Essays on Advertising and Pricing Strategies in Digital Markets

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Chapter 1

Introduction

The rapid growth of online markets and technological advances have brought forth many benefits for consumers. These include easier access to a larger variety of products, lower search costs and lower costs for multi-homing. New business models are emerging and many of the fast-growing digital companies are multi-sided platforms, which enable interaction between two or more types of agents, such as consumers, advertisers and suppliers. However, digitalization also raises important policy challenges, among others, in the areas of competition and consumer policy. The aim of this thesis is to analyze some critical aspects of digital markets and draw policy conclusions to identify circumstances under which regulatory intervention in markets serving consumers is warranted.

In light of the technological changes and opportunities brought about by the advancement of the Internet, also the media industry has undergone substantial change. One trend that stands out is the steady migration from raising revenue exclusively through advertisements to establishing direct pay systems. Until a few years ago, selling advertising space was the dominant form of financing among media platforms. Especially so in the tv-sector; nowadays it is closely followed by pay-tv (Waterman *et al.*, 2012). In Chapter 2 these observations serve as a stepping stone to investigate the implications of switching from free-to-air (where revenues come from advertisements only) to pay-tv (where revenues come from both advertisements and subscriptions) for both media and product markets. In Chapter 2 conditions are derived under which one business model is more profitable for platforms than the other. A product and a media market are considered and it is shown how a change in the business model employed by the media platforms affects consumers, producers (or advertisers), and price negotiations for advertisements. On both markets, two firms differentiated à la Hotelling compete for consumers. On the media market, consumers can mix between the two outlets whereas on the product market, consumers have to decide for one supplier. Advertising is assumed to be informative and a larger number of advertisements increases the probability that consumers are informed about a product's existence.

Chapter 2 makes four important contributions to the existing literature on two-sided markets. First, the effect of different business models in a setting in which advertising rates are determined via a bargaining process is analyzed. It is established that, as opposed to free-to-air, pay-tv platforms have a higher negotiating leverage vis-à-vis the producers which leads to an increase in advertising rates and higher platform profits. Second, the product market is modeled explicitly. As a result the chapter can make clear statements about how business model choice affects competition and consumer welfare on the product market. In case of pay-tv, the increased advertising rates result in softer price competition and a lower consumer surplus on the product market. Considering both markets, with pay-tv consumers are always worse off, as the change in business model toward a subscription regime also affects their mixing behavior on the media market. Total welfare may be higher or lower. This result is in contrast to models analyzing similar questions while pursuing different modeling approaches which have mostly emphasized the benefits of subscription services. Third, Chapter 2 explores under which circumstances platforms prefer one business model over the other. Platforms have greater incentives to choose pay-tv when differentiation on the product market or on the media market is high. In addition, platforms prefer pay-tv when their bargaining power vis-à-vis producers is low. Switching to pay-tv allows them to mitigate the negative profit implications of their limited bargaining position. In summary, Chapter 2 helps explain the steady migration from free-to-air to subscription services in the tv sector in the past decades. However, the findings suggest that this trend may not be beneficial for consumers and under certain circumstances even leads to a deterioration of total welfare. Finally, the model can also be extended to study newer business models such as pay-per-view where instead of a fixed subscription fee viewers' charges are based on the amount of content they use. It is shown that this business model leads, as traditional pay-tv, to higher platform revenues, but is preferred from a consumer perspective as it still allows consumers to consume their ideal variety via mixing.

The literature on behavioral economics demonstrates that the way in which information is presented or choices are framed can have a significant influence on consumer decisions. In particular in online markets several pricing practices have emerged which try to take advantage of these behavioral biases. One such practice is drip pricing. It is generally referred to as a pricing technique in which sellers only advertise a part of a product's price and reveal additional charges later in the purchasing process. In a series of laboratory experiments Chapter 3 examines the effects of drip pricing on seller strategies, buyer behavior and total welfare. Sellers set two prices: a base price and a drip price. At first, buyers only observe the base prices and make a tentative purchase decision. Revealing the sellers' drip prices, however, comes at a cost.

Chapter 3 contributes to the literature on price obfuscation and addresses five key issues which have turned out to be highly relevant in the competition policy debate. First, it analyzes whether drip pricing hampers competition. It shows that firms fiercely compete in base prices, but not in drip prices. Compared to the standard Bertrand setup, the total price (slightly) increases when firms use drip pricing. Second, Chapter 3 shows how drip pricing affects consumers' search behavior. It finds that given costly search, consumer search is mostly optimal from an ex-post perspective. Third, the implications of drip pricing for consumer surplus and firm profits are investigated. It is shown that when firms use drip pricing, consumers are worse off, whereas firms benefit. This leads to the fourth aspect of the analysis: the effects of regulating drip pricing on consumer surplus. The case in which there is a cap on the drip size is analyzed and it is shown that this may have a negative effect on consumer surplus. This implies that efforts to counter the anti-competitive effects of drip pricing by capping its size might have the opposite effect, resulting in higher prices and profits. Finally, a case where buyers face uncertainty regarding the drip price limit of the sellers is examined. These situations are relevant in practice as in many markets (in particular those where consumers buy infrequently) consumers are unaware whether or not a firm is using a drip price strategy. This is captured by randomly varying the drip price limit a firm may charge. The experiments show that this affects competition in drip prices for sellers with a high drip price limit. Moreover, buyers increasingly fail to identify the cheapest seller. This leads to the conclusion that policy interventions may be more effective when buyers are less experienced with drip pricing, as this seems to have a larger impact on their welfare.

Especially in high-tech and information based industries it is common for firms to announce new technologies well in advance of market availability. One purpose of these preannouncements is to convince consumers to delay their purchase decision in favor of the announced technology. There are two important features which these types of industries have in common. First, they are often characterized by network effects which gives rise to coordination problems. Second, product cycles are relatively short, that is, consumer demand is fundamentally influenced by the release of new versions of a technology. In a controlled laboratory experiment Chapter 4 examines a cheap talk setting with one sender and multiple receivers playing a repeated coordination game. The experiments are framed as a model of technology adoption in a market with two competing firms, A and B, where both firms develop a sequence of technologies. Consumers choosing firm A's technology benefit from network effects but are faced with quality uncertainty while technology B serves as a safe outside option. Furthermore, firm A can communicate its technology's quality via a cheap talk message to consumers and consumers make repeated purchases. In addition, consumers are unable to verify the technology's quality prior to the purchase. From a theoretical perspective, in the short run, firms have an incentive to distort the truth and exploit the asymmetry in information to some financial advantage. In the long run, however, firms risk losing credibility by being untruthful and have an incentive to build a reputation for being honest.

Chapter 4 makes two contributions to the existing literature on sender-receiver games. First, it examines the effect of announcements on technology adoption when network effects are present. This is particularly interesting since with network effects, preannouncements may become a powerful tool as they can be used by consumers to coordinate and may therefore critically influence the outcome of a standards competition. Chapter 4 establishes that when network effects are strong, coordination on the announced product is lower when firm A can communicate its technology's quality. When network effects are weak, this effect is reversed. Consumers, on average, are always better off when technologies are preannounced. This leads to the conclusion that not only are product preannouncements not a threat to competition in this setting but they can even be beneficial for consumers. Second, the chapter examines reputational concerns when network effects are present, purchases are made repeatedly and the announcing firm has an incentive to distort the truth. It is shown that with strong network effects more firms succumb to the temptation of exaggerating their quality, encouraged by more forgiving consumers. As a result, regulations penalizing deceptive preannouncements may be more effective in industries with strong network effects.

References

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Chapter 2

Business Models in Commercial Media Markets: Bargaining, Advertising, and Mixing

Co-authored with Alexander Rasch and Tobias Wenzel

2.1 Introduction

In light of the technological changes and opportunities brought about by the advancement of the Internet, the media industry is undergoing substantial change and as a result, new trends are emerging at rapid speed. One trend that stands out is the steady migration from raising revenue exclusively through advertisements to establishing direct pay systems. Especially newer platforms increasingly choose to charge subscription fees instead of offering their content for free (e.g., CBS Access, Hulu Plus). This trend can also be observed in the television market. In many countries, the television market is still heavily polarized between free-to-air businesses (where revenues come from advertisements only) and pay-tv businesses (where revenues come from both advertisements and subscriptions). Until a few years ago, selling advertising space was the dominant form of financing among media platforms in the television sector; nowadays it is closely followed by pay-tv. To be more precise, in 1970 total revenue from subscriptions in the tv sector accounted for 0.03% of total GDP in the U.S., whereas total tv advertising revenues amounted to 0.35% of GDP. More than four decades later, subscription revenues measured in terms of GDP have surpassed those from advertising. Moreover, in 1970, less than 7% of the households in the US were subscribers to pay-tv channels, but since then this number has risen steadily up to 87% in 2010.[1] This indicates that not only do different forms of financing exist in the television market, but there is also a substantial amount of migration to the pay-tv business model.[2]

We take these observations as a starting point to investigate the implications of switching from free-to-air to pay-tv for both media and product markets and derive conditions under which one business model is more profitable for platforms than the other. In addition we evaluate each business model in terms of its impact on consumer behavior and total welfare. To do so, we build on the theoretical models developed in Dukes and Gal-Or (2003) as well as Gal-Or and Dukes (2003). In those papers as well as in ours, both the product and the media market are modeled à la Hotelling and media firms bargain with producers over the price for advertising space. Advertising is informative and a higher number of advertising messages raises the likelihood of a consumer becoming informed about the advertised product, but also increases competition on the product market. In addition to this, viewers can split their time between the two platforms on the media market but can only buy from one of the producers on the product market. Analyzing the choice of business model in this setting has the advantage that we can identify the effects on advertising

[1] See Waterman *et al.* (2013).

[2] There are also some examples for channels which switched from pay-tv to free to air. In 2014, three French subscription channels (TF1, M6, and Canal+) applied to France's broadcast regulator to become fully ad-supported. In the following year, PBS America, the UK arm of the US public broadcaster, lifted its encryption and went free-to-air.

prices and determine the repercussions on the product market and consumer choice when a switch in business model occurs.

Our paper makes four important contributions. First, we analyze the effect of different business models in a setting in which advertising rates are determined via a bargaining process. This yields important insights with respect to platform profits and advertising rates. We find that, as opposed to free-to-air, pay-tv platforms have a higher negotiating leverage vis-à-vis the producers which leads to an increase in advertising rates and higher platform profits.

