, the coefficient of the interaction term was not significant and its inclusion did not affect the other coefficient estimates in any meaningful way. The same applies to the regressions reported in sections 4.3 and 4.4 below. We therefore decided to report all regression results without the interaction term.

Table 4: Regression analysis of mispricing. OLS regressions of mispricing at the close of consecutive 10s windows starting at the time of the announcement. The dependent variables for Model 1 and 2 are the geometric deviation (GD) and the geometric absolute deviation (GAD) in percent, calculated using closing midpoints for each window as in Powell (2016) and Equation 1 and 2. 'Frictions' is a dummy to denote observations from the frictions treatment. 'Positive earnings change' is a dummy to denote observations following a positive earnings change. 'Period0' is the period number within the session, rebased to the range $0 \ldots 3$ (instead of $1 \ldots 4$). 'Phase0' is the phase number within the period, rebased to $0 \ldots 3$ (instead of $1 \ldots 4$). 'Window' is the consecutive ID number of the time window ($0 \ldots 17$), starting with the "announcement window", i.e., the 10s window starting at the time of the announcement.

	(1) GD	(2) GAD
Constant	17.140^{***}	22.321^{***}
	(2.591)	(1.982)
Frictions	2.795	0.459
	(1.428)	(1.706)
Positive earnings change	-13.644^{***}	-6.542^{***}
	(1.876)	(0.769)
Period0	-1.080^{*}	-1.019^{**}
	(0.491)	(0.382)
Phase0	-2.611^{***}	-1.127^{***}
	(0.288)	(0.322)
Window	-0.505^{***}	-1.035^{***}
	(0.071)	(0.066)
Window^2	0.015^{***}	0.037^{***}
	(0.004)	(0.003)
R^2	0.291	0.145
Adj. R^2	0.291	0.145
Num. obs.	11501	11501

Note: $^{***}p<0.005$; $^{**}p<0.01$; $^{*}p<0.05$.
Standard errors, clustered at the Session level, in parentheses.

4.3. Post Earnings Announcement Drift

We hypothesized that the initial price reaction to an earnings announcement would be smaller in the presence of frictions while the subsequent drift would be stronger. We commence our analysis of these hypotheses with a visual inspection of the results in Figure 3. We base our analysis on quote midpoints to eliminate the effect of bid-ask bounce.[13] However, for ease of exposition we will refer to the midpoints as "prices".

Figure 3 presents results separately for the two treatments and for surprising and non-surprising earnings announcements. Remember from section 3 that surprising announcements trigger a much larger change in fundamental value and, consequently, should be followed by larger price adjustments. The overall pattern we observe is fully consistent with the existence of a PEAD. Prices move in the direction of the announcement immediately but fail to fully adjust. During the remainder of the trading phase prices drift further into the direction of the announcement.

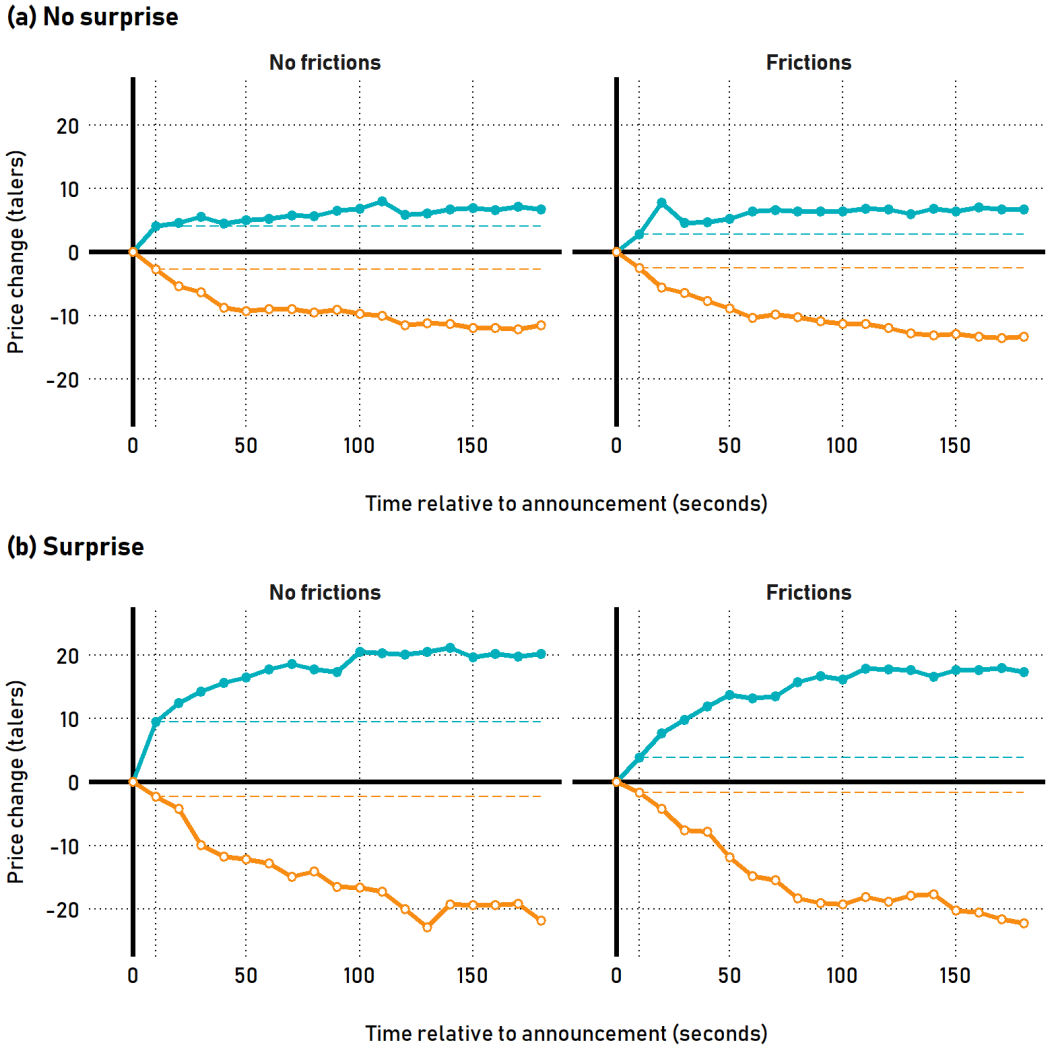
We measure the immediate price reaction over the first 10s window following the announcement.[14] Price changes occurring later in a trading phase are categorized as drift. The dotted horizontal lines in Figure 3 represent the immediate price reaction defined in this way. Visual inspection suggests that the initial price adjustment is indeed smaller in the frictions treatment.

