

Horstmann, Niklas; Krämer, Jan; Schnurr, Daniel

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Upstream Competition and Open Access Regimes: Experimental Evidence

– *Very Preliminary and Incomplete* –

Niklas Horstmann* Jan Krämer† Daniel Schnurr‡

March 15, 2015

Abstract

We investigate the effects of alternative open access regimes on market performance. In particular, by means of an economic laboratory experiment we compare the market outcomes under unregulated wholesale competition, under a price-fixing rule (where firms must maintain their wholesale price for a fixed period of time), and under a margin squeeze rule (where the retail price of integrated firms must exceed their wholesale price). Our analysis suggests that wholesale and retail prices are substantially reduced by the introduction of a price-fixing rule at the upstream level compared to the unregulated scenario. In contrast, we do not find evidence that a margin squeeze regulation reduces retail market prices. In fact, while such a rule benefits the reselling firm by allowing for a viable profit margin, prices for consumers tend to be even higher than in the unregulated case.

Keywords: Next Generation Access Networks; Access Regulation; Open Access; Upstream Competition; Experimental Economics; Margin Squeeze

JEL classification: C92; L51; L90

*Institute of Information Systems and Marketing, Karlsruhe Institute of Technology, Englerstr. 14, 76131 Karlsruhe, Germany. Tel: +49 721 608 48387, fax: +49 721 608 48399, e-mail: horstmann@kit.edu.

†Chair of Internet and Telecommunications Business, University of Passau, Dr.-Hans-Kapfinger-Str. 12, 94032 Passau, Germany. Tel: +49 851 509 2580, fax: +49 851 509 2582, e-mail: jan.kraemer@uni-passau.de.

‡Corresponding author. Institute of Information Systems and Marketing, Karlsruhe Institute of Technology, Englerstr. 14, 76131 Karlsruhe, Germany. Tel: +49 851 509 2585, fax: +49 851 509 2582, e-mail: schnurr@kit.edu.

1 Introduction

Across industries, the presence of a bottleneck resource which is owned by a single integrated firm has led to numerous discussions about the right approach with regard to access for non-integrated competitors that may not be able to replicate the resource. While the bottleneck may exist *naturally*, e.g., due to a subadditive cost structure such as in the case of infrastructure industries, it may also have been deliberately created and protected such as in the case of patents. When the bottleneck resource constitutes an essential upstream good, *open access* is often demanded in order to strengthen (potential) downstream competition. Under such a regime, non-integrated downstream competitors may obtain the upstream good under non-discriminatory conditions, i.e., they are not handicapped by a relative disadvantage in the retail market, particularly with regard to the integrated firm. While the debate is ongoing and expanding into new markets of the digital economy (Evans, 2008), an extensive strand of the economic literature has informed the discussion by investigating the involved effects and trade-offs with regard to static and dynamic efficiency.

Next to the case of a true upstream monopoly, a set of new issues arise in the case when there is more than one upstream firm but the wholesale market is still highly concentrated. Especially in the duopoly case, the question arises whether access provision is still required and whether it is promoted by the newly introduced competition at the upstream market level. These expectations may directly influence the approach of regulators and competition agencies that deal with these kind of market structures, but may at the same time be relevant for markets with a single integrated firm and where access remedies are explicitly aimed at promoting the entry of a second integrated firm that can constitute an effective competitor at the wholesale level.

The relevance of such a scenario is illustrated by telecommunications markets and the

current trends of convergence and consolidation. Fixed-mobile integration and the technological evolution of broadband cable networks lead to co-existing integrated infrastructure operators that compete most notably in densely populated urban areas. At the same time, ongoing mergers and acquisitions in mobile telecommunications markets reduce the number of operators that maintain a distinct infrastructure, thus increasing market concentration at the wholesale level. In addition, the importance of virtual network operators (MVNOs) is increasing with regard to their market share as well as an element of a competitive downstream market. With the rollout of next-generation access networks (NGANs), operators will be even more concerned with amortizing their high-bandwidth infrastructure, providing an incentive to offer wholesale services to differentiated or more efficient downstream resellers. In addition, the large investments necessary for the roll-out of NGANs may require a reassessment of regulatory policies that were largely based on cost-based price regulation and may instead increasingly rely on inter-modal competition between infrastructures that are used by resellers and IP-based service providers.

The telecommunications industry is therefore a prototypical example with respect to how technical progress and accompanying changes of the market environment pose new challenges to policy makers and regulators. In particular, the *ex ante economic replicability test* introduced by the European Commission (2013) exemplifies the will to implement new rules in regulatory practice that may constitute an alternative to price regulation. As indicated by the legal preconditions for the application of the replicability test, the instrument explicitly refers to the competition between multiple infrastructures which are able to provide an essential wholesale service on their own. In addition, the legal codification of the replicability test illustrates that regulators are willing to employ ex post competition policy instruments in an ex ante manner, as the underlying rationale of the rule clearly resembles a margin squeeze test. However, since the margin squeeze rule is already controversially debated in the case of a single access provider, the consequences that can be expected from

an application in the context of competing access providers are highly uncertain.

As indicated by previous examples, policy makers and regulatory authorities that have relied on the essential facility doctrine or the notion of a dominant firm with significant market power in the past will need to reassess the legitimation for sector-specific regulation with regard to fixed telecommunications networks. More generally, competition policy and particularly merger control are posed with the question of how to ensure effective competition in industries with a concentrated wholesale market, e.g., in mobile telecommunications markets. Finally, the industry itself requires a sound understanding of the effects that are to be expected from simultaneous wholesale and retail competition. However, because of the forward-looking nature, data from field-studies is hardly available. Hence, next to theoretical analysis, economic laboratory experiments provide an adequate alternative to test hypothetical access regimes and regulatory rules.

While experiments have been rarely used in the evaluation of regulatory concepts so far, they provide several unique advantages when assessing the effects and the precise underlying mechanics of a rule or when the particular scenario does not exist in practice (yet). A major advantage of experimental analyses is the explicit control over the relevant independent variables of a particular scenario. By the means of systematic variation, experimenters are able to isolate effects and identify the underlying causes for observed outcomes. Thus, experiments are especially suited to benchmark concepts against each other by using established econometric methodology. Moreover, the experimental setting can be employed as a testbed for the specific application of a regulatory instrument. In this vein, market behavior and potential sources for errors may be anticipated before implementing a regulatory regime in practice. Finally, experimental evaluation is able to test the robustness of implications derived by theoretical models and can capture additional elements of strategic interactions by incorporating behavioral aspects.

In the following we develop an experimental framework dedicated to the analysis and

comparison of open access regimes in the context of simultaneous wholesale and retail competition. In particular, we employ a model where three firms compete at the retail level, while two of the three firms simultaneously compete in the wholesale market. Next to an unregulated upstream market, where firms are free to set and change wholesale prices in each period, we investigate a price-fixing rule that requires the firms to maintain their wholesale price for a fixed time period. Finally, we consider a margin squeeze regulation that restricts the firms' ability to set prices freely in the upstream market to the extent that the wholesale price cannot exceed the downstream price.

Along these lines, the remainder of this paper is structured as follows: in Section 2 we survey the related literature on wholesale access and infrastructure competition as well as wholesale competition. Furthermore, we summarize recent studies which have dealt with the margin squeeze rule. In Section 3, the basic model and the experimental design are described. Section 4 presents the experimental results and conducts an empirical analysis based on the obtained data. Finally, Section 5 provides a discussion of the results along with explanatory approaches and concludes by identifying possible limitations and extensions.

2 Related literature

2.1 Access regulation and facilities-based competition

The issue of whether and how to secure access to an upstream bottleneck infrastructure for downstream competitors is a central topic in the economic literature. It has been investigated most prominently in the context of access to telecommunications infrastructure, but is also regularly discussed in other industries, e.g., regarding the access to intellectual property. Since the fixed telecommunications network, in particular the local loop, has traditionally been viewed as a natural monopoly, the majority of the literature in the telecommunications field is concerned with a scenario where a single vertically integrated

incumbent provides a monopolistic bottleneck resource. In consequence of an access obligation or a voluntary access provision, the integrated firm may offer its downstream services directly to consumers, while at the same time, providing wholesale services to potential downstream competitors. The anti-competitive effects that possibly arise in such a scenario as well as alternative access obligations and the optimal price regulation have been widely studied by the literature for the case of a single access provider (see Laffont and Tirole, 2001, for an overview).

A more recent strand of the economic literature studying access obligations has investigated the effects of access prices and regulatory regimes with regard to investments and dynamic incentives (Cambini and Jiang, 2009). Several studies have focused on the incumbent's incentives to invest in a new infrastructure or to upgrade its existing facilities (see, e.g., Klumpp and Su, 2010), while others have analyzed the incentives of a downstream firm to duplicate the incumbent's infrastructure in order to produce the wholesale good on its own. Studies have particularly dealt with the question whether the regulated access price is at all relevant for the entrant's *make-or-buy decision* (Sappington, 2005; Gayle and Weisman, 2007; Mandy, 2009; Bender and Götz, 2011) as well as the implications of different access rules on an entrant's investment incentives (see, e.g., Avenali et al., 2010). Finally, dynamic incentives have been studied under the more general assumption that both, the incumbent and the entrant, possess the ability to invest. Both firms may then be viewed as symmetric (Lestage and Flacher, 2014) or the incumbent may be attributed with a first-mover advantage (Bourreau et al., 2012). Beyond the theoretical analysis, Bacache et al. (2014) and Briglauer et al. (2013) are two recent examples of empirical studies that have investigated the relationship between service-based competition (based on access regulation) and the emergence of infrastructure competition based on field data.