Second, we explicitly model the product market which allows us to make clear statements about how the business model choice affects competition and consumer welfare on the product market. In case of pay-tv, the increased advertising rates result in softer price competition and a lower consumer surplus on the product market as compared to free-to-air. Considering both markets, consumers are always worse off, as the change in business model toward a subscription regime also affects their mixing behavior on the media market. Mixing means that consumers may choose to allocate their time between the two media outlets such that they get their preferred combination of media content (i.e., their transport costs are reduced, possibly down to zero). On the media market with free-to-air, all consumers mix. In contrast, with pay-tv, consumers no longer mix which means that they have to bear transport costs and pay subscription fees. We show that consumer surplus is reduced despite the benefits of a lower advertising intensity. On the product market, fewer informed consumers and higher prices lead to a loss of consumer surplus. With regard to total welfare, we find that it may be higher or lower. This result is in contrast to models analyzing similar questions while pursuing a different modeling approach which have mostly emphasized the benefits of subscription services. In our model, only platforms always gain from switching to pay-tv.

Our third contribution is that we explore under which circumstances platforms prefer one business model over the other. We find that platforms have greater incentives to choose pay-tv when differentiation on the product market or on the media market is high. Interestingly, we also find that platforms prefer pay-tv when their bargaining power vis-à-vis producers is low. Switching to pay-tv allows them to mitigate the negative profit implications of their limited bargaining position. Overall, our paper contributes to the understanding of the effect a switch in business model has on the respective media market, its viewers, producers, and the number of advertisements.

Fourth, our findings may help to explain the steady migration from free-to-air to subscription services in the tv sector in the past decades. However, this trend may not be beneficial for consumers and under certain circumstances even leads to a deterioration of total welfare if it results in a traditional pay-tv business model.

Importantly, however, our model can also be extended to study newer business models such as pay-per-view where instead of a fixed subscription fee viewers' charges are based on the amount of content they use. We find that this business model leads, as traditional pay-tv, to higher platform revenues, but is preferred from a consumer perspective as it still allows consumers to consume their ideal variety via mixing.

The rest of the paper is organized as follows. Section 2.2 relates our work to the relevant literature. Section 2.3 describes the model. In Section 2.4, the symmetric equilibrium with pay-tv competition is derived, which is followed by a comparison with the results under free-to-air competition according to Gal-Or and Dukes (2003). Furthermore, the impact of a switch in business model for consumer surplus and total welfare is derived. In Section 2.5, we discuss the profit implications of the different platform business models and also consider pay-per-view business models. Section 2.6 concludes.

2.2 Related literature

Our paper is generally related to the growing literature on two-sided markets but more closely to the economics of media markets (see Anderson and Gabszewicz (2006) for a survey). Starting with the seminal work by Anderson and Coate (2005) who determine conditions under which advertising is either under- or overprovided compared to the social optimum, important insights could be gained from the literature that followed. In many cases, the media market was analyzed assuming that consumers choose only one platform while advertisers are able to advertise on all platforms creating a competitive bottleneck (Armstrong, 2006). However, particularly when it comes to watching television viewers can divide their time between several channels and platforms not only need to compete for advertisers but also for consumers (Gabszewicz *et al.*, 2004). In addition, some of the literature on media markets has solely focused on free-to-air competition between media platforms (Kind *et al.*, 2007; Reisinger *et al.*, 2009; Reisinger, 2012), while others have analyzed media markets with subscription fees (Prasad *et al.*, 2003; Reisinger, 2014) or pay-per-view pricing strategies (Godes *et al.*, 2009).

Our modeling approach builds on the models in Dukes and Gal-Or (2003) and Gal-Or and Dukes (2003) and shares their main ingredients which are bargaining between advertisers and media platforms, mixing on the viewer side, and the implications for product market competition. Both their papers focus on free-to-air competition. In their model, Dukes and Gal-Or (2003) investigate the effect of exclusive contracts between media platforms and advertisers on advertisements, consumers, and product market competition. They show that exclusive contracts lead to fewer informed consumers and less competition among advertisers. In Gal-Or and Dukes (2003), the same authors demonstrate that with free-to-air and endogenous location choice by media platforms, differentiation among them is minimal. Unlike their contributions, we evaluate the effects of different business models in a similar environment. By contrast, we neither consider location choice nor exclusive contracts in our setup. A platform's location is exogenous such that content is maximally differentiated on both product and media market and negotiations always take place between each media firm and advertiser. This makes the model more tractable and it is easier to identify the effects of a change in business model by the platforms on the relevant variables.

Few papers have addressed the topic of business model choice in media markets. For example, Peitz and Valletti (2008) analyze a tv market with consumers who do not mix between channels and multi-homing advertisers with the aim to compare content choice and advertising decisions between the two business models. They find that neither pay-tv nor free-to-air lead to socially optimal outcomes as market failures arise in response to a misalignment of incentives between competing platforms and society. As a result, they find an underprovision of advertising with pay-tv competition as compared to the social optimum and a tendency to advertise more with free-to-air under the assumption that content is sufficiently differentiated. Endogenizing the location choice leads to less differentiation with free-to-air than with pay-tv which is socially preferable. While the model by Peitz and Valletti (2008) is similar to ours, in our model also consumers are able to mix and we show that the choice of business model by the platform influences their mixing decision. Furthermore, in our model we do not focus on the question of content but rather on how the business model affects the bargaining mechanism between platforms and advertisers and thereby advertising prices.

Kind *et al.* (2009) study the effect different forms of competition have on business model choice in a setup with a representative consumer. In their model, platforms can choose to finance themselves through advertising only, through subscription revenues or a combination of both. Here, advertisers and consumers are both able to mix between platforms. Kind *et al.* (2009) find that a higher substitutability between media platforms makes platforms more dependent on advertising revenues, while a higher number of competitors on the media market has the opposite effect. By comparison, our model does not consider different forms of competition. Instead we focus on the case where there are two suppliers on both the product and the media market and on both markets firms are maximally differentiated. This allows us to identify the effects of a change in business model on producers, consumers, and platforms. In contrast to their approach, we also examine how business model choice affects the bargaining power of platforms vis-à-vis producers.

Choi (2006) examines the implications of different business models in a setting where entry into the market is endogenous. Unlike our paper with a fixed number of media platforms, the product market is not explicitly modeled and there is no bargaining over advertising rates between producers and media platforms. Furthermore, media consumers are single-homing. In this setting, the author shows that with pay-tv there is insufficient advertising and excessive entry into the media market. With free-to-air the results are more ambiguous and excessive as well as insufficient advertising levels may occur.

To the best of our knowledge, we are the first to analyze the effect of different business models in the context of media markets when the product market is characterized by a duopoly instead of perfect competition and platforms bargain over advertising prices with producers.

2.3 The model

There are two markets: the media market and the product market. Two platforms $j = 0, 1$ are active on the media market.[3] The media platforms earn revenues from selling advertising space and potentially charging viewers. On the product market, two producers (or advertisers) $i = A, B$ are competing for consumers by advertising their products on either or both of the platforms. Each market is modeled via a Hotelling unit line where platforms and producers are differentiated maximally (Hotelling, 1929). Platforms are competing for both advertisers and a unit mass of homogeneous consumers. Consumers are uniformly located between 0 and 1 on both markets. Preferences for platforms are distributed independently from those for producers.

2.3.1 Media market

Each consumer can decide whether she wants to allocate all her time to one of the platforms or divide it between them, i.e., she can mix (Anderson and Neven, 1989). The distance of a consumer on the media market to platform 0 is denoted by x and the time a consumer at location x allocates to platform 0 is designated by $\lambda(x)$. In turn, with total time normalized to one, $1 - \lambda(x)$ is the time a consumer at location x allocates to platform 1.

A consumer of type x who allocates her time to both platforms derives a net utility of $v_m - t_m[1 - \lambda(x) - x]^2 - s_0 - s_1$. The closer a consumer's allocation of time to her preferred program mix, reflected by her type x, the smaller the disutility she incurs. A consumer who chooses a mix of programs which perfectly matches

[3] The model is described in a television context, but it also applies to other media outlets, like the Internet, radio, or magazines.

her preferences derives utility v_m and does not incur any disutility. We assume that viewers' disutility from not consuming their preferred programming content is quadratic, where t_m denotes the disutility parameter which measures the degree of differentiation between the two platforms. Platforms charge a subscription fee $s_j \geq 0$ to consumers.

2.3.2 Advertisers and advertising technology

In our model, advertising is informative (Grossman and Shapiro, 1984). Producers can inform consumers about their product by sending advertising messages φ_i^j via each of the platforms. The probability that a given producer informs a consumer on a given platform, i.e., the outreach probability, is $G(\varphi_i^j)$. It increases in the number of advertisements at a decreasing rate such that $G(0) = 0$, $G'(\cdot) > 0$, and $G''(\cdot) < 0$.[4] The higher the number of advertising messages, the better the chances that a consumer will make a purchase on the product market. Furthermore, to ensure that producers choose positive levels of advertising and that its net marginal contribution is positive, we define

$$T(\varphi) \equiv \frac{G'(\varphi)}{G(\varphi)} - \frac{1}{2\varphi}, \tag{2.1}$$

where $T(\varphi) > 0$ and $T'(\varphi) < 0$.

Consumers buy at most one unit of the product. A consumer who has only seen the advertisement of one of the producers will buy the advertised product, unaware of the competing producer's offer and regardless of her location.[5] A consumer who has not seen any advertisements refrains from making a purchase on the product market. Consumers who have seen advertising messages from both producers can decide whether to buy from producer A or producer B.[6]

The distance of a consumer to producer A is denoted by y. A consumer located at y derives a net utility of $v_p - t_p y^2 - p_A$ when purchasing the product of producer A and $v_p - t_p(1-y)^2 - p_B$ when purchasing from producer B, where t_p is the differentiation parameter for the product market. The price charged by producer i is denoted by p_i.

[4] These assumptions are sufficient to guarantee the existence of an interior solution to the producers' maximization problem in section 2.4.2. A proof can be found in Gal-Or and Dukes (2003, p. 317-318).

[5] We assume that the product market is fully covered, i.e., a consumer will always make a purchase as long as she knows about at least one of the products.

[6] We assume that mixing is not possible on the product market.

2.3.3 Consumer demand

Given the advertisements φ_i^j on either of the platforms by the producers and the subscription fees s_0 and s_1, a consumer with preferences of x derives the following utility from consuming media products:

$$U(x) = v_m - t_m\Big\{1-\lambda(x)-x\Big\}^2 - \gamma\Big\{\lambda(x)\Big(\varphi_A^0+\varphi_B^0\Big)+[1-\lambda(x)]\Big(\varphi_A^1+\varphi_B^1\Big)\Big\} - s_0 - s_1, \tag{2.2}$$

where $\gamma > 0$ is a nuisance parameter which captures consumers' dislike for commercial interruptions. On the media market, consumers can choose their favorite programming mix but still incur a utility loss due to advertisements. The disutility parameter from not consuming the ideal media content is t_m.