We report the results of a more formal analysis in Table 5. We regress the price change in the announcement window on dummy variables identifying the frictions treatments and positive earnings announcements. We further include count variables for the period within a session and the phase within a period. The price change after negative earnings announcements is multiplied by (-1) to permit pooled estimation. The overall results, shown in

[13] As documented in more detail in section 4.4 below, we observe substantial bid-ask spreads in our experimental markets.

[14] Note that Fink et al. (2020) show that the qualitative results are insensitive to the precise choice of the announcement window length. They also use a 5s and a 15s window to measure the initial price reaction and arrive at similar conclusions.

Figure 3: Price change in talers relative to the quote midpoint at the time of the announcement. Average price changes relative to the quote midpoint at the time of the announcement, using the closing quote midpoint for each 10s window following the announcement, restricted to data from Phases 2 through 4. Panels compare the no frictions (left) and frictions treatment (right). Panel (a) plots results for unsurprising announcements; Panel (b) reports results for surprising announcements. The blue [orange] line plots the cumulative price changes following positive [negative] earnings news. The dashed horizontal lines of the same colors indicate the price levels reached by the end of the 10s announcement window.



column 1, imply that prices generally move in the direction of the announcement, but significantly less so in the frictions treatment. Furthermore, the immediate price reaction is stronger following positive announcements. When we disaggregate the results by running separate regressions for first announcements, surprising announcements and unsurprising announcements, we obtain similar, albeit weaker results. The dummy for the frictions treatment is always negative, but is significant only for the first announcements. Similarly, the dummy for positive announcements is always positive, but significantly so only after surprising announcements. Overall the results provide some support for the first part of Hypothesis 3 in that the immediate price reaction to earnings announcements tends to be weaker in the presence of frictions.

Table 5: Regression analysis of announcement window changes in taler closing quote midpoints. OLS regressions of returns within the announcement window. The dependent variable is the absolute change in taler closing midpoints. Returns are signed based on the direction of the preceding earnings change (i.e., the signs of returns following negative announcements are reversed). 'Frictions' is a dummy variable for the frictions treatment. 'Positive earnings change' is a dummy variable for a positive earnings change. 'Period0' is the period number within the session, rebased to the range $0 \ldots 3$ (instead of $1 \ldots 4$). 'Phase0' is the phase number within the period, rebased to $0 \ldots 3$ (instead of $1 \ldots 4$ in Model 1) or $0 \ldots 2$ (instead of $2 \ldots 4$; thus excluding the phase following the first announcement, in Models 3 and 4).

	(1) Pooled	(2) First announcement	(3) No surprise	(4) Surprise
Constant	3.324^{***}	2.304	2.715^{***}	3.284^{**}
	(0.647)	(1.477)	(0.871)	(1.238)
Frictions	-1.475^{**}	-1.738	-0.808	-3.064^{*}
	(0.524)	(1.232)	(0.743)	(1.505)
Positive earnings change	1.763^{***}	1.973	0.785	4.456^{**}
	(0.518)	(1.337)	(0.544)	(1.626)
Period0	0.728^{***}	1.547^{**}	0.211	1.109
	(0.253)	(0.544)	(0.244)	(0.621)
Phase0	-0.566^{*}		0.033	-1.460
	(0.280)		(0.430)	(0.987)
R^2	0.050	0.079	0.010	0.163
Adj. R^2	0.043	0.058	-0.002	0.132
Num. obs.	585	140	332	113

Note: $^{***}p < 0.005$; $^{**}p < 0.01$; $^{*}p < 0.05$. Standard errors, clustered at the Session level, in parentheses.

Table 6: Post-earnings-announcement drift. Mean taler changes based on quote midpoints from the end of the announcement window until the end of the phase. We report standard errors in parentheses.