The majority of this literature points to a trade-off between static efficiency and dynamic efficiency, where traditional price regulation may have a negative effect on investment

incentives. In order to secure the investments that would enable *facilities-based competition*, an evaluation of regulatory alternatives to price regulation that still safeguard effective competition is therefore of great academic interest, and in addition particularly important to current regulators and policy makers, as, e.g., indicated by the goals of the European Commission's digital agenda (European Commission, 2014).

Facilities-based competition has often been referred to as the ultimate goal of regulatory policy in telecommunications, in particular by advocates of the *ladder of investment* theory (Cave and Vogelsang, 2003; Cave, 2006). However, with regard to the importance attributed to the goal of facilities-based competition, surprisingly little attention has been devoted to the explicit analysis of the desired outcome: competition in the context of co-existing infrastructures and resale (exceptions include Höffler (2007) and Van Gorp and Middleton (2010)). Given the well-known result of high tacit collusion among competitors in duopoly markets, the duplication of infrastructure may not represent a per-se solution to the market deficiencies experienced in the case with a single provider of the bottleneck resource. Moreover, empirical findings by Höffler (2007) cast doubt on whether gains in competition outweigh duplication costs. On the contrary, the presence of a second infrastructure may introduce competition at the wholesale level and foster the entry of resellers, thus, allowing for a larger number of firms in the retail market. Therefore, the issue of wholesale competition seems of particular importance when evaluating the effects of facilities-based competition.

2.2 Wholesale competition

Next to regulatory access obligations, access may also be granted on a voluntary basis even in the case of a single integrated firm, since wholesale profits may represent an additional revenue stream next to retail profits (Boudreau, 2010). The access provider, then, has to trade-off revenues generated at the wholesale level with the additional competitive

pressure that is created in the retail market through the reseller (Ordover and Shaffer, 2007). The incentives to provide input services to competitors may be manifold: e.g., the utilization and monetization of excess capacity subsequent to large and sunk lump-sum investments are frequently mentioned as reasons for voluntary access provisions by network operators. More generally, if downstream organizations exhibit efficiency advantages or if consumer services are quality-differentiated, the provision of wholesale services will allow the integrated firm to generate additional revenues in the absence of a commitment problem (Rey and Tirole, 2007). In this case, the access provider benefits from a demand expansion effect relative to a situation where the integrated firm is the single seller of its goods in the retail market. The incentives to provide access on a voluntary basis may be augmented in the presence of a competing infrastructure that is offering wholesale access as well. Wholesale competition has been investigated based on theoretical models by Bourreau et al. (2011), which was further extended by Bourreau et al. (2013) and Matsushima and Mizuno (2014), Höffler and Schmidt (2008), and Kalmus and Wiethaus (2010). Most notably, Bourreau et al. (2011) show that wholesale competition may not necessarily lead to a competitive outcome in the upstream market, depending on the degree of horizontal product differentiation in the retail market.

As discussed by the literature on wholesale competition, the role as an access provider is associated with important implications for strategic considerations and ensuing competition between integrated firms that both can produce the wholesale product on their own and at the same time are active in the retail market. It is well-known within the economic literature that the wholesale provider chooses its retail price with regard to its opportunity costs in the upstream market (DeGraba, 2003). In comparison, the access provider will therefore be less aggressive in the retail than the non-access providing, vertically integrated rival. Bourreau et al. (2011) call this the *softening effect*, since the consideration of opportunity costs weakens competition in the retail market and may, at the same time,

make it less attractive to compete for wholesale revenues in the upstream market. As long as goods are sufficiently differentiated, however, the *upstream revenue effect* offsets the softening effect and promises higher overall profits for the access provider compared to the integrated rival that does not supply the input good (Bourreau et al., 2011).

2.3 Open access and the margin squeeze rule

In the presence of a duplicated infrastructure, the traditional economic rationale for ex ante price regulation is no longer applicable as the bottleneck does not represent a single essential facility anymore (Renda, 2010). In consequence, regulators and competition agencies may be concerned with identifying suitable alternatives and regulatory rules that still ensure *open access* for downstream competitors, but give integrated firms more freedom in setting their wholesale prices (Krämer and Schnurr, 2014). Policy makers and regulatory agencies must then choose the most adequate instrument from a set of alternative regulatory regimes. Thus, a relative benchmark of different regulatory regimes, as e.g., provided by Nitsche and Wiethaus (2011), with regard to different measures of market performance is considered highly relevant for regulatory practice.

With regard to alternative regimes to price regulation that ensure open access, the *margin squeeze rule* represents a potential surrogate that is already applied in various forms and different contexts. Next to its application in (European) competition law, the basic mechanism, which is designed to ensure a viable wholesale-retail margin for a downstream reseller, has been implemented by *retail minus X regulation* (see, e.g., Gonçalves, 2007) and the *efficient component-pricing rule* (Baumol et al., 1997). Ever since the landmark decision *Deutsche Telekom*¹ in 2003, the application of the margin squeeze rule as an antitrust instrument has been controversially debated within the economic and the legal literature (see, e.g., Briglauer et al., 2011; Carlton, 2008; Geradin and O'Donoghue, 2005).

¹Commission Decision 2003/707/EC.

Jullien et al. (2014) provide an overview of the economic theories of harm that may qualify a margin squeeze as an abuse of market power and could provide the basis for a stand-alone antitrust doctrine. While the European Commission has repeatedly convicted firms based on a margin squeeze accusation² and has been confirmed by European courts³, the US Supreme Court has dismissed allegations based on the margin squeeze rationale in *Trinko* and *linkLine*. The margin squeeze rule has mostly been investigated in the case of a single access provider, as indispensability constitutes a central criterion in its application as an antitrust instrument. Petulowa and Saavedra (2014) qualify the circumstances under which a margin squeeze can occur in the case of differentiated goods and state that a margin squeeze may indeed represent a competitive outcome instead of an exploitative abuse. Jullien et al. (2014) conclude that the effects of a margin squeeze rule are ambiguous as wholesale prices may decrease, but retail prices may also rise, due to a *price umbrella effect*. With regard to retail minus X regulation Höffler and Schmidt (2008) criticize that its application may lead to consumer welfare losses and higher prices.

As illustrated by the *ex ante economic replicability test* (Jaunaux and Lebourges, 2014) in the European Commission's Recommendation on consistent non-discrimination (European Commission, 2013), the margin squeeze test may also be applied to an environment with competing infrastructures. While this rule is already applied in practice, little research has been conducted with regard to the actual consequences and the particular application context. In the following, we develop an experimental testbed that allows us to test alternative access regimes and particularly the margin squeeze rule in the context of infrastructure and wholesale competition. Beyond regulatory regimes that prescribe conditions on the actual price level, open access may be facilitated by a set of instruments that set restrictions with regard to the manner of how prices are set. For instance, access

²See the Commission Decision of 4 July 2007 (Case COMP / 38.784 *Wanadoo España v Telefónica*).

³See the cases *Deutsche Telekom* (T-271/03, C-280/08), *Telefónica* (T-336/07, T-398/07 C-295/12) and *TeliaSonera* (C-52/09).

provider may be obliged to make a non-discriminatory, transparent wholesale and commit to a particular price offer for a specified period of time. Our experimental analysis suggests that these rules are indeed promising and deserve more attention in the context of infrastructure competition and open access considerations.

3 Experimental framework

We compare different regulatory institutions that may ensure open access in the context of facilities-based competition based on an experimental analysis. The underlying experimental framework explicitly addresses the presented issues of wholesale competition and open access regimes by incorporating a market design that allows for simultaneous upstream and downstream competition.

3.1 Conceptual and theoretical model

The general experimental design is based on the model of upstream competition developed by Bourreau et al. (2011), illustrated in Figure 1, where two integrated firms (Firm A & Firm B) are able to supply the wholesale good, while a third firm (Firm D) is only active in the retail market. In order to supply the retail good, the downstream reseller D is required to purchase the wholesale good on the upstream market from one of the two integrated firms, which offer respective wholesale prices a_A and a_B . Subsequently, the timing within the one-shot game assumed by Bourreau et al. (2011) is as follows: After the integrated firms have made their wholesale offers in the first stage, the downstream reseller chooses its access provider. In the second stage, the firms compete in the retail market and choose their downstream prices p_k ($k \in \{A, B, D\}$), given the wholesale charges.

It is assumed that Firm D chooses the wholesale product with the lowest price and does not split its demand. Thus, the integrated firms compete à la Bertrand with homogeneous

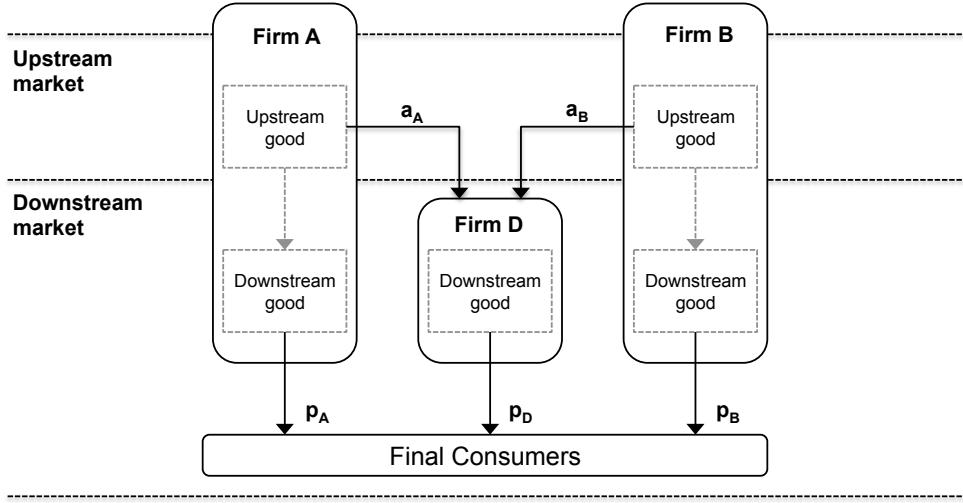


Figure 1: Conceptual model of wholesale competition with two integrated firms and a downstream reseller (based on Bourreau et al., 2011, p.683) .

goods. For each quantity that the downstream reseller supplies to consumers in the retail market, it must buy an identical quantity of the wholesale good. If Firm A and Firm B offer the identical wholesale price, Firm D chooses the firm that has previously offered the lower price. If both integrated firms offer an identical wholesale price at the beginning of the competition phase, the access provider is chosen randomly.