Consumers decide on the optimal amount of time they want to spend on platform 0 by maximizing (2.2) with respect to $\lambda(x)$. This results in the allocation rule and platforms' market shares summarized in Lemma 2.1.[7]

Lemma 2.1. *Viewers allocate their time according to the following rule:*

$$\lambda(x) = \begin{cases} 1 & \text{if } x \leq \sqrt{\frac{s_1}{t_m}} - R, \\ 1-x-R & \text{if } \sqrt{\frac{s_1}{t_m}} - R < x \leq 1 - \sqrt{\frac{s_0}{t_m}} - R, \\ 0 & \text{otherwise}, \end{cases} \tag{2.3}$$

where $R \equiv \frac{\gamma[(\varphi_A^0+\varphi_B^0)-(\varphi_A^1+\varphi_B^1)]}{2t_m}$.
As long as advertising levels and subscription fees do not differ too much between platforms, this allocation rule results in the following market shares for each of the outlets:[8]

$$X^0 = \frac{1}{2} - R - \frac{(s_0-s_1)}{2t_m} \quad \text{and} \quad X^1 = \frac{1}{2} + R + \frac{(s_0-s_1)}{2t_m}. \tag{2.4}$$

Consumers with less extreme preferences, i.e., those located between $\sqrt{\frac{s_1}{t_m}} - R$ and $1 - \sqrt{\frac{s_0}{t_m}} - R$ are subscribers to both platforms. Within this interval, consumers who are located closer to platform 0, spend most of their time viewing platform 0 but less so with increasing proximity to platform 1. Those consumers with a very strong preference for one of the two media platforms, i.e., consumers located

[7]The proof of this lemma, as well as of all other lemmas and propositions is included in Appendix B.

[8]The restriction concerning advertising levels and subscription fees does not affect our results as throughout the paper we focus on those cases in which producers and platforms behave symmetrically.

outside the interval, prefer to subscribe exclusively to the platform closest to them. An increase in the subscription fee by one of the platforms causes a shift in viewer shares. The number of exclusive subscribers to the rival outlet increases while the total amount of consumers mixing between the two outlets declines. By the same token, an increase in the advertising intensity by one platform increases the market share of its competitor. Contrary to higher subscription fees, this increase is only driven by a shift in exclusive subscribers. The amount of viewers that mix between both outlets remains unchanged.

The optimal viewing time $\lambda(x)$ a consumer allocates to platform 0 determines how likely she is to be informed by each producer's advertisement. The probability that producer i informs a consumer about his product when advertising it on both platforms is $\lambda(x)G(\varphi_i^0) + (1-\lambda(x))G(\varphi_i^1)$. The expected share of consumers a producer reaches via messages on both platforms is $X^0G(\varphi_i^0) + X^1G(\varphi_i^1)$. Now we can define the demand for producer i's product, i.e., the probability that a viewer is not only aware of but also purchases i's product:

$$D_i^j = \left[\left[1 - G(\varphi_k^j)\right] + G(\varphi_k^j)\left(\frac{1}{2} + \frac{p_k - p_i}{2t_p}\right)\right]G(\varphi_i^j), \qquad i \neq k;\; i = A, B. \quad (2.5)$$

A consumer who only sees producer i's advertisement but not his rival's advertisement will purchase his product for sure. A consumer's purchase decision after having seen both advertisements depends on product prices and her type. The expected market share on a given platform for producer i is then the probability D_i^j that a consumer purchases from i multiplied with the share of consumers X^j the platform entertains. This results in the following total market share for producer i: $MS_i = X^0D_i^0 + X^1D_i^1$.

2.3.4 Payoffs and bargaining

The payment for advertising is a linear function of the number of advertising messages, assuming that platforms and producers cannot engage in long-term contracting. If producer i chooses to advertise amount φ_i^j on platform j, his payment to the platform is $a_i^j\varphi_i^j$, where a_i^j is the rate paid per advertising message. Payments are determined in pairwise negotiations between platforms and producers which are modeled using the Nash bargaining solution.[9][10] The bargaining process between each platform-producer pair happens simultaneously and neither one can observe

[9] In many media markets negotiations over advertising rates seem to be common. See, for instance, the discussion in Dukes and Gal-Or (2003), the OFCOM (PWC) report, or Lotz (2007) for the US television market.

[10] If platforms and producers bargain over both the advertising rate and the number of advertising messages the equilibrium results change in size, not in direction.

the outcome of their competitors negotiations before signing the advertising agreement. The bargaining process is modeled à la Nash and the gains from an agreement are split equally among the two negotiating parties.[11] Here, the gain from a successful negotiation is defined as the sum of the differences between each parties' agreement and disagreement payoffs. After successful negotiations, half of this gain will then go to the platform, the other half to the producer.

A platform's payoff Π_j is equal to its revenue from selling advertising space to producers and subscriptions to consumers less a fixed operating cost of f. For the main part of our analysis we will assume that fixed costs are the same in both business models.[12] The profit of platform j is therefore

$$\Pi_j = a_A^j \varphi_A^j + a_B^j \varphi_B^j + R_j s_j - f, \qquad j = 0, 1, \tag{2.6}$$

where $R_0 \equiv 1 - \sqrt{\frac{s_0}{t_m}} - R$ and $R_1 \equiv 1 - \sqrt{\frac{s_1}{t_m}} + R$, and R_j denotes the share of subscribers to platform j.

For production each producer incurs a fixed cost of k and a variable cost of c. A producer's payoff π_i then consists of the profit made from selling his product to consumers less the cost for advertising. A producer's payoff is

$$\pi_i = (p_i - c)(X^0 D_i^0 + X^1 D_i^1) - (a_i^0 \varphi_i^0 + a_i^1 \varphi_i^1) - k, \qquad i = A, B. \tag{2.7}$$

To determine the gains from an agreement, the payoffs in case of disagreement need to be specified. As we focus on equilibria where both producers advertise on both platforms, disagreement in this model implies that if negotiations between one platform-producer pair break down the same platform still comes to an agreement with the respective other producer and the producer still comes to an agreement with the respective other platform. Disagreement payoffs are:

$$\begin{aligned} \Pi_j^{-i} &= a_l^j \varphi_l^j + \left(R_j + \frac{\gamma \varphi_i^j}{2t_m}\right) s_j - f, \\ \pi_i^{-j} &= \tilde{X}^r D_i^r (p_i - c) - a_i^r \varphi_i^r - k, \qquad i \neq l;\ j \neq r;\ j = 0,1;\ i = A, B, \end{aligned} \tag{2.8}$$

where $\tilde{X}^r = \frac{1}{2} - \frac{\gamma(\varphi_A^r + \varphi_B^r - \varphi_l^j)}{2t_m} - \frac{s_1 - s_0}{2t_m}$. The effect of a disagreement between one platform-producer pair on the platform's payoffs is twofold. On the one hand, the payoff is reduced as advertising income now consists of payments by only one pro-

[11] The model can straightforwardly extended to asymmetric Nash bargaining where the bargaining power of the parties differs. We discuss this in Section 2.5.

[12] In Section 2.5 we will discuss the case when operational fixed costs are higher with pay-tv than with free-to-air. This may arise, for instance, due to additional costs of setting up a pay-wall and collecting subscription fees.

ducer. On the other hand, the platform's program now features fewer commercials as compared to its rival. This, in turn, attracts more consumers and subscription revenues increase. For producers, disagreeing with one of the platforms results in lower advertising costs and fewer product sales. The latter is a direct consequence of the change in platform market shares and a lower outreach probability. The platform with which bargaining was successful loses viewers to its rival who only shows commercials by one of the producers. As a result, commercials by the disagreeing producer reach fewer consumers.

2.3.5 Timing

The game consists of two stages. In the first stage payment negotiations between platforms and producers take place, producers choose the optimal amount of advertising messages to be broadcasted on each platform and decide on product prices. Advertising rates and advertising intensities are determined simultaneously. This implies that all negotiations take place at the same time and producers cannot observe the bargaining outcome of their rival. The same holds true for platforms. In the second stage consumers choose how much time to devote to either platform and make a purchase on the product market, contingent on their information on the products available.

2.3.6 Free-to-air

Here, we briefly review the results of Gal-Or and Dukes (2003), i.e., the results under the assumption that there is competition between two free-to-air platforms. In section 2.4.3 we will then compare those results to the ones with pay-tv competition.[13]

Under free-to-air each platform has only one source of income, namely advertising revenues, and contents of the media channels are provided to consumers for free. In the model setup presented in the previous sections this is the case when $s_j = 0$. In the model this results in the following symmetric equilibrium outcomes:[14]

Advertising quantities in equilibrium are

$$\varphi_F^* = T^{-1}\left(\frac{\gamma}{2t_m}\right). \tag{2.9}$$

[13]A derivation of the equilibrium results can be found Appendix A.
[14]The equilibrium results under free-to-air are indexed by "F".

Equilibrium product prices are

$$p_F^* - c = \frac{t_p[2 - G(\varphi_F^*)]}{G(\varphi_F^*)}. \tag{2.10}$$

This results in the following payoffs for both platforms and producers in the symmetric equilibrium:

$$\begin{aligned} \Pi_F^* &= \frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 + \frac{\gamma\varphi_F^*}{t_m}\right) - f, \\ \pi_F^* &= \frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 - \frac{\gamma\varphi_F^*}{t_m}\right) - k. \end{aligned} \tag{2.11}$$

Note that in the symmetric equilibrium all consumers are mixing, that is, they are able to choose a combination of programs which exactly satisfies their tastes. Formally, this means that in equilibrium $R^* = 0$. As a result, no consumer incurs any disutility cost from consuming media products and a consumer's utility located at x is: $U(x) = v_m - \gamma\{(1 - x)(\varphi_A^0 + \varphi_B^0) + x(\varphi_A^1 + \varphi_B^1)\}$. As compared to a case where only some consumers mix or consumers do not mix at all between platforms, viewers are better off because none of them have to bear disutility costs.

2.4 Pay-TV

In this section we analyze the equilibrium under competition between two pay-tv platforms and compare the results to those under free-to-air competition. With pay-tv, platforms have two sources of income instead of one: the revenues from selling advertising space to producers and revenues from selling subscriptions to consumers. Here, this implies that $s_j > 0$.

2.4.1 Consumer demand in the symmetric equilibrium

One result from Gal-Or and Dukes (2003) is that when platforms solely finance themselves though advertising revenues all consumers mix. Viewers then choose the optimal mix of programs and do not incur any transportation costs. With pay-tv competition this is not the case.