	Pooled			No surprise[a]			Surprise[a]		
	No frictions	**Frictions**	**Δ**	**No frictions**	**Frictions**	**Δ**	**No frictions**	**Frictions**	**Δ**
Long	4.42***	6.78***	2.36	2.75*	3.91***	1.16	10.22***	13.41***	3.19
	(1.07)	(0.92)	(1.41)	(1.22)	(1.06)	(1.62)	(2.34)	(1.90)	(3.02)
Short	-11.36***	-13.16***	-1.80	-8.71***	-10.30***	-1.60	-18.42***	-20.75***	-2.33
	(1.00)	(0.83)	(1.30)	(1.02)	(0.82)	(1.31)	(3.32)	(2.00)	(3.87)
Long-Short	16.20***	20.47***	4.28	11.94***	14.12***	2.18	26.09***	34.80***	8.72
	(1.38)	(1.68)	(2.18)	(1.76)	(1.88)	(2.57)	(3.45)	(3.40)	(4.84)

Note: *$p<0.05$, **$p<0.01$, ***$p<0.005$ (two-tailed t-test)

Only includes phases where both the first and the last 10s windows following an announcement (windows 0 and 17) have both a bid and an ask, thus permitting us to calculate quote midpoints (includes 88.4% , 81.2% , and 72.9% of Long, Short, and Long-Short phases, respectively)

[a] Analyses separated by the surprise variable exclude the first announcement

The smaller immediate price adjustment in the frictions treatment may be accompanied by a more pronounced subsequent drift. To analyze whether this is the case we proceed as follows. We calculate the returns of a long [short] strategy that buys [sells] the stock with positive [negative] earnings announcement at the end of the 10s announcement window and holds it until the end of the phase. Similarly we calculate the returns of a long-short strategy which combines the long and the short leg. We then test whether the average returns of these strategies are significantly different from zero, and we also test whether they are different in the frictions and the no frictions treatments. The first test addresses the question of whether there is significant PEAD, while the second tests whether the PEAD's strength is different in the presence of frictions. As before the analysis is based on quote midpoints and therefore ignores transaction costs. We explicitly consider transaction costs in sections 4.4 and 4.5.

Table 6 presents the results. We find strong evidence of a PEAD in both treatments. Prices drift upward following positive and downward following negative announcements. The drift is significant, both in the pooled sample and when we analyze surprising and non-surprising announcements separately. The point estimates of the returns furthermore are larger in the frictions than in the no frictions treatment in each single case. However, the difference between the two treatments is not significant. As a robustness check, we regress

the price changes of all windows (except for the announcement window itself) on dummy variables for the treatment and for positive announcements, and on count variables for the period, phase and window. The results are fully consistent with those shown here in that the coefficient of the dummy for the frictions treatment is always positive—implying larger drift—but not significant (see Table A.1 in the appendix).

Overall, the results of this section can be summarized as follows.

Result 3. *Trading frictions lead to weaker immediate price reactions to earnings announcements. There is at best weak evidence of a stronger PEAD in the presence of frictions.*

4.4. Spreads

Figure 4 illustrates the quoted bid-ask spreads in our experimental markets. Note that we center the bid and ask prices in the figure on the fundamental value of the asset, not on the quote midpoint. Note further that our spreads in the frictions treatment include the fee. In other words, we add the 2-taler fee to the ask price and subtract it from the bid price. We make three observations. First, spreads are generally wide, meaning that trading is costly for traders using market orders. Second, spreads are particularly wide immediately after an earnings announcement and tend to narrow subsequently. Third, spreads do not appear to be wider in the frictions treatment.

The results of a regression analysis, shown in Table 7, complement the observations from the visual inspection of Figure 4. The independent variables are the same as in sections 4.2 and 4.3 above. The negative coefficients on the count variables imply that spreads tend to narrow over the periods of a session, over the phases of a period, and over the windows of a phase (i.e., between two successive earnings announcements). The coefficient of the frictions treatment dummy fis positive (implying higher spreads in the frictions treatment) but not significant. We thus do not find support for Hypothesis 4.

Result 4. *Despite the introduction of a trading fee, bid-ask spreads are not significantly larger in the frictions treatment.*