On the downstream market, firms compete likewise in prices, but goods are differentiated. We employ a competition model with horizontally differentiated goods based on Shubik and Levitan (1980)⁴, where the retail demand of each firm k in the case of $n = 3$ firms is given by $q_k = \frac{1}{3}(1 - p_k - \gamma(p_k - \frac{\sum_{i=1}^3 p_i}{3}))$ and the differentiation parameter γ defines the degree of substitution between firms' retail goods. We choose $\gamma = 30$ across all treatments, which corresponds to a diversion ratio of $10/21$ for each pair-wise relationship between firms. Under the given parametrization, there exists a unique Nash equilibrium in the upstream market, as shown by Bourreau et al. (2011): the symmetric competitive outcome with $a_A = a_B = 0$. The corresponding equilibrium retail prices are given by $p_k = 30.3 \forall k$.

⁴We follow Höfler (2008) with regard to the active number of firms in the market.

3.2 Experimental design

The experimental design is based on a continuous time framework where participants can observe competitors' price changes immediately and market variables are updated in real-time. Similar designs have recently been used in experimental economics, e.g. in the context of the prisoner's dilemma game by Bigoni et al. (2014) and Friedman and Oprea (2012). The continuous feedback loop allows participants to directly evaluate the impact of their decisions on their individual performance and on aggregate market performance. By this means, participants are able to assess the interdependencies between prices in the downstream and upstream market. As shown by Horstmann et al. (2015), tacit collusion in an oligopoly setting is found to be lower in the case of a continuous time framework compared to discrete time. Thus, the chosen time framework is considered the more conservative approach regarding the evaluation of the empirically observed market performance and the effectiveness of the regulatory regimes.

The timeline of the experiment includes two phases: the practice phase and the competition phase. During the practice phase subjects are able to test various price configurations for all firms in the market and observe according payoffs, while these actions do not impact the subjects' earnings. The competition phase starts after all subjects have confirmed their initial prices in the practice phase interface and lasts exactly 30 minutes. All decisions in this phase directly impact the monetary payoff of the subjects, as earnings are calculated as the cumulative profits over the time horizon of the experiment. Current profits and cumulative earnings are displayed to subjects over the entire competition phase.

We study the following four different treatment scenarios in a full-factorial manner:

No Regulation (NR): Firm A and Firm B are free to set and change upstream prices continuously.

Price-fixing (FX): A firm's upstream price is fixed for a period of 30 seconds after a

change of the wholesale offer. In contrast to a discrete period logic, however, participants decide on their own when to change their wholesale price and are able to observe rivals' actions. Thus, firms rather act in a sequential than a simultaneous setting.

Margin squeeze regulation (MSQ): Firm A and Firm B are not able to set wholesale prices above their own retail prices nor to set retail prices below their own access prices, respectively. If participants set prices that violate the conditions of these rules, the experimental software displays a warning and sets the price to maximum (minimum) price allowed, which is the current own retail (wholesale) price, in case of a wholesale (retail) price change.

Price-fixing with margin squeeze regulation (FXMSQ): The price-fixing and the margin squeeze rule are applied in combination.

Across all treatments, the integrated firms, Firm A and Firm B, are represented by human subjects, while the downstream reseller, Firm D, is represented by an automated software agent. Given the wholesale and retail prices set by the integrated firms, the reseller chooses the retail price according to its best response. The software agent reacts immediately to any price change made by one of the other market participants.

The experimental design was computerized using the a newly-developed experimental software (Müller et al., 2014), which supports implementations in the *Java* programming language and uses the *Swing* framework for the design of the graphical user interface. See Appendix A for a screenshot of the graphical user interface as displayed during the competition phase.

3.3 Experimental procedures

The experimental sessions have been conducted with students of the Department of Economics and Management at the Karlsruhe Institute of Technology, Karlsruhe, Germany, who have been recruited via the *ORSEE* platform (Greiner, 2004). Overall, 82 subjects participated in the study and each participant played only one of the treatments (between-subject design). The average experimental session lasted 70 minutes. On average, subjects earned a performance-based payment of 16.80 Euro in addition to a base fee of 5 Euro. Participants were randomly assigned to groups of two and interacted with the same firm for the entire time horizon of the experiment (fixed partner matching). Consequently, we obtain 41 independent observations at the market level: 9 observations for *NR*, 10 observations for *FX*, 10 observations for *MSQ*, 12 observations for *FXMSQ*. The current market data is obtained every 500 ms, thus, we obtained 3,600 data points per market that include wholesale and retail prices, respective quantities and profits.

In a complementary validation study, we have conducted the *FX* treatment with 16 practitioners of a major German telecommunications operator (*FXPRAC*). The study was executed under identical conditions as in student experiments with three exceptions. First, the duration of the continuous competition phase was shortened to ten minutes. Second, we changed the payment scheme to a lottery system, where participants could win one of three vouchers with a monetary value of 30 Euro each. The number of lottery tickets that participants received were dependent on their payoff in the experiment. By this means, we ensure monotonicity with regard to the relationship between individual performance and payoffs. Third, each participant played a second *FX* treatment with a more differentiated retail market ($\gamma = 50$). The sequence of the two treatments was randomized over the three experimental sessions.

All experimental sessions with students as well as practitioners have been conducted with the identical experimental software and hardware in order to ensure consistency, par-

ticularly with regard to the graphical user interface, across all treatments. Upon entering the laboratory, subjects were randomly assigned to a seat, from which they could neither see nor speak to any other participant of the experiment. Subsequently, the experimental instructions were handed to the participants in print and read aloud from a recording. Paragraphs that were identical across treatments were recorded once and the recording was used in all treatments. Prior to the beginning of the experiment, each subject had to complete a computerized comprehension test that included a set of questions regarding the experimental instructions and the experimental procedure. Participants could proceed to the next question only after entering the correct answer to the current one. After all subjects had successfully completed the test, the experiment started automatically. In addition, student participants wore ear protectors during the competition phase in order to avoid any influence by clicking noises of computer mouses.

4 Results

In the following, we evaluate market prices, firms' profits, and the transaction price across treatments. The upstream market price a_m is given by the effective wholesale price that the entrant faces, i.e., the minimum of both wholesale offers. The downstream market price p_m is defined as the average retail price of all active downstream firms, i.e., all firms that face a positive consumer demand. Profits are computed as the amount of money that participants earn during the competition phase, i.e. the final payoff excluding the fixed base fee. We denote the average profit of both integrated firms by π_{AB} and the profit of the downstream reseller as π_D . The transaction price ψ is the average retail price weighted by the demand of each individual firm, i.e. $\psi = \sum_k \frac{q_k}{Q} \cdot p_k$ where Q is the aggregate market demand and $k \in \{A, B, D\}$. Since the transaction price represents the effective retail price that the average consumer faces, it may serve as a proxy for consumer surplus. Throughout

the analysis we use median measures for all these market variables.⁵

As we are mainly interested in general market performance that occurs in a stable market environment, we focus our analysis on the steady state that occurs after initial adjustments and avoids potential endgame effects. Therefore, we base our subsequent analysis on the market data from recorded ticks 300 to 1,500 (1 tick $\hat{=}$ 500ms period), i.e. the first five and last five minutes are dropped.

In order to evaluate treatment effects, we ran a quantile regression⁶ (Koenker and Hallock, 2001) given by:

$$X_{jt} = \beta_0 + \beta_t \cdot t + \beta_{MSQ} \cdot MSQ + \beta_{FX} \cdot FX + \beta_{FXMSQ} \cdot FXMSQ + \epsilon_{jt},$$

where X_{jt} denotes the respective market variable X in market j and period t . MSQ , FX and $FXMSQ$ are dummy variables that take a value of one if the respective treatment condition is active and a value of zero if not.⁷ Standard errors are computed allowing for intra-cluster correlation over periods t , clustering market level observations j (Parente and Silva, 2015). Table 1 reports the estimates for the coefficients and treatment effects on the respective market variables.

⁵Alternatively to the median analysis, an analogous analysis can be conducted based on period and session averages. However, the median measure exhibits a number of advantages regarding the evaluation of experimental data and the goal to compare alternative regulatory institutions. For instance, extreme outliers have obviously a lesser impact on the median than on the average of a sample. In the case of complex laboratory experiments with human subjects, we have to account for the possibility that subjects may fail to understand the rules or may not follow them in individual cases. Then, the median measure represents a more conservative criterion with regard to the external validity of the obtained results. Moreover, regulators and policy makers are arguably more interested in the “medium” outcome that can be expected from a single scenario than the average effect across multiple co-existing scenarios. That being said, the reported results hold qualitatively when the analysis is conducted based on averages rather than on medians. The respective graphs of treatments’ period averages can be found in Appendix B.

⁶For a similar approach in the case of a continuous time experiment see Friedman and Oprea (2012).

⁷Note that $FXMSQ$ can be interpreted as the interaction effect of FX and MSQ .