Proposition 2.1. *In the symmetric equilibrium, no mixing by consumers occurs.*

Proposition 2.1 says that every consumer will subscribe to exactly one platform. Pay-tv increases the cost of watching a program for every consumer and as a result consumers prefer to subscribe to only one of the platforms instead of subscribing twice but viewing their favorite programming mix. The market share of platform 0, when each consumer only subscribes to one platform, is $X^0 = \frac{1}{2} - R - \frac{s_0 - s_1}{2t_m}$, where R is as specified in Lemma 2.1. The market share of platform 1 is $X^1 = 1 - X^0$. Based on these market shares platforms have the following payoffs in case of agreement and disagreement:[15]

$$\begin{aligned} \Pi_j &= a_A^j \varphi_A^j + a_B^j \varphi_B^j + X^j s_j - f, \\ \Pi_j^{-i} &= a_l^j \varphi_l^j + \left(X^j + \frac{\gamma \varphi_i^j}{2t_m} \right) s_j - f, \qquad j = 0, 1;\ \ i \neq l. \end{aligned} \tag{2.12}$$

As compared to the case where platforms' only income are advertising revenues, i.e., when $s_j = 0$, their disagreement payoffs increase. This is due to the additional source of income of the platforms. In case of disagreement with one of the producers a platform now loses advertising revenue but still has an income from selling subscriptions to consumers. This income even increases as a direct result of the disagreement. Disagreement leads to fewer advertisements on the platform and consequently attracts a higher number of subscribers. This mechanism affects the bargaining outcome. The Nash bargaining solution with pay-tv is

$$a_i^j \varphi_i^j = \frac{p_i - c}{2} \left(X^j D_i^j + \frac{\gamma \varphi_i^j D_i^r}{2t_m} \right) + s_j \frac{\gamma \varphi_i^j}{4t_m}. \tag{2.13}$$

The bargaining solution consists of the split profits from the sales on the product market and the premium paid to the platforms to compensate for the foregone viewers. The term $s_j \frac{\gamma \varphi_i^j}{4t_m}$ is an additional premium paid as a result of the forgone subscription revenues. In presence of subscription fees the disagreement between a platform and producer pair and consequently more viewers not only result in higher product market profits but also higher subscription revenues. This is taken into account during the bargaining process and thus increases the advertising payments. As subscription fees increase, so does the additional premium producers have to pay to platforms. In other words, by raising the subscription fee media platforms can improve their bargaining position vis-à-vis the advertisers. This is summarized by the following proposition:

[15] Also in case of disagreement among a platform-producer pair consumers have no incentive to mix between platforms.

Proposition 2.2. *On a pay-tv market, media platforms have higher disagreement payoffs than on a free-to-air market. This improves their bargaining position towards advertisers and results in higher advertising prices.*

In the related literature media outlets typically benefit from pay-tv competition because of a redistribution of rents between platforms and consumers (see e.g., Hoernig and Valletti, 2007). Mixing by viewers increases the surplus available to them on the media market, since the disutility from not consuming the preferred content is reduced. Platforms capture part of this surplus by raising subscription fees. This redistribution also takes place in our model but in addition there is a redistribution from producers to platforms. This is not driven by the change in consumers' mixing behavior as is typically the case in related models of two-sided markets (see e.g., Armstrong, 2006). Here, producers still have an incentive to advertise on both platforms, even when all consumers are mixing. The reason for this is that even though consumers are active on both platforms a consumer closer to platform 0 will spend more time on this platform than a consumer located closer to platform 1. The more time each consumer spends on a given platform, the higher the probability that she will see an advertisement and thus the likelihood of informing a consumer is higher when advertising on both platforms. As a result platforms' monopoly power is not affected by the business model. In comparison, in this model, the effect of a switch in business model on rents is owed to the way advertising prices are determined, namely via a bargaining process. As stated in Proposition 2.2 the subscription fee affects the platforms' bargaining position and by this has a direct impact on advertising rates. The additional source of income helps platforms to extract rents from producers via the bargaining process. This, in turn, influences the producers' decisions on advertising intensities and thereby affects competition and prices charged on the product market. The effect is more prominent when consumers' disutility from commercial interruptions is high and when the transportation cost parameter in the media market is small. A switch from free-to-air to pay-tv competition then not only allows platforms to capture a part of their viewers' surplus but it also increases producer rents and advertising rates, as will be elaborated in more detail on the following pages. To our knowledge this effect has not been analyzed in the previous literature.

2.4.2 The symmetric equilibrium

Producers maximize their payoffs with respect to prices and the advertising intensity, while taking the advertising rate as given. At the same time negotiations take place resulting in (2.13) and platforms maximize their payoffs with respect to the subscription fee s_j. The price each platform charges to consumers is given by:

$$s_j = t_m - \frac{\gamma((\varphi_A^j + \varphi_B^j) - (\varphi_A^r + \varphi_B^r))}{3}. \tag{2.14}$$

With asymmetric advertising intensities, the platform broadcasting more commercials charges a lower subscription fee. If advertising on platforms is symmetric, both will charge the same amount to consumers.

Producers face the following maximization problem in the symmetric equilibrium under pay-tv competition:

Lemma 2.2. *The following first-order conditions characterize producers' choices of advertising intensity and product prices in the symmetric equilibrium:*

$$\begin{aligned} \frac{\partial \pi_i}{\partial \varphi_i^j}\bigg|_{Sym} &= (p-c)\left(X^j D^j T(\varphi^j) - \frac{\gamma(2D^j - D^r)}{4t_m}\right) - \frac{\gamma s_j}{4t_m} = 0, \\ \frac{\partial \pi_i}{\partial p_i}\bigg|_{Sym} &= (X^j D^j + X^r D^r) - (p-c)\left(X^j \frac{G(\varphi^j)^2}{2t_p} + X^r \frac{G(\varphi^r)^2}{2t_p}\right) = 0, \end{aligned} \tag{2.15}$$

where $X^0 \equiv \frac{1}{2} - \frac{\gamma(2\varphi^0 - 2\varphi^1)}{2t_m} - \frac{s_0 - s_1}{2t_m}$, $X^1 \equiv 1 - X^0$ *and* $D^j \equiv D_A^j = D_B^j = \frac{1}{2}\Big[2 - G(\varphi^j)\Big]G(\varphi^j)$.

Proposition 2.3 characterizes the symmetric equilibrium results for the case of pay-tv competition. All equilibrium results referring to pay-tv are denoted by "P".

Proposition 2.3. *In the symmetric equilibrium producers choose identical amounts of advertising and identical product prices. The amount of advertising messages by a producer broadcasted via each of the platforms is*

$$\varphi_P^* = T^{-1}\left(\frac{\gamma}{2t_m} + \frac{\gamma}{t_p(2 - G(\varphi_P^*))^2}\right). \tag{2.16}$$

Equilibrium product prices are

$$p_P^* - c = \frac{t_p(2 - G(\varphi_P^*))}{G(\varphi_P^*)}. \tag{2.17}$$

Platforms charge the same subscription fee to consumers in equilibrium,

$$s^* = t_m. \tag{2.18}$$

This results in the following payoffs for both platforms and producers in the symmetric equilibrium:

$$\Pi_P^* = \frac{t_p[2 - G(\varphi_P^*)]^2}{4}\left(1 + \frac{\gamma\varphi_P^*}{t_m}\right) + \frac{\gamma\varphi_P^*}{2} + \frac{t_m}{2} - f,$$
$$\pi_P^* = \frac{t_p[2 - G(\varphi_P^*)]^2}{4}\left(1 - \frac{\gamma\varphi_P^*}{t_m}\right) - \frac{\gamma\varphi_P^*}{2} - k. \tag{2.19}$$

Charging a subscription fee affects the platforms' profit functions in two ways: First, the platform has an additional source of income and the revenues from selling subscriptions are represented by the term $\frac{t_m}{2}$ in the platforms' equilibrium profit function. Second, disagreement with one of the producers not only increases profits on the product market which are then split in the bargaining process but also increases subscription sales. As a result, producers now have to pay an additional premium to compensate for the foregone subscription revenues. This is represented by the term $\frac{\gamma\varphi_P^*}{2}$ which constitutes a transfer from producers to platforms.

A lower advertising intensity in equilibrium has a negative impact on both premiums as fewer consumers are to be gained in case of disagreement between a platform-producer pair. At the same time fewer advertisements increase prices on the product market but have no impact on the subscription fee in equilibrium.

A change in the exogenous parameters of the model has similar effects. A higher product differentiation on the media market increases the equilibrium advertising intensity and product prices fall while the subscription fee increases. For platforms this means higher subscription revenues but lower premiums paid by producers and lower overall producer revenues as a result of increased competition. A higher differentiation on the product market increases the equilibrium advertising intensity but has an ambiguous effect on equilibrium profits and prices. In contrast, a higher dislike for commercial interruptions leads to lower levels of advertising and higher product prices. The impact on platform profits is ambiguous as there are two opposing effects on the premiums paid to platforms. On the one hand, premiums increase as more consumers will shift in case of disagreement due to the increased dislike for commercial breaks. On the other hand, as equilibrium advertising levels decrease, fewer consumers can be gained by disagreeing with a producer. The effects of changes in parameters on prices and advertising levels are summarized in the following lemma:

Lemma 2.3. *In the equilibrium with pay-tv, i) a larger utility loss from not consuming the preferred content mix results in more advertisements, lower product prices and higher subscription fees; ii) more differentiation on the product market leads to* *more advertisements but has opposing effects on product prices; iii) a higher disutility from commercial breaks reduces advertising levels but increases product prices.*

2.4.3 Comparison with free-to-air

We are now able to compare the equilibrium results with pay-tv competition to the ones with free-to-air competition. Advertising intensities in equilibrium are higher with free-to-air competition. This result is intuitive, since platforms' improved bargaining power with pay-tv competition leads to higher advertising rates and therefore producers choose to advertise less in equilibrium, i.e., $\varphi_F^* > \varphi_P^*$. Furthermore, we can conclude that since there are fewer commercials with pay-tv competition prices charged to consumers on the product market are higher as compared to free-to-air competition, such that $p_F^* < p_P^*$. This can be explained by the following mechanism: fewer advertisements result in fewer informed consumers and consequently higher prices on the product market due to alleviated competition.