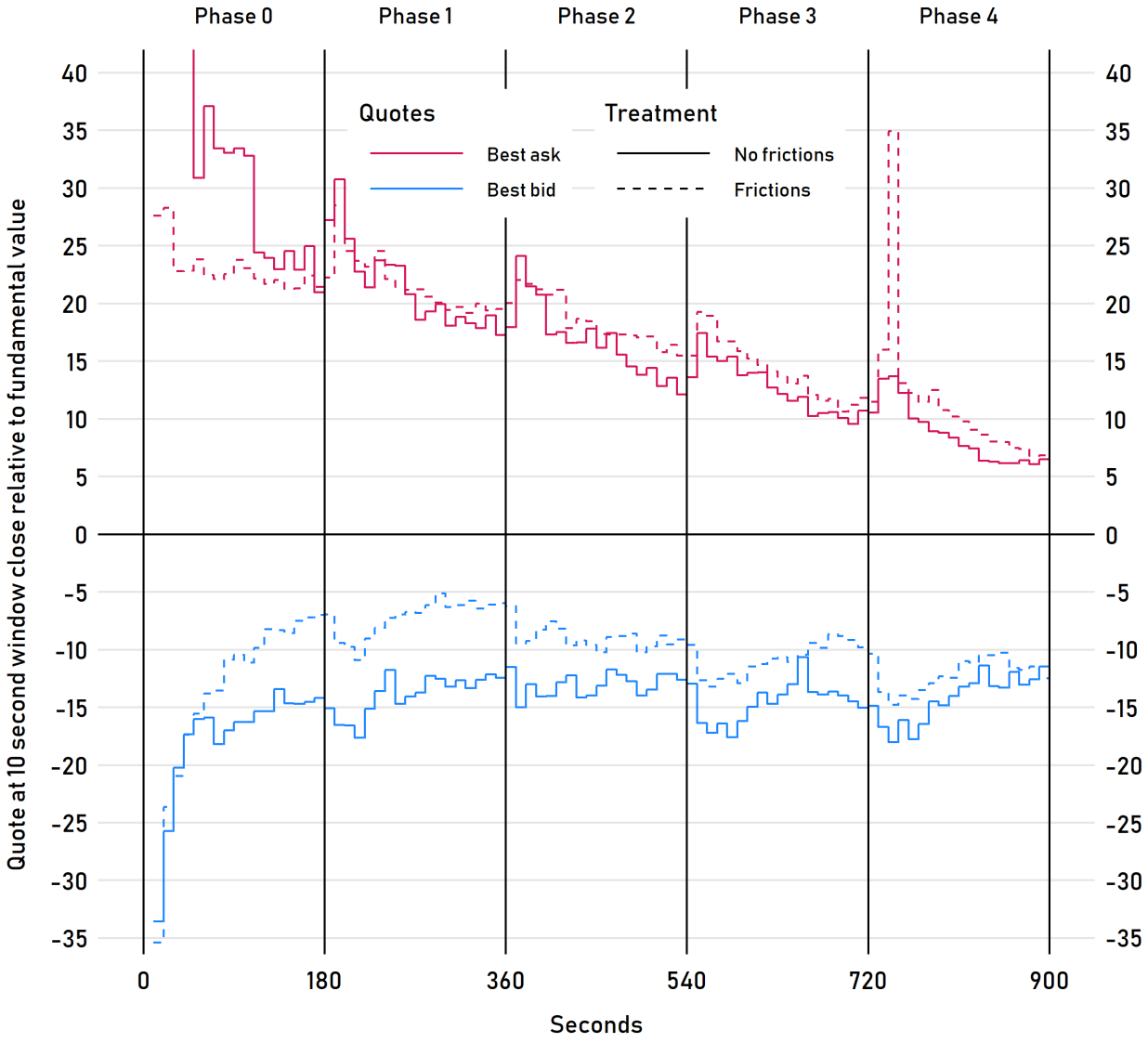


Figure 4: Development of spreads over time. Average difference between best ask quote and FV (red), and between best bid quote and FV (blue), in talers, over the trading period. Spreads include trading fees in the frictions treatment. Solid lines plot the no frictions, dashed lines the frictions treatment data.

Table 7: Spread regressions. OLS regressions of taler spreads at the close of consecutive 10s windows starting with the announcement window. The dependent variable is the effective spread in talers (including the trading fees of 2 talers on the bid and on the ask side). 'Correlated' is a dummy variable for the no frictions treatment. 'Positive earnings change' is a dummy variable for a positive earnings change. 'Period0' is the period number within the session, rebased to the range $0 \ldots 3$ (instead of $1 \ldots 4$). 'Phase0' is the phase number within the period, rebased to $0 \ldots 3$ (instead of $1 \ldots 4$; thus excluding the phase preceding the first announcement, and designating the first post-announcement phase with 0). 'Window' is the consecutive ID number of the time window ($0 \ldots 17$), starting with the "announcement window", i.e., the 10s-window starting at the time of the announcement.

	Model 1
Constant	47.812^{***}
	(10.972)
Frictions	1.565
	(1.579)
Positive earnings change	-2.841
	(8.594)
Period0	-5.670^{***}
	(1.595)
Phase0	-2.992^{***}
	(0.694)
Window0	-1.350^{***}
	(0.169)
Window0^2	0.043^{***}
	(0.008)
R^2	0.086
Adj. R^2	0.085
Num. obs.	11501

Note: $^{***}p<0.005$; $^{**}p<0.01$; $^{*}p<0.05$

Standard errors, clustered at the Session level, in parentheses.

The result that spreads (including the trading fee) are not significantly larger in the frictions treatment may imply that the fee is eventually borne by the suppliers of liquidity. Compared to the no frictions treatment, spreads narrow by the amount of the fee, thereby reducing the revenue to the suppliers of liquidity while leaving the total transaction cost of market order traders unchanged. This finding is best interpreted in the context of the lower overall trading activity documented in section 4.1 above. Traders are reluctant to submit market orders when they are liable to pay a transaction fee. Their reluctance puts pressure on the suppliers of liquidity to improve their quoted prices. In fact we find that the ratio of limit order submissions to transactions is higher in the frictions treatment than in the no frictions treatment (2.38 vs. 1.79, as can be calculated from Table 2 above). Traders more frequently cancel and resubmit limit orders in the frictions treatment, as evidenced also by the higher ratio of cancellations to limit order submissions (.45 in frictions, .35 in no frictions). Overall, there are an average of 13.18 [10.12] orders in the books in the no frictions [frictions] treatments.

4.5. Trading strategies

The profitability of trading strategies aimed at exploiting the PEAD depends on two factors, the strength of the drift and the cost of transacting in the market. Fink et al. (2020) find that trading strategies based on market orders are unprofitable because high bid-ask spreads eat up all potential profits. However, they also show that a strategy based on limit orders is profitable. Specifically, they propose the following strategy.[15] Following an announcement with positive earnings news, submit a limit buy order, priced at the quote midpoint. If this order does not get executed in the first 90s of the phase, cancel it and do nothing else. Otherwise submit a limit sell order when 90s have elapsed since the announcement, priced

[15]Fink et al. (2020) also show that the profitability of the strategy does not depend on (1) the exact timing of the submission and cancellation of the limit orders and (2) on the exact position of the price limit relative to the prevailing quotes. They provide robustness checks in which they vary both variables and find that profits are always positive and sometimes even higher than those obtainable from the base strategy.

at the quote midpoint. If this limit order gets executed before 170s have elapsed since the announcement, do nothing else. Otherwise cancel it and submit a market sell order when 170s have elapsed since the announcement. Following an announcement with negative earnings news, do the reverse.