Table 1: Quantile regression of wholesale market prices a_m , retail market prices p_m , integrated firms' average profits π_{AB} , reseller's profits π_D and transaction price ψ .

| Covariate | (1) a_m | (2) p_m | (3) π_{AB} | (4) π_D | (5) ψ |
|--------------|-----------------------|-----------------------|-----------------------|----------------------|-----------------------|
| FX | -52.206*** (8.675) | -39.076*** (5.997) | -10.282*** (1.566) | 1.931*** (0.449) | -38.055*** (7.063) |
| MSQ | -15.253* (8.363) | 2.261 (5.717) | -0.148 (1.275) | 2.084*** (0.468) | 2.940 (6.271) |
| FXMSQ | 23.200 (14.815) | 14.608 (9.743) | 4.203* (2.491) | -1.892*** (0.635) | 14.166 (11.229) |
| Period | 0.004 (0.004) | 0.003 (0.002) | 0.001 (0.000) | -0.000 (0.000) | 0.004 (0.003) |
| Constant | 88.189*** (14.149) | 85.566*** (4.862) | 21.441*** (1.459) | 0.550 (0.592) | 82.074*** (5.701) |
| Observations | 98,359 | 98,359 | 98,359 | 98,359 | 98,359 |

Clustered standard errors (by market) in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.1 Unregulated wholesale competition

In line with previous experimental studies on Bertrand competition, we find that empirically observed market prices are located substantially above the equilibrium prices predicted by economic theory (Engel, 2007). Large and significant constants in the models for upstream and downstream market prices indicate a high degree of tacit collusion in both markets. The constant of the reseller's profit is statistically indifferent from zero, which points to the fact that the integrated firms extract almost the entire rent of the reseller's downstream earnings via the wholesale charge.

In addition to the estimates reported in Table 1, we evaluate the market price levels over the time horizon of the experiment. Figure 2 depicts the period medians of upstream and downstream market prices across individual markets for each of the four treatment

combinations.⁸

In the *NR* treatment, the overall medians of upstream market prices $a_m^{NR} = 97.096$ and retail market prices $p_m^{NR} = 90.757$ are close to the maximum price of $a_{max} = p_{max} = 100$. Moreover, the comparison of both market prices suggests the presence of a margin squeeze where the wholesale offers are higher than the retail prices of the integrated firms. In fact, we can frequently observe effective foreclosure of the non-integrated firm, i.e., retail prices of both integrated firms are set below the current minimum wholesale offer. The median rate of foreclosure at the individual market level is measured at 26.03%, i.e., foreclosure occurs in a quarter of the total time horizon of the experiment. As a consequence, the downstream reseller is unable to compete in the retail market under such a price configuration.⁹

With regard to temporal effects, there is a general positive and significant trend of the upstream market price across treatments. While the coefficients for retail prices and profits of the integrated firms show positive absolute values, the effects are insignificant.

4.2 Price-fixing rule

With regard to the *FX* treatment, we find significant effects on all five market variables as portrayed in Table 1. Most notably, there is a strong negative impact on wholesale and retail prices. In accordance, the integrated firms' profit is decreasing, while the downstream reseller's profit is increasing and consumers benefit from a lower transaction price. The overall median upstream (downstream) market price $a_m^{FX} = 43.043$ ($p_m^{FX} = 52.385$) corresponds to a 56% (42%) decrease relative to the *NR* treatment. Because the lower wholesale price is accompanied by a substantially lower retail price, the margin between upstream and downstream prices is still relatively slim, as indicated by the lower left panel in Figure 2. In consequence, the median rate of foreclosure decreases, but still amounts to 18.87%

⁸Graphs are plotted based on medians of 50 ticks.

⁹Note that the non-integrated firm may still be marginally active in the retail market, since goods are differentiated. In any case, the firm is not able to exercise any significant competitive pressure.

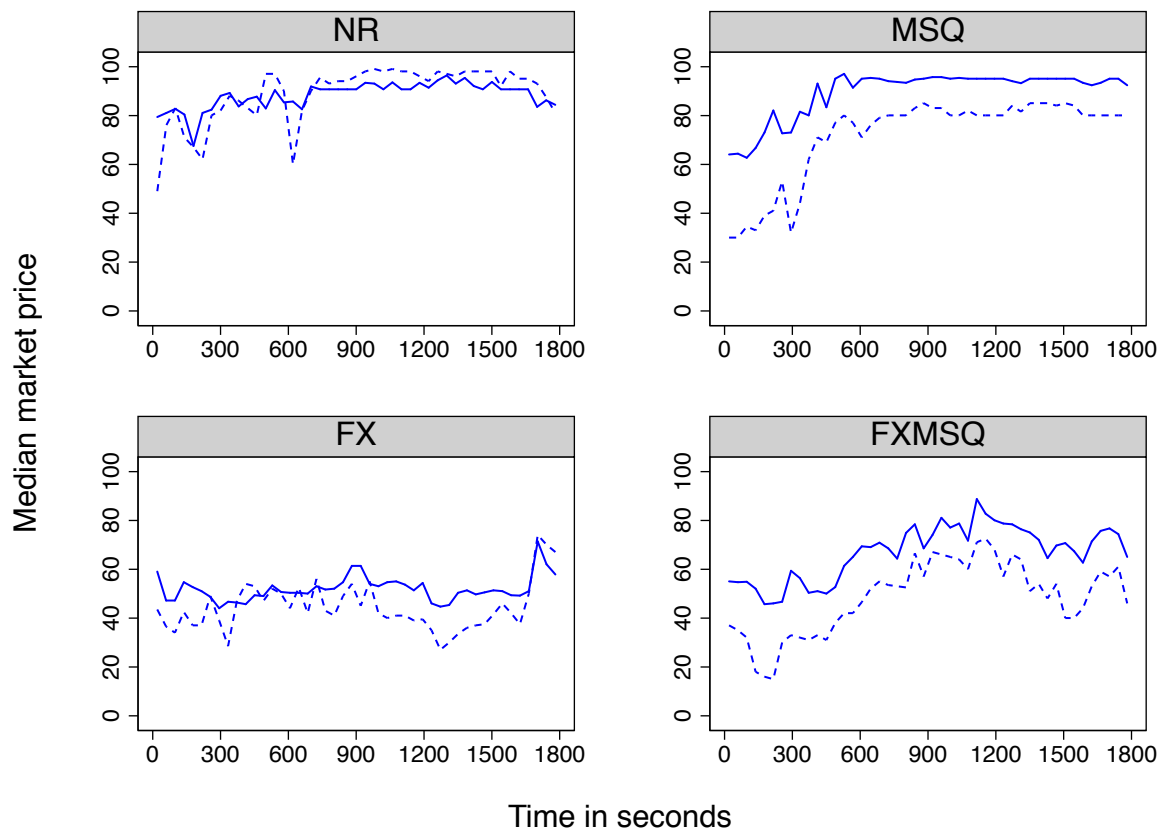


Figure 2: Median upstream market prices (*dashed*) and median downstream market prices (*solid*) for each of the four treatments.

of total periods on the individual market level. Overall, consumers benefit from the drastic fall in prices: the median transaction price is $\psi^{FX} = 50.419$ compared to $\psi^{NR} = 88.407$.

Result 1 *The introduction of a price-fixing rule in the wholesale market reduces wholesale prices and retail prices substantially. In consequence, profits of the integrated firms decrease, while the downstream reseller and consumers are better off.*

4.3 Margin squeeze regulation

Exclusionary and exploitative abuses are frequently mentioned as the primary justification for a margin squeeze regulation (see, e.g., Jullien et al., 2014). In light of the considerable rate of foreclosure under the *NR* and the *FX* treatments, the investigation of this specific rule seems thus explicitly relevant in the presented context. As shown by the upper right panel in 2, wholesale prices are indeed lower in the *MSQ* treatment compared to *NR*, i.e., in the pair-wise comparison of scenarios with price-flexibility. With regard to retail prices, however, the level of the median market prices is similar to the price level in *NR*. On the contrary, the overall median $p_m^{MSQ} = 95.094$ is even higher under margin squeeze regulation.

In contrast to the clear-cut negative price effects under *FX*, the impact of the margin squeeze rule is less definite at first sight. On the one hand, significant effects reveal that that the non-integrated downstream firm benefits from a significantly lower wholesale price in the *MSQ* case. On the other hand, effects on retail market prices and on the transaction price are not significant. Thus, the results do not provide any evidence that consumers benefit from the regulatory pricing rule. Instead, the absolute values of coefficients point to a price increase in the retail market rather than a price decrease, despite the fact that the effective wholesale price is lower under *MSQ*.

We further investigate the effect of the margin squeeze regulation by applying the rule in combination with the price-fixing condition (see panel *FXMSQ* in Figure 2). In contrast

to the negative effect on wholesale prices in the *MSQ* case under price-flexibility, we do not observe a decline of wholesale prices in *FXMSQ* relative to *FX*. The overall median $a_m^{FXMSQ} = 50.050$ is even found to be higher than the respective a_m^{FX} . On the other hand, the increase of the downstream firm's profit margin in consequence of the margin squeeze rule is replicated under price-fixing. However, this can be attributed mainly to the rise of the retail price level indicated by an overall median of $p_m^{FXMSQ} = 69.736$.

Result 2 *The introduction of a margin squeeze regulation benefits the downstream reseller as its profit increases, while wholesale prices decrease. However, there is no evidence that consumers benefit from such a price rule as no negative impact on retail market prices can be observed.*

In order to investigate the impact of MSQ under price-flexibility and price-fixing, we ran the following (reduced) quantile regression separately for both scenarios:

$$X_{jt} = \beta_0 + \beta_t \cdot t + \beta_{MSQ} \cdot MSQ + \epsilon_{jt},$$

Estimates are reported in Table 2 for the case of price-flexibility (*MSQ* relative to *NR*) and in Table 3 for the case of price-fixing (*FXMSQ* relative to *FX*).