These changes in advertising prices and levels have an impact on payoffs of platforms and producers. Intuitively, platforms' profits should increase when switching from free-to-air to pay-tv competition as a result of higher bargaining power and the additional source of income. It is easy to see that this is also the case here, as producers have to pay an additional premium and platforms now collect subscription revenues. Yet, there are two opposing effects of a lower advertising intensity on profits. On the one hand, platform profits further increase because higher product prices lead to higher producer profits which are then split in the bargaining process. On the other hand, platform profits decrease because the premium paid by producers to compensate for foregone profits on the product market is lower.[16]

The change from free-to-air to pay-tv competition also has two implications for producer profits. As with platforms, profits increase due to higher profit margins and a partly lower premium. Profits also decline because of the increased bargaining power of platforms and the resulting increased advertising rates, i.e., the additional premium. Which effect dominates depends on how big the effect of a reduction in advertisements is on the outreach probability. This will determine how much the product price and therefore also producer revenues will increase after a switch to pay-tv. If changes in the advertising intensity have a large effect on viewer product awareness, producers can benefit from a switch to pay-tv, despite the additional premium they have to pay. To illustrate this point, Figure 2.1 shows producer profits in the symmetric equilibrium as the differentiation parameter for the product market

[16] The assumption we made towards the elasticity of the outreach probability guarantees that the positive effect of a lower advertising intensity outweighs the negative one, i.e., as long as the elasticity of $G(\varphi)$ is non-increasing, $\Pi_P^* > \Pi_F^*$. The same proof used by Gal-Or and Dukes (2003) applies here, details are included in the Appendix as part of the proof of Proposition 2.4.

increases, with two different examples of outreach probability functions, namely $G(\varphi) = (\varphi)^\eta$ and $G(\varphi) = (\varphi)^2 e^{-\varphi}$.[17]

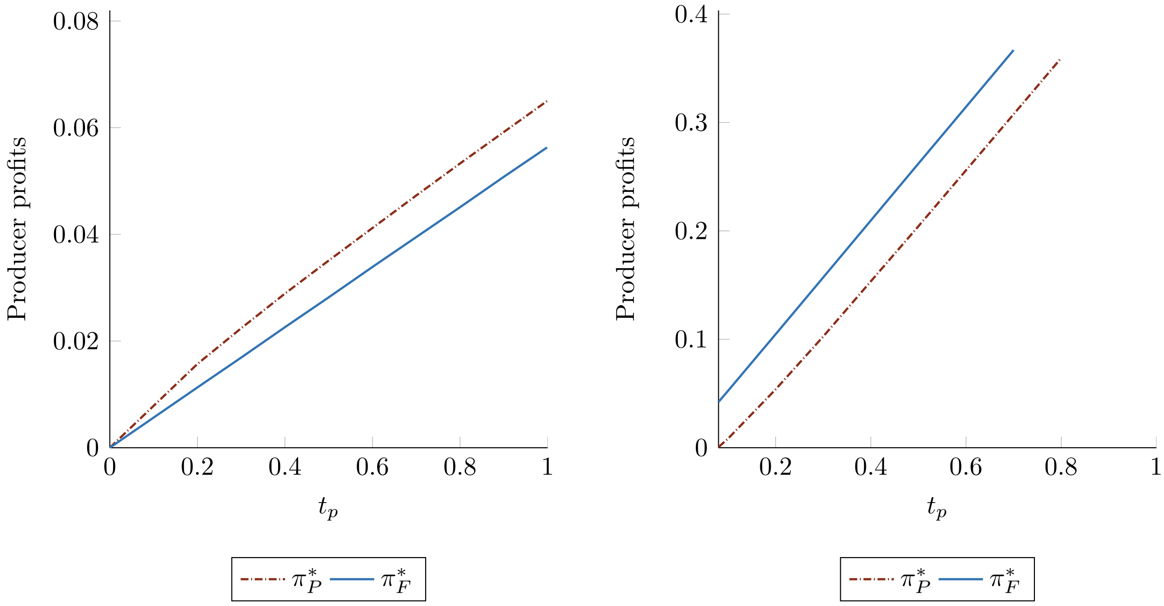

Figure 2.1: Equilibrium producer profits with different outreach probability functions: $G(\varphi) = \varphi^\eta$ (*left*) and $G(\varphi) = \varphi^2 e^{-\varphi}$ (*right*)

In both graphs equilibrium producer profits increase with the degree of differentiation on the product market. However, with $G(\varphi) = \varphi^\eta$ producer profits are higher with pay-tv for all values of t_p, while with $G(\varphi) = \varphi^2 e^{-\varphi}$ producer profits are always higher with free-to-air competition. In fact, for very low degrees of differentiation it would not be profitable for advertisers to stay in the market with pay-tv under this parametrization. Consequently, the effect of a change in business model by the platforms on producer profits remains ambiguous.

We summarize the comparison of free-to-air and pay-tv in the following proposition:

Proposition 2.4. *Compared to free-to-air, with pay-tv, i) the advertising volume is lower and advertising rates are higher; ii) producer prices are higher; iii) platform profits are higher; iv) producer profits may be higher or lower.*

[17] Both functions, also used in Gal-Or and Dukes (2003), satisfy the assumptions made with respect to $G(\varphi)$ as long as $\frac{1}{2} < \eta < 1$ in the first function and $\varphi < \frac{3}{2}$ in the second function. All exogenous parameters were chosen such that $G(\varphi_F^*)$ is close to 0.5. The right graph is only shown for $t_p \geq 0.08$ as for all values smaller 0.08 producers have no incentive to participate in the market with pay-tv competition.

2.4.4 Consumer surplus and total welfare

In the symmetric equilibrium consumers derive utility from both the product and the media market. With free-to-air competition all consumers are able to choose their favorite programming mix and only have to bear the cost of commercial interruptions. With pay-tv none of the consumers mixes and they have to pay a subscription fee to the platforms. However, in the latter case there are also fewer advertisements. Consumer surplus in the symmetric equilibrium under the two different pricing schemes is

$$\begin{aligned} CS_F^* &= (v_m - \gamma\varphi_F^*) + Z(\varphi_F^*), \\ CS_P^* &= \left(v_m - \gamma\varphi_P^* - \frac{13}{12}t_m\right) + Z(\varphi_P^*), \end{aligned} \tag{2.20}$$

where $Z(\varphi_n^*) \equiv G(\varphi_n^*)\left[2\left(v_p - \frac{1}{3}t_p - p_n^*\right) - G(\varphi_n^*)\left(v_p - \frac{7}{12}t_p - p_n^*\right)\right]$ and $n = F, P$. The first, bracketed part of both equations in (2.20) is the utility consumers derive from the media market. $Z(\varphi_n^*)$ represents the utility they obtain on the product market. The comparison of consumer surplus in (2.20) shows that viewers will always fare worse on the product market when platforms switch from free-to-air to pay-tv competition. Product prices increase and fewer advertisements imply less informed consumers and therefore more consumers that incur high transportation costs or even abstain from making a purchase altogether. On the media market, however, consumers benefit from lower levels of advertising, but still have to pay a subscription fee and consume programming content that does not entirely satisfy their tastes. The term $\frac{13}{12}t_m$, which only appears in the consumer surplus with pay-tv, contains both the subscription fee and the total transportation cost for consumers and decreases consumer surplus. The extra utility received from fewer commercial interruptions cannot compensate for the utility loss from the subscription fees, increased disutility on the media market and the lower utility derived on the product market. Hence, consumers are always better off with free-to-air competition.

As we will see now, in our model welfare need not be decreasing when switching to pay-tv. Total welfare is the sum of producer and platform profits and consumer surplus:

$$\begin{aligned} W_F^* &= t_p[2 - G(\varphi_F^*)]^2 - 2(f+k) + v_m - \gamma\varphi_F^* + Z(\varphi_F^*), \\ W_P^* &= t_p[2 - G(\varphi_P^*)]^2 - 2(f+k) + v_m - \gamma\varphi_P^* - \frac{1}{12}t_m + Z(\varphi_P^*). \end{aligned} \tag{2.21}$$

Subscription fees only play an indirect role when comparing total welfare under the two forms of competition as they merely constitute a redistribution from consumers to platforms. However, subscription fees affect the mixing behavior of consumers and thereby also their utilities. There are three factors determining the welfare effects. Welfare in case of free-to-air competition tends to be higher due to a larger extent of consumer mixing and a higher coverage of the product market. However, a larger amount of advertising messages tends to reduce welfare with this form of competition. It is unclear which effect dominates but we can derive certain conditions, under which welfare with free-to-air competition is higher than with pay-tv. For example, this is the case when the free-to-air equilibrium advertising intensity is low and the cost of transport on the product market is neither too high nor too low. When looking at explicit functions for the outreach probability, the case is clear. Figure 2.2 shows that for the same functions and parameter values as in Figure 2.1 total welfare with free-to-air competition is always higher for $t_p \in [0, 1]$. This is the result of a substantially higher consumer surplus with free-to-air.

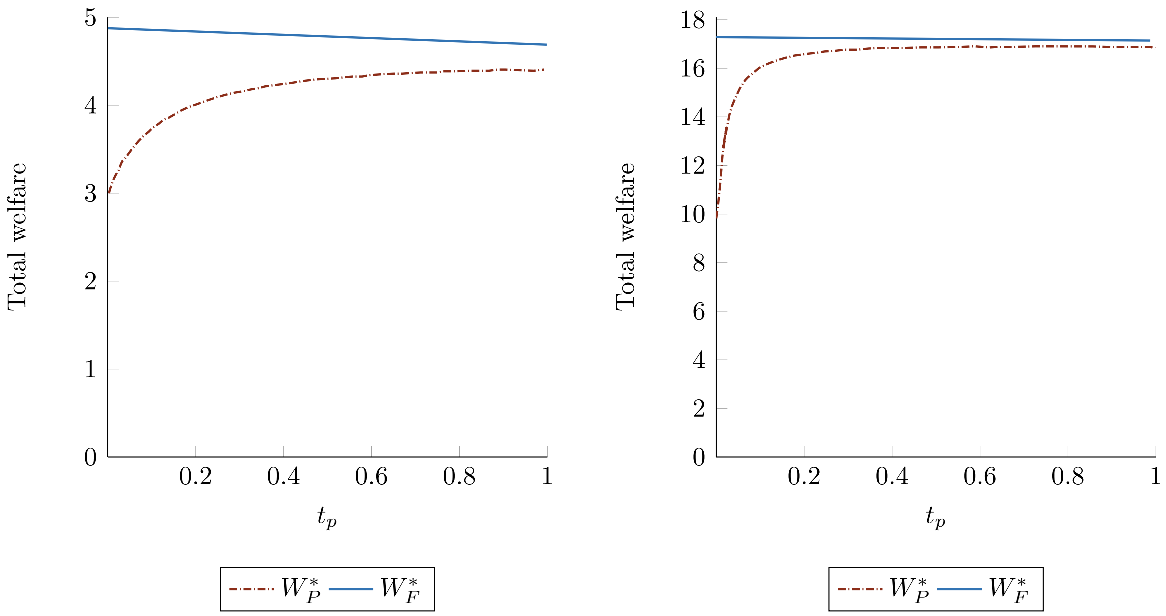

Figure 2.2: Total welfare in equilibrium with different outreach probability functions: $G(\varphi) = \varphi^\eta$ (*left*) and $G(\varphi) = \varphi^2 e^{-\varphi}$ (*right*)

Furthermore, with pay-tv, in both cases, equilibrium welfare increases with higher differentiation on the product market. This effect is reversed with free-to-air competition. Moreover, an increase in the nuisance parameter increases welfare on the media market but decreases welfare on the product market. If viewers are not at all bothered by commercial interruptions (i.e., $\gamma = 0$), advertisement levels in the symmetric equilibrium are the same under both business models and total welfare with free-to-air is higher than with pay-tv. In Proposition 2.5 the effects of the form of competition on consumer surplus and total welfare are summarized.