We use the same specification to compare the profitability of trading strategies in the no frictions and frictions treatments (including the trading fee as a cost component in the latter) and present the results in Table 8. The table presents separate results for unsurprising and surprising earnings announcements as well as for the pooled sample. The results are presented conditional on the exact time (relative to the earnings announcement) at which the initial limit order is submitted.

The results for the no frictions treatment are, of course, identical to those in Fink et al. (2020) because we use their data. The profitability of the strategy in the frictions treatment is significantly lower both for the pooled sample and for the subsample of unsurprising announcements. Yet there is no relevant treatment difference in the subsample of surprising announcements. Taken together, these findings support hypothesis 5B and can be summarized as follows.

Result 5. *The profits of trading strategies aimed at exploiting the PEAD tend to be lower in the presence of frictions, particularly after unsurprising earnings announcements.*

The finding that a trading strategy to exploit the PEAD is less profitable in the presence of frictions, while intuitively plausible, is somewhat surprising against the backdrop of the results presented earlier. So far we have documented that the PEAD is not stronger in the frictions treatment. There is thus no reason to expect higher profits in this treatment. Nevertheless, we also documented that bid-ask spreads, including the trading fee, are not higher in the frictions treatment. Seen from this point of view, there is thus no reason to expect lower profitability.[16] Why, then, do we find lower profitability? The reason is the

[16]The trading strategy we analyzed is mainly based on limit orders submitted at prices equal to the quote

Table 8: Trading strategy returns per phase. Average single-phase aggregated log returns (in percent) to the long and short legs of our trading strategy. The strategy is to open a position with a limit order at the midpoint after the announcement and close it by submitting a limit order halfway through the phase (i.e., 90s after the announcement), or close it by a market order if the limit order would not have executed until 10s before the end of the phase. 'Delay' is the time (in seconds) between the earnings announcement and the time at which the position is opened. 'No surprise' ['Surprise'] designates phases in which earnings change in the same [opposite] direction as in the prior announcement (excluding the first announcement, since it is neither unambiguously surprising nor unsurprising). 'Pooled' includes all phases (except the phases prior to the first announcement).

	No frictions		**Frictions**		**Δ**
Delay	**Mean**	**SE**	**Mean**	**SE**	***t*-stat (*p*)**
No surprise					
0	2.86***	(0.57)	0.76*	(0.37)	-3.09 (0.002)
2	2.47***	(0.54)	0.65	(0.37)	-2.78 (0.006)
4	2.44***	(0.54)	0.42	(0.38)	-3.06 (0.002)
6	1.90***	(0.57)	0.30	(0.37)	-2.37 (0.019)
8	1.42**	(0.54)	0.04	(0.35)	-2.15 (0.032)
10	1.08	(0.58)	-0.41	(0.39)	-2.15 (0.032)
Surprise					
0	4.04*	(1.69)	2.88**	(1.01)	-0.59 (0.556)
2	2.21	(2.24)	2.86**	(1.02)	0.26 (0.793)
4	3.54*	(1.51)	3.35***	(1.09)	-0.10 (0.918)
6	2.41	(1.50)	3.34***	(1.07)	0.51 (0.614)
8	2.49	(1.69)	3.16***	(1.04)	0.34 (0.734)
10	1.52	(1.66)	3.10***	(1.04)	0.81 (0.419)
Pooled					
0	3.51***	(0.60)	1.25***	(0.33)	-3.30 (0.001)
2	2.93***	(0.66)	1.20***	(0.33)	-2.34 (0.020)
4	2.94***	(0.54)	1.08***	(0.34)	-2.90 (0.004)
6	2.26***	(0.55)	0.83*	(0.36)	-2.18 (0.029)
8	1.85***	(0.54)	0.62	(0.36)	-1.90 (0.058)
10	1.41*	(0.55)	0.06	(0.34)	-2.09 (0.037)

Note: *$p<0.05$, **$p<0.01$, ***$p<0.005$ (two-tailed t-test)

lower overall trading activity in the frictions treatment that we also documented earlier. If a limit order submitted to open a position is not executed, the profit is recorded as zero (put differently, the figures in Table 8 are *not* conditional on execution of the initial limit order). Because of the lower overall activity, the probability that a position is opened in the first place is lower in the frictions treatment, resulting in lower overall profitability of the strategy. The existence of short selling and margin buying restrictions obviously works in the same direction because both of these constraints prevent traders from implementing some strategies that might otherwise be profitably endeavoured.