In the case of price-flexibility, the coefficient for the upstream market price show a clear negative impact of the *MSQ* treatment. The magnitude of the effect is found to be stronger as in the general regression model (Table 1) and is found to be significant with a p-value of 0.062. Again, we do not find a negative impact on retail prices, nor on the transaction price. Instead, estimates indicate a positive effect, but p-values are above the threshold of the ten percent level of significance.

The estimates in the case of price-fixing, portrayed in Table 3, provide insight into the consequences of the margin squeeze regulation with regard to the retail market. The magnitude of the respective price increase is found to be stronger compared to the general

Table 2: Quantile regression of wholesale market prices a_m , retail market prices p_m , integrated firms' average profits π_{AB} , reseller's profits π_D and transaction price ψ in case of price-flexibility.

| Covariate | (1) a_m | (2) p_m | (3) π_{AB} | (4) π_D | (5) ψ |
|--------------|-----------------------|----------------------|----------------------|---------------------|----------------------|
| MSQ | -14.637* (8.265) | 3.744 (2.820) | -0.150 (1.031) | 2.051*** (0.526) | 3.908 (3.528) |
| Period | 0.005 (0.005) | 0.001 (0.001) | 0.000 (0.000) | -0.000 (0.000) | 0.000 (0.002) |
| Constant | 86.004*** (15.968) | 89.332*** (4.272) | 22.072*** (1.629) | 0.649 (0.891) | 88.126*** (5.350) |
| Observations | 45,581 | 45,581 | 45,581 | 45,581 | 45,581 |

Clustered standard errors (by market) in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Quantile regression of wholesale market prices a_m , retail market prices p_m , integrated firms' average profits π_{AB} , reseller's profits π_D and transaction price ψ in case of price-fixing.

| Covariate | (1) a_m | (2) p_m | (3) π_{AB} | (4) π_D | (5) ψ |
|--------------|----------------------|----------------------|----------------------|---------------------|----------------------|
| MSQ | 7.986 (10.882) | 16.731** (7.885) | 4.158* (2.254) | 0.189 (0.474) | 17.079** (8.072) |
| Period | 0.003 (0.004) | 0.006* (0.004) | 0.001 (0.001) | -0.000 (0.000) | 0.006* (0.003) |
| Constant | 37.486*** (8.130) | 41.436*** (6.148) | 10.376*** (1.920) | 2.331*** (0.612) | 39.171*** (5.662) |
| Observations | 52,778 | 52,778 | 52,778 | 52,778 | 52,778 |

Clustered standard errors (by market) in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

model and the case of price-flexibility. Moreover, effects on the retail market price and the transaction price are found to be significant with p -values of 0.075 and 0.065 respectively.

4.4 Validation study

Figure 3 illustrates the median upstream and downstream market price for the FX treatment conducted with students (the left-hand panel) and for the FX treatment conducted with practitioners (the right-hand panel). While wholesale market prices are similar, but lower in the case of the practitioner treatment according to the overall median measure over all periods ($a_m^{FXSTUD} = 43.043$, $a_m^{FXPRAC} = 29.029$), retail prices are almost identical ($p_m^{FXSTUD} = 52.385$, $p_m^{FXPRAC} = 51.051$). Note that in the practitioners treatment, wholesale prices also significantly depart from zero, i.e., the theoretical prediction.

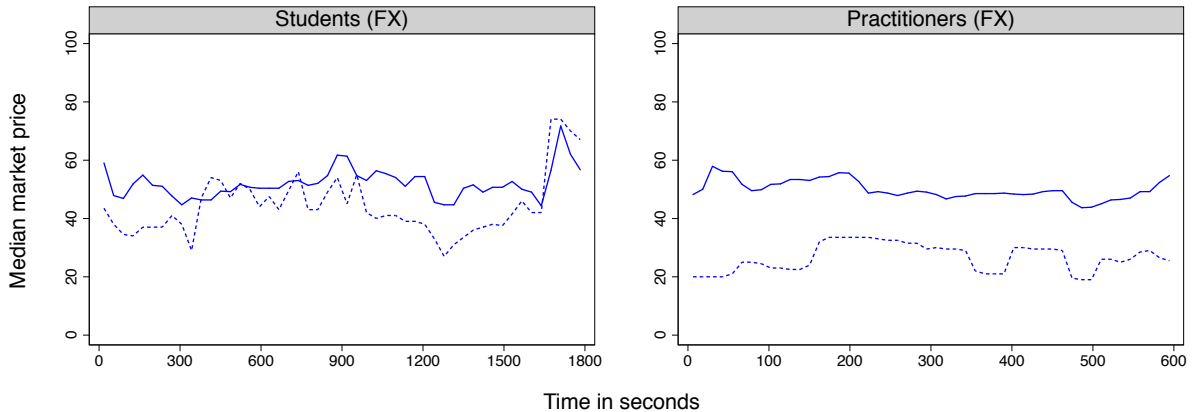


Figure 3: Comparison of median upstream (*dashed*) and downstream (*solid*) market prices between students and practitioners.

We further compare the market outcomes in the practitioners treatment to the students treatment based on median prices at the market level. In particular, we test the hypothesis that the median market prices in the students sample and the median market prices the practitioners sample over the entire time horizon of the experiment are from populations with the same distribution. According to the Mann-Whitney U test, we do not find a

significant difference in upstream market prices ($z = 1.42$, $p = 0.155$) or in downstream market prices ($z = 0.80$, $p = 0.424$). Furthermore, we test whether the overall medians, i.e., the median of market medians, are equal based on a Fisher’s exact test: Again, equality of the median market price cannot be rejected at the upstream level ($\chi^2 = 0.90$, $p = 0.637$) as well as the downstream level ($\chi^2 = 0.0$, $p = 1.0$). Finally, we ran a quantile regression that investigates the effect of the practitioners treatment, while controlling for the impact of period and clustering observations at the market level. In order to obtain a comparable data basis with an equivalent number of periods, we average the measures of the students treatment for every three subsequent 500 ms intervals.

Table 4: Estimates for the impact of the practitioners treatment in case of price-fixing.

| Covariate | (1) a_m | (2) p_m | (3) π_{AB} | (4) π_D | (5) ψ |
|--------------|----------------------|----------------------|----------------------|---------------------|----------------------|
| PRAC | -14.465 (10.259) | -0.392 (10.317) | -0.613 (2.923) | 1.839*** (0.600) | 1.170 (10.908) |
| Period | 0.001 (0.011) | 0.003 (0.007) | 0.001 (0.002) | 0.000 (0.000) | 0.003 (0.008) |
| Constant | 42.297*** (9.791) | 50.430*** (6.932) | 11.974*** (2.179) | 2.043*** (0.427) | 48.270*** (6.920) |
| Observations | 21,618 | 21,618 | 21,618 | 21,618 | 21,618 |

Clustered standard errors (by market) in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As shown in Table 4, the effect of the treatment variable is found to be insignificant for all market measures, with the exception of the downstream reseller’s profit. The higher profit of the entrant can be attributed to a larger spread between upstream and downstream prices in a subset of individual markets in the practitioners treatment, which is also indicated by the negative coefficient for the median upstream market price a_m .

Naturally, we cannot derive general, conclusive evidence based on findings of statistical insignificance. However, descriptive measures, as portrayed in Figure 3, show a quantitative

similar and qualitatively equal behavior in both treatments, in addition to the finding of statistically indifference. Moreover, since average and median payoffs in absolute terms are higher in the student treatment, we can conclude that student participants perform at least as good in the experiment compared to practitioner participants. This shows that the implemented experimental design and the employed incentive scheme are well understood by participants even when they are no experts in the particular domain. Finally, the fact that wholesale prices in terms of absolute value are higher in the experiment with students, indicate that the findings of this study can be viewed as conservative with regard to the threat of tacit collusion and strategic behavior of firms in the presented scenarios.

5 Discussion and conclusion

The analysis of the experimental data has revealed that the evaluated regulatory regimes differ significantly with regard to their effect on market performance. In the case of unregulated wholesale competition, a high degree of tacit collusion among the integrated firms in the upstream market effectively foreclosed the downstream firm from exercising any competitive pressure in the retail market. Strikingly, the integrated firms frequently coordinated themselves on a price above the monopoly price that a single access provider would set in the theoretical one-shot game. In this vein, the integrated firms forewent higher access profits, but were able to achieve higher rents in the downstream market. This result is obtained although tacit collusion is impeded by the fact that upstream firms are not able to share the demand of the non-integrated downstream firm. Hence, it may be concluded that the threat of immediate competition, which can be employed as an instrument of punishment if the upstream rival firm deviates from a collusive level, supports prices above the monopoly level. By this means, the ability to compete prevents the actual competition process where firms would undercut each other.

Moreover, this explanatory approach is further substantiated by the drastic fall of market prices in the price-fixing treatment. Under the price-fixing rule, the second-mover, i.e., the firm that sets the wholesale price after the rival has committed to a price for the next thirty seconds, is able to extract a guaranteed wholesale profit while the other firm is bound to its price decision. In other words, the threat of immediate punishment which would erase any gains in wholesale revenues is suspended by the price-fixing. The observed retail price level is essentially in line with the theoretical equilibrium prediction given the empirical wholesale charges. Ultimately, the unambiguity and the strength of the observed effect on market prices and the associated gains for consumers indicated by the transaction price, leads to the conclusion that a price-fixing rule can substantially improve market performance. Since the application of the price-fixing rule is much simpler, requires less information and intervention by the regulator, and is moreover easily monitored, such a behavioral rule seems especially promising for regulatory practice.