Proposition 2.5. *Compared to free-to-air, with pay-tv, i) consumer surplus is lower; ii) total welfare may be higher or lower.*

Table 2.1 contains a summary of our results and an overview of the comparison to the results of Gal-Or and Dukes (2003):

Competition	Mixing	Consumers	Platforms	Producers	Welfare
Free-to-air	[0,1]	CS_F^*	Π_F^*	π_F^*	W_F^*
	$\vee$	$\vee$	$\wedge$	$\vee\wedge$	$\vee\wedge$
Pay-tv	$\emptyset$	CS_P^*	Π_P^*	π_P^*	W_P^*

Table 2.1: Equilibrium results with free-to-air and pay-tv competition

Platforms prefer pay-tv over free-to-air competition, while consumers are better off with free-to-air. This is also due to the result that there are no mixing incentives with pay-tv competition whereas with free-to-air all consumers mix. Finally, advertisers have ambiguous preferences in our model and the effect of the form of competition on total welfare is not clear.

2.5 Platform structure and profitability

In this section we elaborate on the implications of business model choice for platform profits. We consider the joint incentives to adopt pay-tv when pay-tv leads to higher operational fixed costs. We also consider the effects when platforms and producers differ in their bargaining power.

Business model and profit implications

In Proposition 2.4 we have established that platforms are always better off with pay-tv. This result hinges on the assumption that fixed costs for operation are the same under both regimes. Especially when looking at the tv sector, however, operational fixed cost are higher when a pay-tv business model is employed as additional costs arise from collecting fees and signing up subscribers. Hence, it may be more reasonable to assume that $f_P > f_F$, where f_P and f_F are the platforms' fixed cost of operation with pay-tv and free-to-air. Under this assumption, choosing pay-tv may now be more or less profitable for platforms under varying sets of exogenous parameters and outreach probability functions. In this setting, we can interpret the difference in platform revenues $Rev_P^* - Rev_F^* \equiv \Delta^*$ as a measure of platforms' incentives to adopt pay-tv. The larger this revenue difference, the larger are the incentives of platforms to chose pay-tv and invest in higher fixed costs. We define $f_P - f_F \equiv \Delta_f$. Figure 2.3 shows the changes in the difference of platform equilibrium revenues Δ^* for increasing values of the differentiation parameters on the product and the media market under two different outreach probabilities:[18]

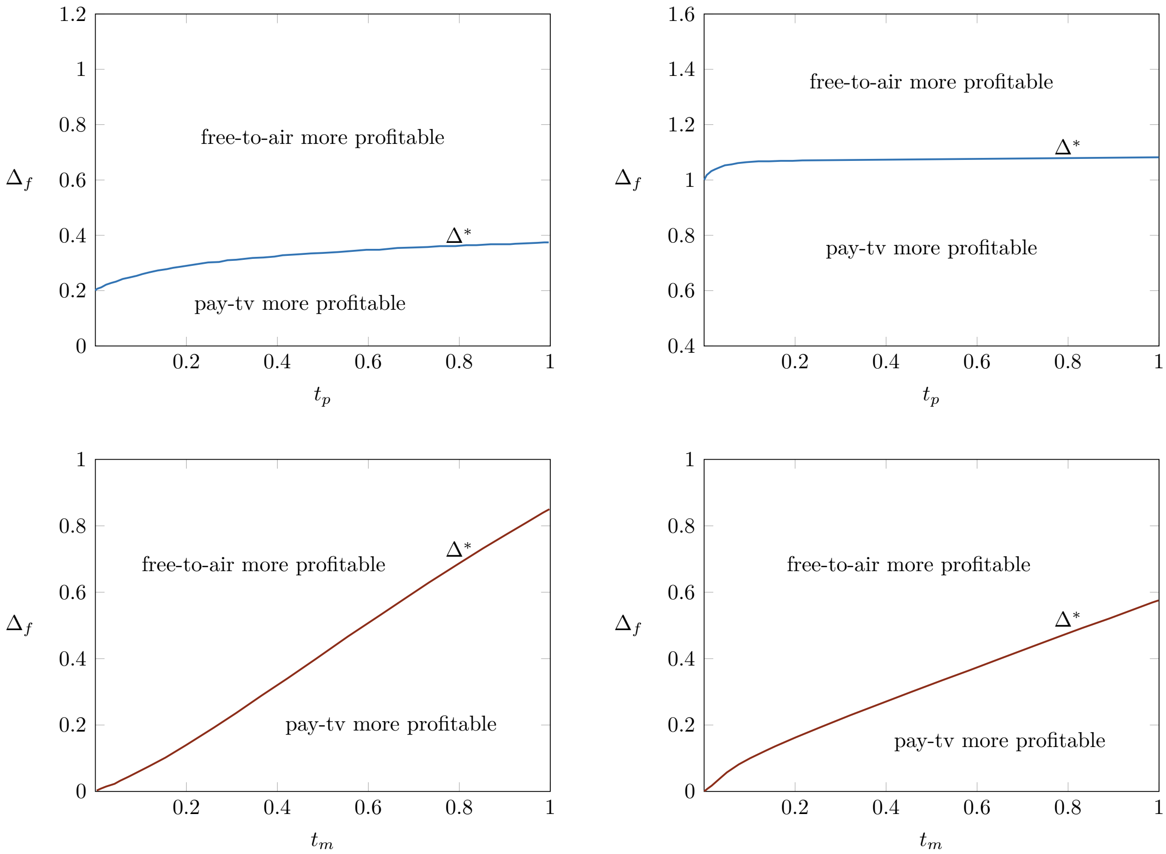

Figure 2.3: Differences in platform revenues when t_p or t_m is increasing for different outreach probability functions: $G(\varphi) = \varphi^\eta$ (*left*) and $G(\varphi) = \varphi^2 e^{-\varphi}$(*right*)

The figure shows that platforms favor pay-tv if the additional fixed costs are not too high. Moreover, it also shows that the revenue difference Δ^* is increasing in both differentiation parameters. While the difference in platform revenues is only slightly increasing as differentiation on the product market rises, it increases more visibly for a growing differentiation on the media market. That is, when the differentiation parameter on the media market is high, platform revenues with pay-tv are substantially higher than with free-to-air. Depending on the exact fixed cost, pay-tv is therefore more likely to be profitable when differentiation on the product

[18]Here, revenues Rev_P^* and Rev_F^* are as defined in equations (2.19) and (2.32), respectively.

market is high. By contrast, for very low values of the differentiation parameter t_m platforms may be better off not charging subscription fees.

Asymmetric bargaining power

Another parameter that could potentially affect the difference in platform profits in our model is the platforms' initial bargaining power. So far our analysis has focused on the case where the bargaining power is split equally between platforms and producers. Here, we discuss the effects of platform profitability when allowing for asymmetries in the bargaining power.

The equilibrium results with free-to-air and pay-tv with asymmetric bargaining are summarized in Proposition 2.6, where the bargaining power of platforms and producers is denoted by β and $1-\beta$, respectively:

Proposition 2.6. *When bargaining power is asymmetric the amount of advertising messages by a producer broadcasted via each of the platforms in the symmetric equilibrium with free-to-air and pay-tv is*

$$\begin{aligned} \varphi_F^{asy} &= T_{asy}^{-1}\left(\frac{\gamma\beta}{t_m}\right), \\ \varphi_P^{asy} &= T_{asy}^{-1}\left(\frac{\gamma\beta}{t_m} + \frac{2(1-\beta)\gamma}{t_p[2-G(\varphi_P^{asy})]^2}\right). \end{aligned} \tag{2.22}$$

This results in the following payoffs for platforms with free-to-air and pay-tv:

$$\begin{aligned} \Pi_F^{asy} &= \frac{\beta t_p[2-G(\varphi_F^{asy})]^2}{2}\left(1+\frac{\gamma\varphi_F^{asy}}{t_m}\right) - f_F, \\ \Pi_P^{asy} &= \frac{\beta t_p[2-G(\varphi_P^{asy})]^2}{2}\left(1+\frac{\gamma\varphi_P^{asy}}{t_m}\right) + (1-\beta)\gamma\varphi_P^{asy} + \frac{t_m}{2} - f_P. \end{aligned} \tag{2.23}$$

As long as producers have bargaining power, advertising intensities will still be lower with pay-tv than with free-to-air. This difference becomes smaller as the bargaining power of platforms increases. Advertising intensities are equal for the case that producers have no bargaining power at all, i.e., $\beta = 1$. At the same time a higher bargaining power decreases advertising levels with free-to-air but has an ambiguous effect on the equilibrium number of advertising messages with pay-tv.

Furthermore, with free-to-air, platform profits increase with a higher bargaining power. On the one hand, when platforms enjoy a higher initial bargaining power

β they can negotiate higher advertising prices. This, on the other hand, results in lower levels of advertising and hence higher platform profits. In case of pay-tv a higher initial bargaining power also increases negotiated advertising rates but at the same time lowers the premium producers pay to compensate platforms for forgone subscription revenues. As a result, the effect identified in Proposition 2.2 is stronger when platforms' initial bargaining power is low. That is, the mechanism that increases platforms' bargaining power when switching from free-to-air to pay-tv is stronger when the bargaining parameter β is small. A direct consequence of this is that platforms favor pay-tv as a business model whenever their initial bargaining power towards advertisers is low. This intuition is confirmed when taking a closer look at the differences in platform revenues as their bargaining power increases. Figure 2.4 reveals that the difference decreases as β increases for both exemplary outreach probability functions.

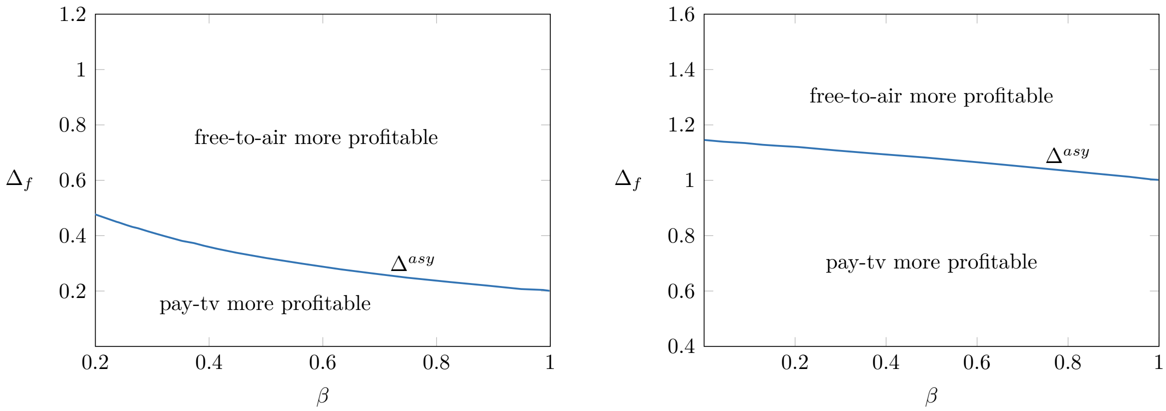

Figure 2.4: Differences in platform revenues when β is increasing for different outreach probability functions: $G(\varphi) = \varphi^{\eta}$ (*left*) and $G(\varphi) = \varphi^2 e^{-\varphi}$ (*right*)

In both examples above an increasing bargaining power is associated with a decreasing spread between platform revenues under the two different business models. As a result, under the assumption that the operational fixed costs with pay-tv are higher than with free-to-air, platforms are more likely to raise subscription fees in addition to showing advertisements when their bargaining power is low. An implication of this finding may be that if platform bargaining power decreases over time, for instance, due to strengthened retail concentration, platforms might react to this loss of bargaining power by switching to pay-tv.