4.6. Price adjustment

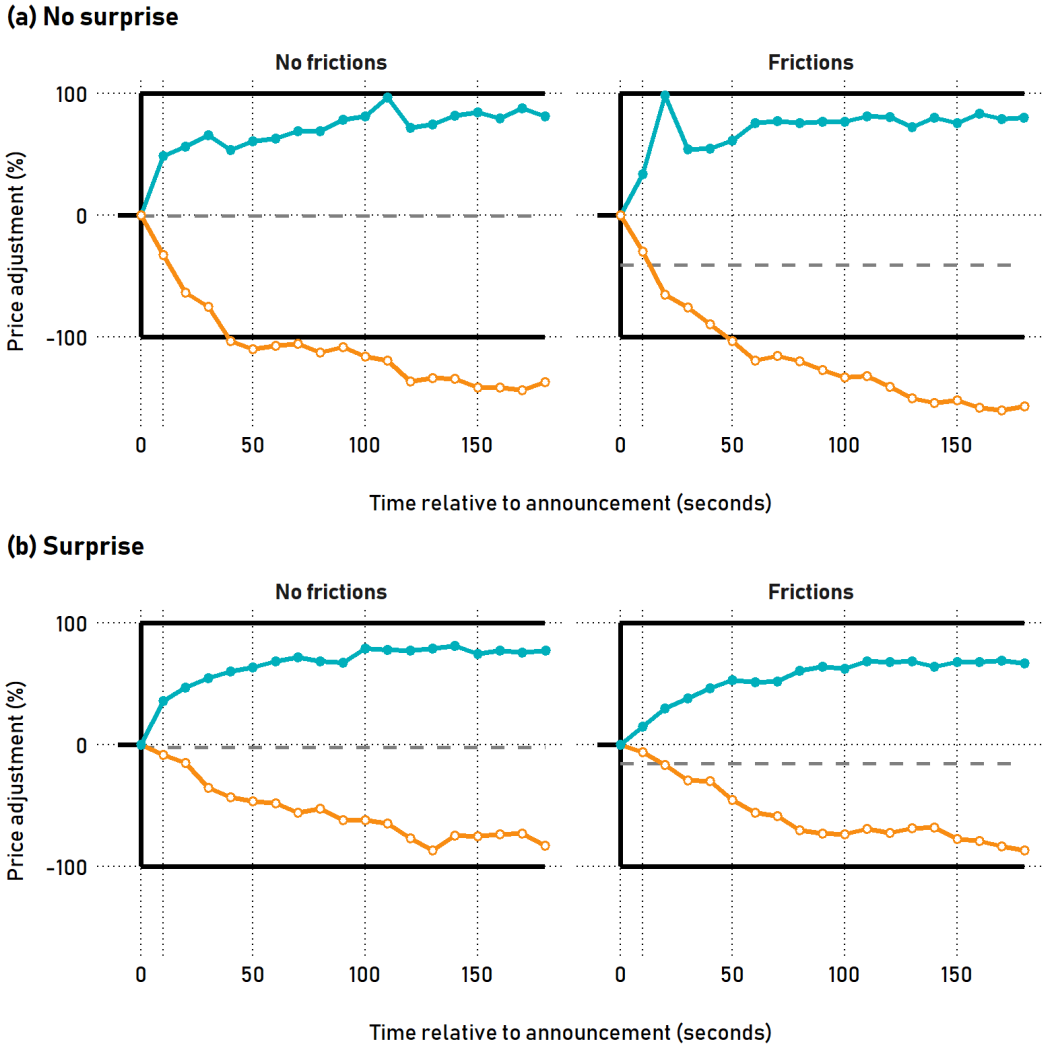
The immediate price reaction to an earnings announcement and the subsequent drift both move prices in the direction of the fundamental value. An important advantage of the experimental method is that we know precisely how the earnings announcement changes the fundamental value. We can therefore test whether the change in prices equals the change in fundamental value, and whether the introduction of frictions affects the extent to which price changes track changes in fundamental value.

We proceed as follows. We set the price level prior to an earnings announcement to 0 and the price level plus the change in fundamental value caused by the announcement to 100 [−100] in the case of a positive [negative] announcement. We then rescale the post-announcement prices accordingly. Note that price levels below 100 [above −100] imply underadjustment of prices, i.e., prices changing by less than the change in fundamental value. Similarly, levels above 100 [below −100] imply overshooting, i.e., prices changing by more than the change in fundamental value. Figure 5 presents price paths, separated by whether they follow non-surprising or surprising announcements. Table 9 lists the adjustment levels

midpoint. The profitability of these orders, if they are executed, thus should not depend on the size of the spread. However, whenever the limit order submitted to close a position does not execute, the position is closed using a market order and thus incurs the spread.

reached by the end of the trading phase and presents results of formal tests for differences between the treatments.

Figure 5: Adjustment of stock price as a percentage of the change in fundamental value induced by an announcement. Panels (a) and (b) report results separately for the no frictions (left) and the frictions treatment (right). Panel (a) plots the adjustment following unsurprising earnings news. Panel (b) plots the adjustment following surprising earnings news. The blue, upward trending [orange, downward trending] line plots price adjustment following positive [negative] earnings news. The bold, black, horizontal lines indicate full adjustment of prices to the change in FV induced by the earnings announcement. The thin, dotted horizontal line at 0 indicates the price level at the moment of the earnings announcement. The dashed horizontal line indicates FV prior to the earnings announcement.



We make several observations. First, and unsurprisingly, Figure 5 confirms the existence of a PEAD in the experimental markets. Second, prices adjust more completely after neg-

Table 9: Absolute price adjustment by phase end. Adjustment of price from before the announcement to the last window before the next announcement, relative to the change in fundamental value. The adjustment variable is based on the time-weighted midpoint in the last 10s-window before the subsequent announcement. Negative changes of price and fundamental value are multiplied by (-1). The t-statistic and the p-value in the last column stem from a two-tailed test of the treatment difference.

Earnings change	**No frictions**	**Frictions**	***t*-stat. (*p*)**
Pooled			
Positive	82.0	75.9	0.62 (0.535)
Negative	117.3	124.8	-0.73 (0.464)
First announcement			
Positive	70.3	68.9	0.11 (0.916)
Negative	89.7	77.9	0.83 (0.409)
No surprise			
Positive	89.1	81.6	0.48 (0.630)
Negative	140.0	158.8	-1.23 (0.221)
Surprise			
Positive	75.7	66.3	0.80 (0.428)
Negative	86.3	84.3	0.15 (0.878)

ative announcements (and, after non-surprising negative announcements, even overshoot). Third, adjustment of prices is more complete after non-surprising announcements. This is in line with the finding of Fink et al. (2020) that traders underestimate the implications of a surprising announcement for future earnings announcements and, consequently, underestimate the implication of surprising announcements for the fundamental value of the asset. Fourth, and in contrast to Hypothesis 6, there is no evidence of systematic differences between the no frictions and the frictions treatments. We therefore have

Result 6. *The price adjustment following earnings announcements does not differ significantly in the presence and in the absence of trading frictions.*

5. Conclusion

In this paper we build on Fink et al. (2020) and use financial market experiments to analyze the determinants of the post earnings announcement drift. The focus of the paper is to analyze whether the existence of trading frictions affects the strength of PEAD. To this end we vary the degree of trading frictions in experimental markets by introducing a trading fee,

short selling and margin buying restrictions and comparing the outcomes to markets absent these frictions.