In contrast to the beneficial effects observed in the price-fixing treatment, the empirical findings in the treatments involving margin squeeze regulation raise considerable doubts about the effectiveness of such a regulatory remedy to safeguard competition in the context of duplicated infrastructures. While the downstream reseller benefits from a larger upstream-downstream margin and the ban of effective foreclosure as experienced in the case of unregulated wholesale competition, there are no indications that consumers are better off. Even in the case where upstream prices decrease in consequence of the margin squeeze regulation, consumers do not benefit from a lower transaction price in the retail market, as the additional surplus is extracted mainly by the downstream reseller. Moreover, comparing the case of price-fixing with and without margin squeeze regulation, the application of the margin squeeze rule leads to substantially higher retail prices and to a significant loss in consumer welfare.

In reference to the work by Petulowa and Saavedra (2014) and Jullien et al. (2014), our

experimental results give a clear indication regarding the theoretically ambiguous effect of margin squeeze regulation for the case of facilities-based competition. The results support the finding that the ban of a margin squeeze can impede the intensity of competition in the retail market. Moreover, the experimental results point to a particular problem of applying the margin squeeze rule to an environment with multiple firms active in the wholesale and retail market. If tacit collusion in the upstream market is stable and leads to prices above the Nash equilibrium, retail pricing is constrained correspondingly. Especially the integrated firm, which naturally has an incentive to be more aggressive in the retail market, as it is not affected by the softening effect, may be restricted in setting lower retail prices as long as it decides not to undercut prices in the wholesale market. While the margin squeeze rule as an implicit open access rule ensures non-discrimination between competitors, the equal treatment is not aligned with the diverse incentives that occur in the case of simultaneous retail and wholesale competition, e.g., due to the consideration of opportunity costs by the access provider. Thus, non-discrimination of competitors may not always be in the best interest of the consumer. Note that an additional negative effect of non-discrimination on competition is articulated by the theory of *restoring monopoly power* (Rey and Tirole, 2007), where non-discrimination allows the upstream firm to resolve its commitment problem.

With regard to the limitations of this study, concerns with regard to the external validity of experimental analysis of oligopoly markets in general, and experimental evaluation of regulatory regimes in particular, may raise questions about whether the obtained results can be transferred to actual practice. While the design and the implementation of economic laboratory experiment necessarily require simplification and assumptions that may partly diverge from the complex scenarios in actual markets, we have, to our best effort, verified that student participants are similar to decision makers in practice with regard to the behavior and outcome in the experimental scenario. Furthermore, our results are based

on the relative differences between treatments, i.e., concerns about external validity apply here only to a lesser extent. Moreover, the experimental design has been explicitly based on established models of the theoretical economic literature. Nevertheless, an empirical field study of access in context of infrastructure competition would certainly represent a highly valuable contribution complementing theoretical and experimental work.

Furthermore, we do not consider investments in our experimental scenario and therefore neglect dynamic incentives that may play an important role in firms' market decisions, particularly in infrastructure industries such as telecommunications.¹⁰ Since investment incentives, however, are mainly influenced by the expectations about the future competitive scenario, the obtained results may inform further research regarding the effects that arise under facilities-based competition with multiple wholesale providers. In addition, investment incentives are strongly impacted by the current regulatory regime. The presented benchmark of regulatory rules may therefore be evaluated with respect to the firms' profits and the resulting investment incentives.

The explanatory approaches inspired by the experimental results raise new questions that may be further investigated by future research. First, the effects of the price-fixing rule may be evaluated by the means of an additional experimental treatment that adds a clocked price-setting mechanism in the wholesale market, i.e., induces the simultaneous setting of upstream prices. This could provide further insight about the underlying mechanics that foster wholesale competition. Second, the analysis of wholesale competition may be complemented by a study that focuses on asymmetric competition, i.e., the case where there is only a single access provider, but a second integrated firm that is able to produce its own input good. Such a market structure is regularly found in the fixed telecommunications industry, where cable tv networks have been upgraded to support broadband services, but mostly do not provide a wholesale product to competitors. Moreover, this treatment would

¹⁰For a theoretical analysis see Bourreau et al. (2013).

introduce an additional benchmark for the results obtained under unregulated wholesale competition and would furthermore represent an important application scenario of margin squeeze regulation.

References

- Avenali, A., G. Matteucci, and P. Reverberi (2010). Dynamic access pricing and investment in alternative infrastructures. *International Journal of Industrial Organization* 28(2), 167–175.
- Bacache, M., M. Bourreau, and G. Gaudin (2014). Dynamic entry and investment in new infrastructures: Empirical evidence from the fixed broadband industry. *Review of Industrial Organization* 44(2), 179–209.
- Baumol, W. J., J. A. Ordover, and R. D. Willig (1997). Parity pricing and its critics: A necessary condition for efficiency in the provision of bottleneck services to competitors. *Yale Journal on Regulation* 14, 145–163.
- Bender, C. M. and G. Götz (2011). Coexistence of service-and facility-based competition: The relevance of access prices for “make-or-buy”-decisions. Working Paper. Available at <http://www.econstor.eu/handle/10419/56526>.
- Bigoni, M., M. Casari, A. Skrzypacz, and G. Spagnolo (2014). Time horizon and cooperation in continuous time. Working Paper. Available at <http://web.stanford.edu/~skrz/BigoniCasariSkrzypaczSpagnolo.pdf>.
- Boudreau, K. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science* 56(10), 1849–1872.
- Bourreau, M., C. Cambini, and P. Doğan (2012). Access pricing, competition, and incentives to migrate from “old” to “new” technology. *International Journal of Industrial Organization* 30(6), 713–723.
- Bourreau, M., C. Cambini, and S. Hoernig (2013). Geographic access rules and investments. Working Paper. Available at <http://cadmus.eui.eu/handle/1814/26678>.

- Bourreau, M., J. Hombert, J. Pouyet, and N. Schutz (2011). Upstream competition between vertically integrated firms. *The Journal of Industrial Economics* 59(4), 677–713.
- Briglauer, W., G. Ecker, and K. Gugler (2013). The impact of infrastructure and service-based competition on the deployment of next generation access networks: Recent evidence from the european member states. *Information Economics and Policy* 25(3), 142–153.
- Briglauer, W., G. Götz, and A. Schwarz (2011). Margin squeeze in fixed-network telephony markets—competitive or anticompetitive? *Review of Network Economics* 10(4), Art. 3.
- Cambini, C. and Y. Jiang (2009). Broadband investment and regulation: A literature review. *Telecommunications Policy* 33(10), 559–574.
- Carlton, D. W. (2008). Should price squeeze be a recognized form of anticompetitive conduct? *Journal of Competition Law and Economics* 4(2), 271–278.
- Cave, M. (2006). Encouraging infrastructure competition via the ladder of investment. *Telecommunications Policy* 30(3), 223–237.
- Cave, M. and I. Vogelsang (2003). How access pricing and entry interact. *Telecommunications Policy* 27(10), 717–727.
- DeGraba, P. (2003). A bottleneck input supplier’s opportunity cost of competing downstream. *Journal of Regulatory Economics* 23(3), 287–297.
- Engel, C. (2007). How much collusion? a meta-analysis of oligopoly experiments. *Journal of Competition Law and Economics* 3(4), 491–549.
- European Commission (2013, september). Commission recommendation on consistent non-discrimination obligations and costing methodologies to promote competition and en-

- hance the broadband investment environment (2013/466/EU. *Official Journal of the European Union L 251*, 13–32.
- European Commission (2014). Commission Staff Working Document. Implementation of the EU regulatory framework for electronic communications - 2014. SWD(2014) 249. Available at <http://ec.europa.eu/digital-agenda/en/download-scoreboard-reports>. Accessed on 10.03.2015.
- Evans, D. S. (2008). Antitrust issues raised by the emerging global internet economy. *Northwestern University Law Review* 102(4), 285–306.
- Friedman, D. and R. Oprea (2012). A continuous dilemma. *The American Economic Review* 102(1), 337–363.
- Gayle, P. G. and D. L. Weisman (2007). Are input prices irrelevant for make-or-buy decisions? *Journal of Regulatory Economics* 32(2), 195–207.
- Geradin, D. and R. O’Donoghue (2005). The concurrent application of competition law and regulation: the case of margin squeeze abuses in the telecommunications sector. *Journal of Competition Law and Economics* 1(2), 355–425.
- Gonçalves, R. (2007). Cost orientation and xdsl services: Retail-minus vs. lraic. *Telecommunications Policy* 31(8), 524–529.
- Greiner, B. (2004). An online recruitment system for economic experiments. In K. Kremer and V. Macho (Eds.), *Forschung und wissenschaftliches Rechnen 2003*, GWDG Bericht 63, pp. 79–93. Gesellschaft für Wissenschaftliche Datenverarbeitung, Göttingen.
- Höfler, F. (2007). Cost and benefits from infrastructure competition. estimating welfare effects from broadband access competition. *Telecommunications Policy* 31(6), 401–418.

- Höfler, F. (2008). On the consistent use of linear demand systems if not all varieties are available. *Economics Bulletin* 4, 1–5.
- Höfler, F. and K. M. Schmidt (2008). Two tales on resale. *International Journal of Industrial Organization* 26(6), 1448–1460.
- Horstmann, N., J. Krämer, and D. Schnurr (2015). Oligopoly competition in continuous time. Working Paper.
- Jauniaux, L. and M. Lebourges (2014). Economic replicability tests for next-generation access networks. Working Paper. Available at <http://ssrn.com/abstract=2462454>.
- Jullien, B., P. Rey, and C. Saavedra (2014). The economics of margin squeeze. Working Paper. Available at http://idei.fr/doc/by/jullien/Margin_Squeeze_Policy_Paper_revised_March_2014.pdf.
- Kalmus, P. and L. Wiethaus (2010). On the competitive effects of mobile virtual network operators. *Telecommunications Policy* 34(5), 262–269.
- Klumpp, T. and X. Su (2010). Open access and dynamic efficiency. *American Economic Journal: Microeconomics* 2(2), 64–96.
- Koenker, R. and K. Hallock (2001). Quantile regression: An introduction. *Journal of Economic Perspectives* 15(4), 43–56.
- Krämer, J. and D. Schnurr (2014). A unified framework for open access regulation of telecommunications infrastructure: Review of the economic literature and policy guidelines. *Telecommunications Policy* 38(11), 1160–1179.
- Laffont, J. J. and J. Tirole (2001). *Competition in telecommunications*. Cambridge, Massachusetts: MIT Press.