Newer business models: pay-per-view

A fairly new form of financing for platforms is pay-per-view. This means instead of paying one subscription fee to the platform, consumers only pay for the content they use. This business model is especially widespread in the market for news. Only recently, some of the biggest publishers in the US have signed up to offer a pay-per-article service via a Dutch provider.[19] But pay-per-view has also become popular in the tv sector, in particular in combination with on-demand content. Prominent examples include the iTunes Video Store, Amazon Instant Video [20] and HBO PPV which offer streaming of movies, TV series and live sports events.

In our model this means that viewers only pay a fee proportional to the time they spend on a given platform. A viewer's utility from using both platforms is then

$$U(x) = v_m - t_m\Big\{1-\lambda(x)-x\Big\}^2 - \gamma\Big\{\lambda(x)\Big(\Big(\varphi_A^0+\varphi_B^0\Big)-q_0\Big)+[1-\lambda(x)]\Big(\Big(\varphi_A^1+\varphi_B^1\Big)-q_1\Big)\Big\}, \tag{2.24}$$

where q_j is the price per unit of time spent on each of the two platforms. The equilibrium analysis in this case remains almost unchanged and also equilibrium prices, advertising messages and profits are identical to the ones with pay-tv.[21] The reason for this is that while consumers now only pay for the time they actually spend on each of the platform, the impact of the payments on viewer shares is exactly the same. A higher pay-per-view-price of one of the platforms results in an increase of viewers for the competing platform. As a result, also the bargaining mechanism remains unaffected as compared to pay-tv and consequently profits for producers and platforms are unchanged.

However, the new form of financing does have an impact on the mixing-incentives of platform users. While with pay-tv, the subscription fee discourages viewers from allocating time to both of the platforms and in equilibrium viewers only subscribe to one of the platforms, with pay-per-view this is not the case. Here, all viewers mix in equilibrium. The reason for this is that the price each viewer has to pay is proportional to the time she spends on a platform. That is, viewers located very close to platform 0, who spend only little time on platform 1, still would have to pay the full subscription fee s_1 under pay-tv competition. With pay-per-view, however, platform 1 only charges a small price to them. As a result, all consumers view their preferred mix and bear no disutility costs, just in the case of free-to-air competition. This, in turn, leads to a higher consumer surplus on the media market than with pay-tv and consequently a higher total welfare, as producer and platform profits remain unchanged. This is shown in the following comparison of consumer surplus:

[19] see http://www.reuters.com/article/us-blendle-titles-idUSKBN0M81KL20150312.

[20] In addition Amazon uses a subscription based business model: members of Amazon Prime have unlimited access to a restricted number of movies.

[21] A detailed derivation of the equilibrium results with pay-per-view is included in Appendix B.

$$CS^*_{PPV} = (v_m - \gamma\varphi^*_P - t_m) + Z(\varphi^*_P),$$
$$CS^*_P = \left(v_m - \gamma\varphi^*_P - \frac{13}{12}t_m\right) + Z(\varphi^*_P), \tag{2.25}$$

where "PPV" refers to pay-per-view. Keeping in mind that the equilibrium number of advertising messages is the same under both business models and that consumer surplus on the product market remains unchanged, it is clear that $CS^*_{PPV} > CS^*_P$.

In summary it should be noted, that while a switch from free-to-air to pay-per-view holds the same benefits for platforms as a switch to pay-tv, consumers are better off with pay-per-view. Consequently, in terms of total welfare a switch from free-to-air to pay-per-view should be favored over a switch to pay-tv. However, free-to-air competition still produces the highest consumer surplus.

2.6 Conclusion

This paper analyzes two business models which are widely popular in media markets: free-to-air and pay-tv. The key ingredients of our model are the bargaining process through which platforms and producers determine advertising rates and informative advertising which can increase or reduce competition on the product market. On the consumer side, we consider a setting where consumers can allocate their viewing time on media platforms in order to reach their optimal consumption mix.

While many papers emphasize the advantages of markets with direct viewer payment, this paper highlights two disadvantages that may arise if the business model changes from free-to-air to pay-tv. The first effect is that media platforms can create additional market power in the advertising market. This is a result of platforms' improved bargaining position as direct viewer payments offer a strong outside option. With informative advertising, this increase in platforms' bargaining power has immediate repercussions on product market outcomes. Higher advertising rates and a lower advertising volume tend to decrease the competitiveness of the product market (i.e., less consumers are informed) and lead to higher prices for consumers. The second effect describes the change in consumers' optimal consumption mix of media products induced by a switch from free-to-air to pay-tv. Here, the model makes a stark prediction. With free-to-air mixing is complete and each viewer consumes the ideal media mix. In contrast, with pay-tv, we find no mixing at all. As a result of not consuming their preferred content mix, consumers face large disutility costs which constitutes a considerable welfare loss. Importantly, however, when we consider pay-tv on a pay-per-view basis this negative effect on consumer vanishes and consumers are still able to consume their ideal content mix. In this sense, pay-tv on a pay-pre-view basis is strictly preferable from a consumer perspective.

When platforms face higher fixed costs of operation with pay-tv than with free-to-air, the model predicts that platforms prefer pay-tv (either traditional pay-tv or pay-tv on a pay-per-view basis) over free-to-air, when differentiation on the product or the media market is high. The model also predicts that platforms have larger incentives to adopt pay-tv when they see their bargaining power towards advertisers reduced. Factors that might lead to greater bargaining power of advertisers (such as, for instance, an increase in retail market or producer concentration) may induce platforms to adopt pay-tv in order to mitigate the negative profit effects of their worsened bargaining position.

2.A Appendix A

Here we derive the equilibrium results of Gal-Or and Dukes (2003) when platform locations are fixed at 0 and 1.

Payoffs and bargaining. The payoffs for platforms and producers in case of agreement and disagreement are:

$$\begin{aligned}
\Pi_j &= a_A^j \varphi_A^j + a_B^j \varphi_B^j - f, \\
\pi_i &= (p_i - c)(X^0 D_i^0 + X^1 D_i^1) - (a_i^0 \varphi_i^0 + a_i^1 \varphi_i^1) - k, \\
\Pi_j^{-i} &= a_l^j \varphi_l^j - f, \\
\pi_i^{-j} &= \tilde{X}^r D_i^r (p_i - c) - a_i^r \varphi_i^r - k, \qquad i \neq l;\ j \neq r;\ j = 0,1;\ i = A, B.
\end{aligned} \tag{2.26}$$

The Nash bargaining solution maximizes the product of the gains from a bargaining agreement of both parties over the negotiated advertising rate a_i^j. This results in an even split of the bargaining gains among both parties, such that $\Pi_j - \Pi_j^{-i} = \pi_i - \pi_i^{-j}$ and therefore advertising revenues are

$$a_i^j \varphi_i^j = \frac{p_i - c}{2} \left(X^j D_i^j + \frac{\gamma \varphi_i^j D_i^r}{2t_m} \right). \tag{2.27}$$

The first term on the left of the bracketed equation multiplied by $p_i - c$ is the gain from producer i's sales induced by advertising on platform j. The term on the right multiplied by $p_i - c$ represents a premium paid to platform j for the forgone product sales to consumers who would have chosen to view platform j if producer i had not advertised on it. Lowering the advertising intensity φ_i^j affects both components of the Nash bargaining solution. On the one hand, profits from product sales increase due to the diminished competition on the product market, induced by fewer informed consumers. On the other hand, part of the premium decreases as the impact of disagreement between a platform-producer pair on viewers is now smaller since there are fewer advertisements to begin with.

The symmetric equilibrium. Producers maximize their payoffs with respect to product prices p_i and the amount of advertising messages φ_i^j while taking the negotiated advertising rate a_i^j as given:

$$\frac{\partial \pi_i}{\partial \varphi_i^j} = (p_i - c)\left(X^j D_i^j \frac{G'(\varphi_i^j)}{G(\varphi_i^j)} - \frac{\gamma(D_i^j - D_i^r)}{2t_m}\right) - a_i^j = 0,$$

$$\frac{\partial \pi_i}{\partial p_i} = (X^j D_i^j + X^r D_i^r) + (p_i - c)\left(X^j \frac{\partial D_i^j}{\partial p_i} + X^r \frac{\partial D_i^r}{\partial p_i}\right) = 0, \;\; r \neq j; \;\; j = 0, 1; \;\; i = A, B. \tag{2.28}$$

Since producers are identical in their payoffs and symmetric in their locations on the Hotelling line, we set our focus on symmetric equilibria. This implies that producers choose the same level of advertising across stations $\varphi_A^j = \varphi_B^j = \varphi^j$, the same prices for their products $p_A = p_B = p$ and are charged identical rates for advertising by a given platform $a_A^j = a_B^j = a^j$. Using the result from the Nash bargaining solution in equation (2.27) and taking the symmetry of producers into account yields the first-order conditions in (2.29)

$$\begin{aligned} \left.\frac{\partial \pi_i}{\partial \varphi_i^j}\right|_{Sym} &= (p - c)\left(X^j D^j \left[\frac{G'(\varphi^j)}{G(\varphi^j)} - \frac{1}{2\varphi^j}\right] - \frac{\gamma(2D^j - D^r)}{4t_m}\right) = 0, \\ \left.\frac{\partial \pi_i}{\partial p_i}\right|_{Sym} &= (X^j D^j + X^r D^r) - (p - c)\left(X^j \frac{G(\varphi^j)^2}{2t_p} + X^r \frac{G(\varphi^r)^2}{2t_p}\right) = 0, \end{aligned} \tag{2.29}$$

where $X^0 \equiv \frac{1}{2} - \frac{\gamma(2\varphi^0 - 2\varphi^1)}{2t_m}$, $X^1 \equiv 1 - X^0$ and $D^j \equiv D_A^j = D_B^j = \frac{1}{2}\Big[2 - G(\varphi^j)\Big]G(\varphi^j)$.

Note that $T(\varphi) > 0$ ensures a positive level of advertising. If that assumption were violated then producers would prefer not to advertise on either platform in the symmetric equilibrium.[22] The symmetric equilibrium can now be fully characterized.