We observe a significant PEAD in both cases. Trading frictions thus do not cause the PEAD. We find that trading activity is dampened significantly in our treatment with frictions. At the same time, price levels tend to be higher, possibly because of the short selling restrictions. We find some evidence suggesting that the initial price reaction to an earnings announcement is weaker in the presence of frictions, but little evidence that the PEAD is more pronounced. One reason for this lack of a treatment effect on PEAD may be the fact that trade execution costs in our frictions treatment (which consist of the bid-ask spread and the trading fee) are no larger than those in the treatment without frictions. In fact, the trading fee is effectively borne by the suppliers of liquidity through lower bid-ask spreads.

Despite the similarity in effective transaction costs in our two treatments, trading strategies aimed at exploiting the PEAD turn out to be less profitable in the presence of frictions. We trace the cause of this reduced profitability to the fact that such strategies require limit orders to be profitable. Because of the lower overall trading activity, the probability that the limit orders necessary to establish positions are executed is lower in the presence of frictions.

Overall our results suggest that trading frictions are not a first-order determinant of the strength of the PEAD and they are certainly not the *cause* for the emergence of PEAD.

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Appendix A. Participant comprehension of the instructions

The post-experiment questionnaire gives an additional indication about participants' understanding of the experiment. We used an open question to ask participants to provide feedback regarding the clarity of the instructions and the explanation of the experiment. A total of 76 (63%) [78 (63%)] out of 120 [124] participants in the no frictions [frictions] treatment answered this question. We coded their answers on a five-point scale (-2 to +2). To do so, we categorized the answers according to the following logic: -2 (did not really understand), -1 (partly understood but with difficulty), 0 (more or less understood), +1 (understood but suggests feedback for improving clarity), +2 (fully understood). Two independent reviewers categorized all answers. They differed in 28 cases (18.2% of the 154 valid answers), by an average absolute difference of 1.29. A third independent reviewer broke the tie between differing assessments. The average understanding in the no frictions [frictions] treatment is 1.67 [1.64], with 86% [77%] of the participants professing "full understanding" (i.e., category +2), and 4% [0%] of the participants professing no understanding (i.e., category -2).

We further checked whether a participant's prior stock trading experience was associated with higher payouts in our experiment. We detect no significant or material differences and take this as an indication that the instructions provided a level playing field in terms of understanding for all participants.