- Lestage, R. and D. Flacher (2014). Infrastructure investment and optimal access regulation in the different stages of telecommunications market liberalization. *Telecommunications Policy* 38(7), 569–579.
- Mandy, D. M. (2009). Pricing inputs to induce efficient make-or-buy decisions. *Journal of Regulatory Economics* 36(1), 29–43.
- Matsushima, N. and K. Mizuno (2014). Competition for access provision: Infrastructure upgrades with spillovers. In *25th European Regional ITS Conference, Brussels 2014*. International Telecommunications Society (ITS).
- Müller, M. B., A. Hariharan, and M. T. P. Adam (2014). A neurois platform for lab experiments. In F. Davis, R. Riedl, J. vom Brocke, P.-M. Léger, and A. Randolph (Eds.), *Proceedings Gmunden Retreat on NeuroIS 2014*, Gmunden, Austria.
- Nitsche, R. and L. Wiethaus (2011). Access regulation and investment in next generation networks a ranking of regulatory regimes. *International Journal of Industrial Organization* 29(2), 263–272.
- Ordover, J. and G. Shaffer (2007). Wholesale access in multi-firm markets: When is it profitable to supply a competitor? *International Journal of Industrial Organization* 25(5), 1026–1045.
- Parente, P. M. and J. S. Silva (2015). Quantile regression with clustered data. *Journal of Econometric Methods*. Forthcoming.
- Petulowa, M. and C. Saavedra (2014). Margin squeeze in a regulatory environment: an application to differentiated product markets. Working Paper. Available at <http://ssrn.com/abstract=2236258>.

- Renda, A. (2010). Competition–regulation interface in telecommunications: What’s left of the essential facility doctrine. *Telecommunications Policy* 34(1), 23–35.
- Rey, P. and J. Tirole (2007). A primer on foreclosure. In M. Armstrong and R. H. Porter (Eds.), *Handbook of Industrial Organization: Vol 3*, pp. 2145–2220. Amsterdam: North-Holland.
- Sappington, D. E. (2005). On the irrelevance of input prices for make-or-buy decisions. *The American economic review* 95(5), 1631–1638.
- Shubik, M. and R. Levitan (1980). *Market Structure and Behavior*. Cambridge, MA: Harvard University Press.
- Van Gorp, A. F. and C. A. Middleton (2010). The impact of facilities and service-based competition on internet services provision in the canadian broadband market. *Telematics and informatics* 27(3), 217–230.

A Experimental software



Figure A1: Screenshot of the graphical user interface as displayed during the competition phase.

B Average market prices

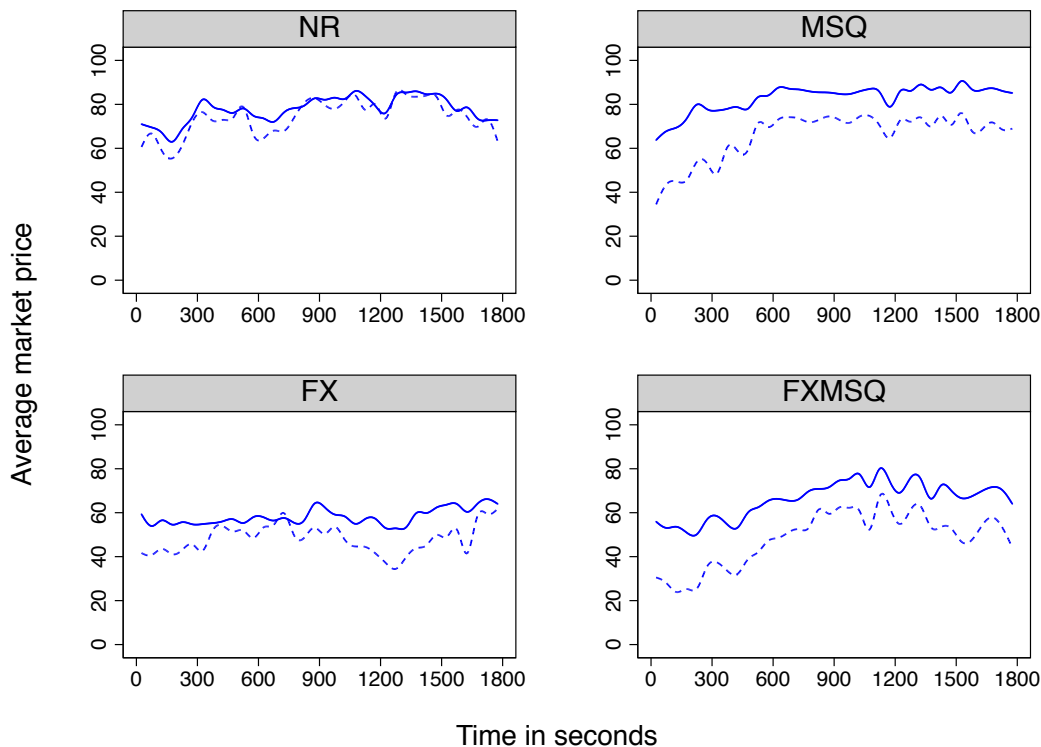


Figure A2: Period averages of upstream (*dashed*) and downstream (*solid*) market prices. Graphs are plotted based on medians of 50 ticks.

C Experimental instructions

The following experimental instructions have been used for the FXMSQ treatment and were translated from German. The instructions for the other treatments are identical except with respect to the specifics of the treatments. Note that the instructions are only translations for information; they are not intended to be used in the lab. The instructions in the original language were carefully polished in grammar, style, comprehensibility, and avoidance of strategic guidance.

C.1 Preliminary remarks

Welcome to the experiment and thank you very much for your participation. In this experiment you can earn an amount of money that depends on your decisions and the decisions of the other participants. Please address the person in charge of the experiment in case of questions. Please do not talk to the other participants during the entire experiment. Throughout the experiment we will use the currency Euro and its subunits cent. At the beginning of the experiment your account balance is 5 Euro. At the end of the experiment, the final account balance will be paid to you in cash.

During the experiment you represent a firm which is selling a good to consumers. Next to you, there are two other firms which are competing with you. All your decisions are made in real time, thus, they are immediately effective and visible to all other firms. Over the entire time horizon of the experiment, you play together with the same firms.

C.2 Experimental structure

There are three firms:

- Firm A
- Firm B
- Firm C

Firm A and Firm B are represented by participants of the experiment. Firm C acts computerized. Which firm you represent is randomly chosen at the beginning of the experiment and does not change over the entire experiment. Furthermore there are two markets:

- Wholesale market
- Retail market

Figure 1 visualizes the structure of the experiment. Each of the three firms offers a retail product on the retail market and chooses its retail price. In order to produce the retail product each firm needs a wholesale product. Only Firm A and Firm B offer the wholesale product in the wholesale market and choose their respective wholesale prices. Firm C has to buy the wholesale product from one of the two other firms in order to be able to offer its retail product.

C.2.1 Wholesale Market

The wholesale products of Firm A and Firm B are equal. Thereby, the following holds:

- Firm C chooses automatically the cheaper wholesale product to satisfy its demand.
- If Firm A and Firm B offer the identical wholesale price, Firm C chooses the wholesale product from the firm which had previously offered the lower price.

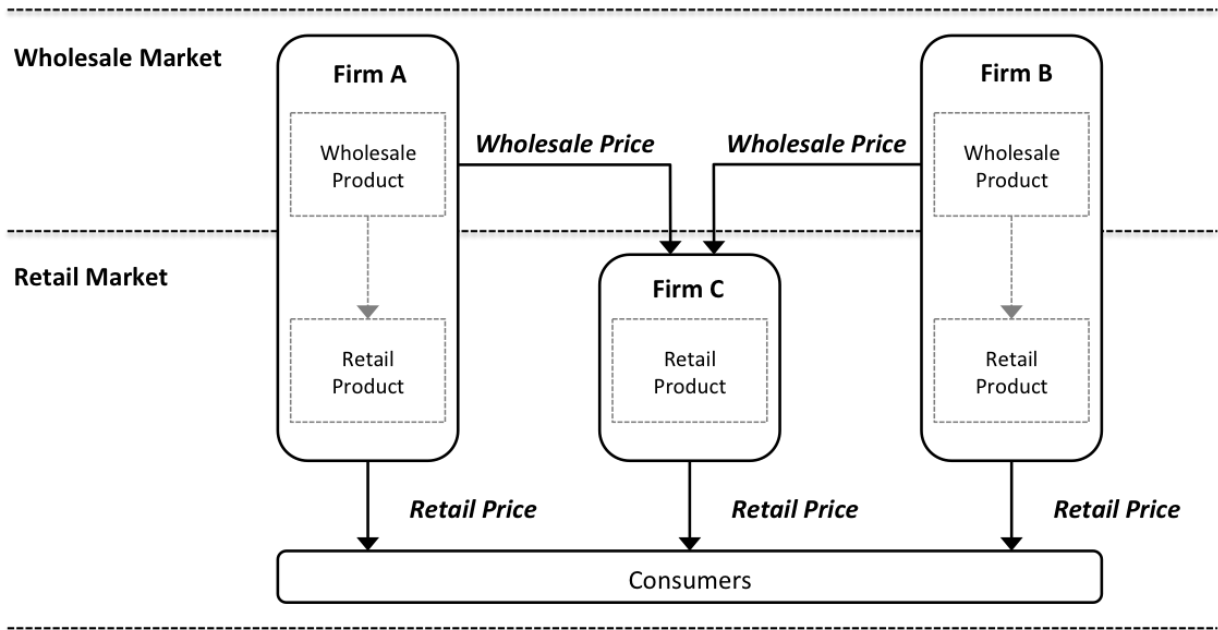


Figure 1: Structure of the experiment

- If Firm A and Firm B offer the identical wholesale price at the beginning, Firm C chooses randomly from which firm it purchases the wholesale product.

There are no handling costs for the wholesale product. The prices of the wholesale products range from 0 to 100.

C.2.2 Retail market

The retail products differ between firms. The demand of your retail product depends on your retail price and the retail prices of the other firms. Thereby, the following holds under the assumption that the other retail prices remain unchanged:

- If you increase your retail price, the demand of your retail product decreases.
- If one of the other firms increases its retail price, the demand of your retail products increases.
- If all firms increase their retail price, the total demand of all retail products decreases.

If your retail price is located below the average of all three retail prices, the demand of your retail product increases. If your retail price is located above the average of all three retail prices, the demand of your retail product decreases. The extent of the deviation of your retail price from the average of all three retail prices determines the magnitude of this effect. If your retail price is above the average of all three retail prices, the demand of your retail product may fall to zero. Firm C chooses its profit-maximizing retail price in

reaction to the effective wholesale price and the retail prices chosen by Firm A and Firm B.

There are no handling costs for the retail product. The prices of the retail products range from 0 to 100.

C.2.3 Profits

The profits of the three firms depend on the retail and wholesale prices. The calculations for the profits of Firm A and Firm B depend on Firm C's decision which firm to choose as its wholesale provider.

If Firm C chooses to purchase its wholesale product from Firm A, the following holds for the profits of each firm:

$$Profit_A = Retail Price_A \cdot Demand_A + Wholesale Price_A \cdot Demand_C$$

$$Profit_B = Retail Price_B \cdot Demand_B$$

$$Profit_C = (Retail Price_C - Wholesale price_A) \cdot Demand_C$$

If Firm C chooses to purchase its wholesale product from Firm B, the following holds for the profits of each firm:

$$Profit_A = Retail Price_A \cdot Demand_A$$

$$Profit_B = Retail Price_B \cdot Demand_B + Wholesale Price_B \cdot Demand_C$$

$$Profit_C = (Retail Price_C - Wholesale Price_B) \cdot Demand_C$$

C.3 Experimental procedure

The experiment is composed of two stages. At the first stage, as Firm A or Firm B, you choose your initial retail price and your initial wholesale price. Before making your final decision, you can test how a price combination affects the profits of all three firms. This does not influence your account balance. After all firms have made their initial price decision and have confirmed their decisions with a click on "apply initial prices", the second stage of the experiment starts.

The second stage lasts exactly 30 minutes. During this period of time, all decisions are made in real time and without any interruptions. Your price decision remains effective until you change your price. Note that subsequent to a change of your wholesale price, the price cannot be changed again for the next 30 seconds. Furthermore, please be aware that your wholesale price can not be located above your retail price.

C.4 Software display

Figure 2 depicts the display of the experiment software. In order to distinguish the firms, their labels are colored as follows:

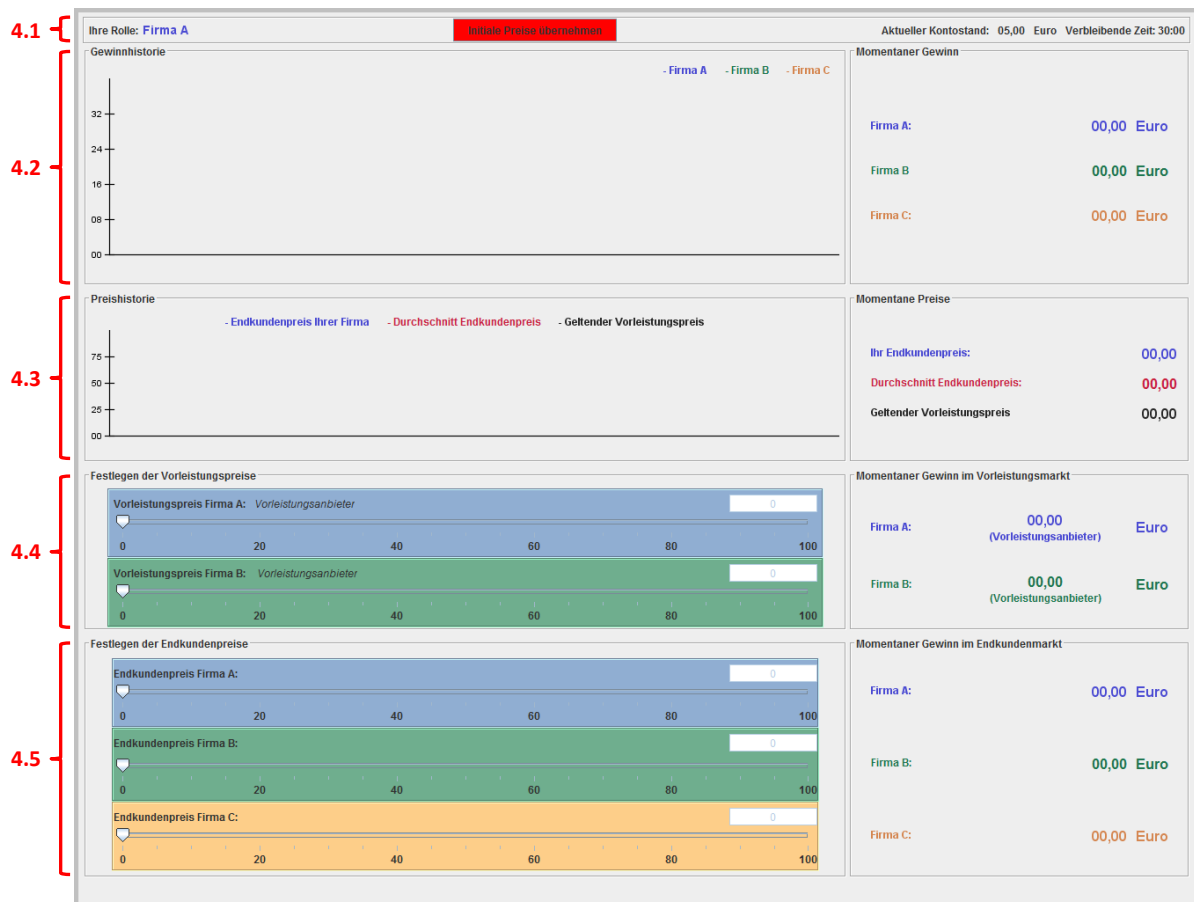


Figure 2: Display of the experiment software

- Firm A: BLUE
- Firm B: GREEN
- Firm C: ORANGE

In the following, the individual sections of the display will be explained from the bottom up:

C.4.1 Experimental progress

On the left-hand side, it is denoted whether you represent Firm A or Firm B. Figure 2 illustrates this exemplarily for Firm A. On the right-hand side, your current account balance as well as the remaining duration of the experiment is displayed. Your current account balance consists of the initial balance of 5 Euro and the additionally earned profits during the experiment.

C.4.2 Current profits and profit history

On the right-hand side, the current profits of all firms are displayed. Note that current profits are scaled to the profit you would earn, if the current combination of all prices would be held over the entire 30 minutes of the experiment. As soon as one of the prices changes, the current profits are recalculated. On the left-hand side, the history of the current profits is displayed.

C.4.3 Current prices and price history

On the right-hand side, the current prices of all three firms are displayed. The effective wholesale price is always the lower wholesale price of both wholesale prices. On the left-hand side, the history of your retail price, the average retail price of all three firms and the effective wholesale price is displayed.

C.4.4 Wholesale prices and current profits in the wholesale market

On the left-hand side, Firm A and Firm B choose their wholesale prices. Be aware that Firm C offers no wholesale product and thus cannot choose a wholesale price. The wholesale price can be set with the corresponding slider by using the mouse or the arrow keys on the keyboard. Note that you can move all sliders at the first stage of the experiment and only the slider of your firm at the second stage of the experiment. The sliders of the other firms show their current wholesale prices. On the right-hand side the current profits in the wholesale market are displayed. Furthermore it is displayed which firms sells its wholesale product to Firm C. Note that subsequent to a change of your wholesale price, the price cannot be changed again for the next 30 seconds. Furthermore, please be aware that your wholesale price can not be located above your retail price.

C.4.5 Retail prices and current profits in the retail market

On the left-hand side, all of the three firms choose their retail price. The retail price can be set with the corresponding slider by using the mouse or the arrow keys on the keyboard. Note that you can move all sliders at the first stage of the experiment and only the slider of your firm at the second stage of the experiment. The sliders of the other firms show their current retail prices. On the right-hand side, the current profits in the retail market are displayed. Note that the displayed current profit of Firm C already includes the costs for the wholesale product.

C.5 Concluding remarks

Before the experiment starts, you will be asked a set of comprehension questions, displayed on the computer screen, that cover the rules and the procedure of the experiment. Please enter the respective answers. Thereupon, the experiment will start automatically and it is displayed which firm you represent.

In case of any questions during the experiment, please remain seated and inform the person in charge of the experiment by the means of a hand gesture. Please wait until the person in charge of the experiment has arrived at your seat. Talk as quietly as possible when asking your question. Please remain seated after the end of the experiment and wait for further instructions from the person in charge of the experiment.