Appendix B. Additional figures and tables

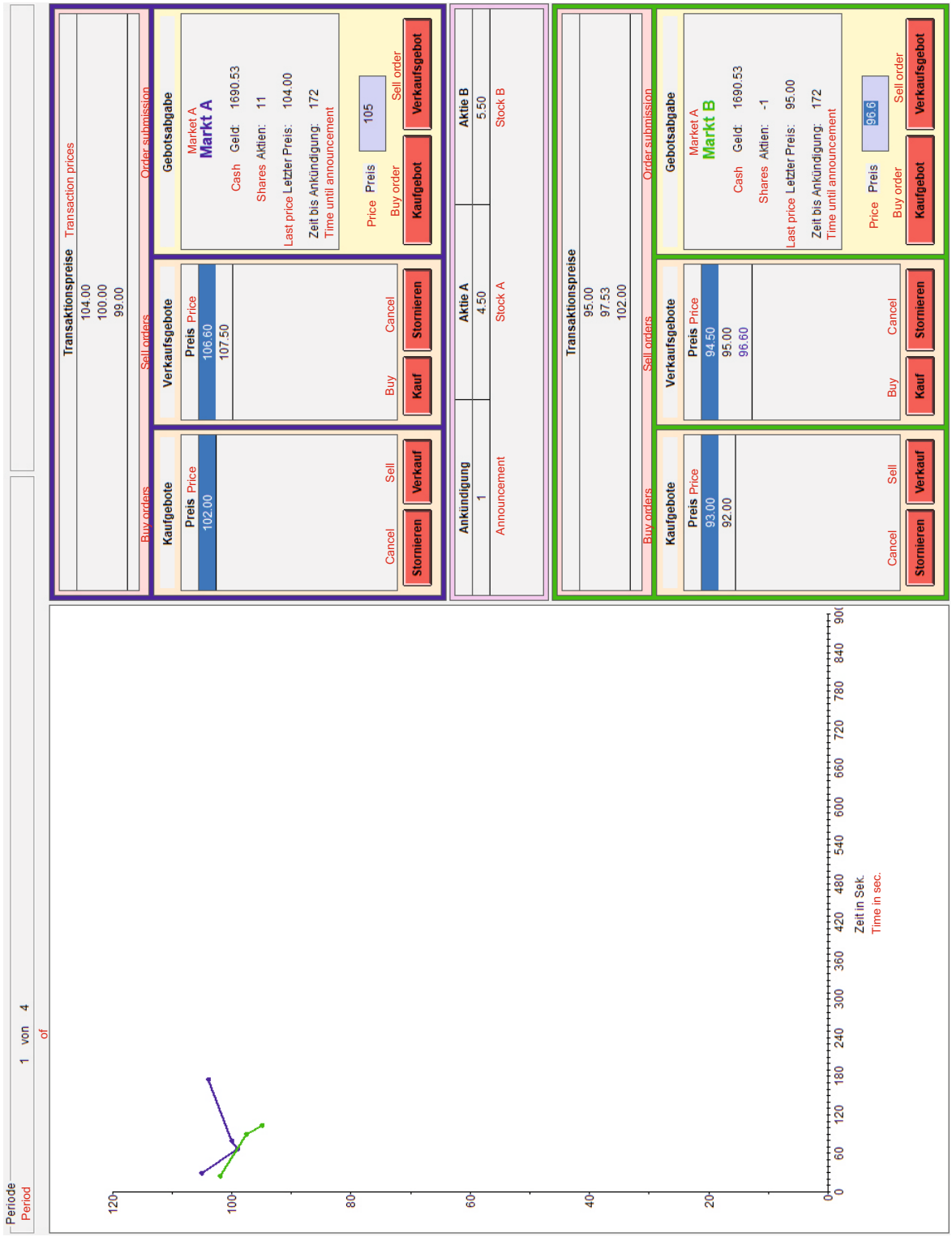

Figure A.1: Screenshot of the trading interface. Translations (in red) were not present in the experiment.

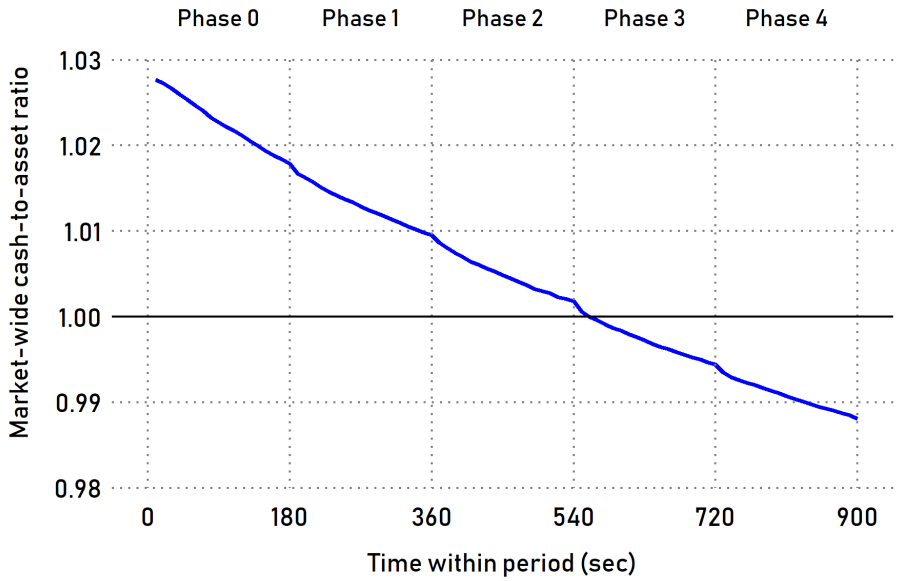

Figure A.2: Cash-to-asset ratio, period average in the frictions treatment. Total market-wide cash divided by total value of assets, at the end of each phase/window combination.

Appendix C. Alternative specifications

Table A.1: Regression analysis of window-to-window changes in taler closing quote midpoints. OLS regressions of returns over consecutive post-announcement windows. The dependent variable is the absolute change in taler closing midpoints per window. Returns are signed based on direction of previous earnings change (i.e., the signs of returns following negative announcements are reversed). 'Frictions' is a dummy variable for the frictions treatment. 'Positive earnings change' is a dummy variable for a positive earnings change. 'Period0' is the period number within the session, rebased to the range $0 \ldots 3$ (instead of $1 \ldots 4$). 'Phase0' is the phase number within the period, rebased to $0 \ldots 3$ (instead of $1 \ldots 4$ in Model 1) or $0 \ldots 2$ (instead of $2 \ldots 4$; thus excluding the phase following the first announcement for Models 3 and 4). 'Window0' is the consecutive ID number of the time window, starting with the window following the announcement window (thus excluding the window directly after the announcement), rebased to $0 \ldots 16$ (instead of $1 \ldots 17$).

	(1) Pooled	(2) First announcement	(3) No surprise	(4) Surprise
Constant	1.970^{***}	2.530^{***}	1.224^{***}	3.088^{***}
	(0.181)	(0.282)	(0.193)	(0.350)
Frictions	0.073	0.040	0.055	0.137
	(0.061)	(0.089)	(0.066)	(0.169)
Positive earnings change	-0.317^{***}	-0.203	-0.316^{***}	-0.432^{*}
	(0.075)	(0.116)	(0.078)	(0.194)
Period0	-0.058	-0.120^{**}	-0.006	-0.103
	(0.036)	(0.045)	(0.040)	(0.103)
Phase0	-0.048^{*}		0.016	-0.055
	(0.023)		(0.030)	(0.110)
Window0	-0.308^{***}	-0.457^{***}	-0.202^{***}	-0.434^{***}
	(0.039)	(0.069)	(0.044)	(0.082)
Window0^2	0.014^{***}	0.022^{***}	0.009^{***}	0.018^{***}
	(0.002)	(0.004)	(0.003)	(0.005)
R^2	0.005	0.009	0.002	0.019
Adj. R^2	0.004	0.007	0.001	0.016
Num. obs.	10675	2731	6041	1903

Note: $^{***}p<0.005$; $^{**}p<0.01$; $^{*}p<0.05$. Standard errors, clustered at the Session level, in parentheses.