Producers choose the following amount of advertising in equilibrium:

$$\varphi_F^* = T^{-1}\left(\frac{\gamma}{2t_m}\right). \tag{2.30}$$

Equilibrium product prices are

$$p_F^* - c = \frac{t_p[2 - G(\varphi_F^*)]}{G(\varphi_F^*)}. \tag{2.31}$$

[22] Note also that as $T'(\varphi) > 0$ it is ensured that reactions functions are stable. See Gal-Or and Dukes (2003, p. 318–320) for the details.

This results in the following payoffs for both platforms and producers in the symmetric equilibrium:

$$\Pi_F^* = \frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 + \frac{\gamma\varphi_F^*}{t_m}\right) - f,$$
$$\pi_F^* = \frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 - \frac{\gamma\varphi_F^*}{t_m}\right) - k. \tag{2.32}$$

The first part of both profit functions corresponds to the profits each advertiser makes on the product market in equilibrium and which are shared in equal parts in the bargaining process. The second part, which is equivalent to a transfer from producers to platforms is the equilibrium premium paid in order to compensate platforms for the forgone viewers. A lower equilibrium advertising intensity φ_F^* has the same effect on profits as it does on the bargaining outcome. Advertisers enjoy higher profit margins, as the price p_F^* rises, while part of the premium to be paid to platforms decreases.

The number of advertising messages chosen in equilibrium increases as disutility from not viewing the preferred media content grows. It decreases when the nuisance parameter is high, i.e., producers advertise less aggressively when consumers' dislike of commercial interruptions is high. The prices decrease in the outreach probability $G(\varphi_F^*)$ and hence in the amount of advertisements but increase in the differentiation parameter on the product market.

2.B Appendix B

Proof of Lemma 2.1. Consumers maximize their utility function $U(x)$ in (2.2) with respect to $\lambda(x)$. A consumer exclusively views platform 0 as long as $v_m - t_m x^2 - \gamma(\varphi_A^0 + \varphi_B^0) - s_0 \geq U(x)$. A consumer exclusively views platform 1 as long as $v_m - t_m(1-x)^2 - \gamma(\varphi_A^1 + \varphi_B^1) - s_1 \geq U(x)$. Substituting the optimal $\lambda(x)$ into both equations and solving for x yields the locations of those two consumers indifferent between exclusively viewing one platform and mixing between both. □

Proof of Proposition 2.1. Platforms choose their optimal subscription fee by maximizing their payoffs $C_j = a_A^j\varphi_A^j + a_B^j\varphi_B^j + R_j s_j - f$ with respect to s_j, where $R_0 = 1 - \sqrt{\frac{s_0}{t_m}} - R$ and $R_1 = 1 - \sqrt{\frac{s_1}{t_m}} + R$. This takes place simultaneously to the bargaining process. The price each platform charges to consumers is then given by

$$s_0 = \frac{4}{9}(1-R)^2 t_m,$$

$$s_1 = \frac{4}{9}(1+R)^2 t_m.$$

However, according to Lemma 2.1 with these subscription fees there will be no mixing by consumers, as $\sqrt{\frac{s_1}{t_m}} - R > 1 - \sqrt{\frac{s_0}{t_m}} - R$. In this case, the platforms' demands will be defined by the viewers choice between the two media outlets and the platform j's profit is

$$\Pi_j = a_A^j \varphi_A^j + a_B^j \varphi_B^j + X_j s_j - f,$$

where $X^0 = \frac{1}{2} - R - \frac{s_j - s_r}{2t_m}$. The subscription fee maximizing this profit function in the symmetric equilibrium satisfies the condition for no mixing, i.e., $R_0 \geq R_1$ since $1 \leq \sqrt{\frac{s_0^*}{t_m}} + \sqrt{\frac{s_1^*}{t_m}}$ with $R^* = 0$ and $s_j^* = t_m$ (see Proposition 2.3). Given s_1^*, platform 0 could deviate by choosing a subscription fee s_0 such that consumers could decide to mix, i.e., such that $1 - \sqrt{\frac{s_1^*}{t_m}} \geq \sqrt{\frac{s_0}{t_m}}$. This deviation, however, cannot be profitable for platform 0 as $1 - \sqrt{\frac{s_1^*}{t_m}} = 0$. □

Proof of Proposition 2.2. For the first and second part of the proposition we compare platforms' disagreement payoffs and negotiated advertising rates under free-to-air with those under pay-tv. In case of free-to-air $s_j = 0$.

$$\Pi_j^{-i} = a_l^j \varphi_l^j + \left(X^j + \frac{\gamma \varphi_i^j}{2t_m}\right) s_j - f,$$

$$a_i^j \varphi_i^j = \frac{p_i - c}{2}\left(X^j D_i^j + \frac{\gamma \varphi_i^j D_i^r}{2t_m}\right) + s_j \frac{\gamma \varphi_i^j}{4t_m}.$$

Both expressions are increasing in the subscription fee s_j. □

Proof of Lemma 2.2. The maximization results in the symmetric case are obtained by substituting $\varphi_A^j = \varphi_B^j = \varphi^j$, $p_A = p_B = p$ and $a_A^j = a_B^j = a^j$ and $a_i^j = \frac{p_i - c}{2\varphi_i^j}\left(X^j D_i^j + \frac{\gamma \varphi_i^j D_i^r}{2t_m}\right) + s_j \frac{\gamma}{4t_m}$ from equation (2.13). □

Proof of Proposition 2.3. Product prices, advertising intensity and payoffs are obtained by substituting $X^0 = X^1 = \frac{1}{2}$, $D^0 = D^1 = \frac{1}{2}[2 - G(\varphi)]G(\varphi)$ and $s_0 = s_1 = t_m$

into equations (2.29) and the expressions for producer and platform profits. □

Proof of Lemma 2.3. The following derivatives show the effects of the parameter changes in the equilibrium with pay-tv competition:

i) $\frac{\partial \varphi_P^*}{\partial t_m} > 0$ as $T'(\varphi) < 0$; $\frac{\partial (p_P^* - c)}{\partial t_m} < 0$ since $\frac{\partial \varphi_P^*}{\partial t_m} > 0$, $G'(\varphi) > 0$ and $\frac{\partial (p_P^* - c)}{\partial G(\varphi_P^*)} < 0$; $\frac{ds^*}{dt_m} = 1$.

ii) $\frac{\partial \varphi_P^*}{\partial t_p} > 0$; $\frac{\partial (p_P^* - c)}{\partial t_p} \lesseqgtr 0$ as $\frac{\partial \varphi_P^*}{\partial t_p} > 0$.

iii) $\frac{\partial \varphi_P^*}{\partial \gamma} < 0$; $\frac{\partial (p_P^* - c)}{\partial \gamma} > 0$ since $\frac{\partial \varphi_P^*}{\partial \gamma} < 0$. □

Proof of Proposition 2.4. i) Advertising volume with free-to-air is $\varphi_F^* = T^{-1}\left(\frac{\gamma}{2t_m}\right)$ while with pay-tv it is $\varphi_P^* = T^{-1}\left(\frac{\gamma}{2t_m} + \frac{\gamma}{t_p(2 - G(\varphi_P^*))^2}\right)$. Since $T'(\varphi) < 0$ and $\frac{\gamma}{t_p(2 - G(\varphi_P^*))^2} > 0$ it follows that $\varphi_F^* > \varphi_P^*$.

Equilibrium advertising rates with free-to-air competition and pay-tv are

$$a_F^* = \frac{t_p[2 - G(\varphi_F^*)]^2}{8\varphi_F^*}\left(1 + \frac{\gamma\varphi_F^*}{t_m}\right)$$

$$a_P^* = \frac{t_p[2 - G(\varphi_P^*)]^2}{8\varphi_P^*}\left(1 + \frac{\gamma\varphi_P^*}{t_m}\right) + \frac{\gamma}{4}.$$

The advertising rates with free-to-air can be rewritten as $a_F^* = \frac{t_p[2 - G(\varphi_F^*)]^2}{8\varphi_F^*}\Big(1 + 2\varphi_F^* T(\varphi_F^*)\Big)$. Since the elasticity of $G(\varphi)$ is non-increasing, i.e. $\varphi_F^* T(\varphi_F^*) = \frac{\varphi^* G'(\varphi^*)}{G(\varphi^*)} - \frac{1}{2}$ is non-increasing, it follows that an increase in φ_F^* leads to a decrease in a_F^*. Since we have just established that $\varphi_F^* > \varphi_P^*$ it must be that $\frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 + \frac{\gamma\varphi_F^*}{t_m}\right) < \frac{t_p[2 - G(\varphi_T^*)]^2}{4}\left(1 + \frac{\gamma\varphi_T^*}{t_m}\right)$ and therefore also $a_F^* < a_P^*$.

ii) equilibrium prices of producers with free-to-air and pay-tv are

$$p_F^* - c = \frac{t_p[2 - G(\varphi_F^*)]}{G(\varphi_F^*)}$$

$$p_P^* - c = \frac{t_p(2 - G(\varphi_P^*))}{G(\varphi_P^*)}.$$

Since we have established under *i)* that $\varphi_F^* > \varphi_P^*$ it follows that $p_F^* < p_P^*$.

iii) Platform profits in equilibrium can be rewritten as

$$\frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 + 2\varphi_F^* T(\varphi_F^*)\right).$$

Following the same argument as in *i)*, we can establish that since the elasticity of $G(\varphi)$ is non-increasing and $\varphi_F^* > \varphi_P^*$, $\frac{t_p[2-G(\varphi_F^*)]^2}{4}\left(1 + \frac{\gamma\varphi_F^*}{t_m}\right) < \frac{t_p[2-G(\varphi_P^*)]^2}{4}\left(1 + \frac{\gamma\varphi_P^*}{t_m}\right)$ and therefore $\Pi_P^* > \Pi_F^*$.

iv) Producer profits in equilibrium with free-to-air and pay-tv are

$$\pi_F^* = \frac{t_p[2 - G(\varphi_F^*)]^2}{4}\left(1 - \frac{\gamma\varphi_F^*}{t_m}\right) - k$$

$$\pi_P^* = \frac{t_p[2 - G(\varphi_P^*)]^2}{4}\left(1 - \frac{\gamma\varphi_P^*}{t_m}\right) - \frac{\gamma\varphi_P^*}{2} - k.$$

We have established under *i)* that $\varphi_F^* > \varphi_P^*$ which increases producer profits under pay-tv in equilibrium. At the same time, however, profits decrease because of the additional term $\frac{\gamma\varphi_P^*}{2}$. As the magnitude of the change in φ^* cannot be determined, equilibrium producer profits could be higher or lower when switching from free-to-air to pay-tv competition. □

Proof of Proposition 2.5. The consumer surplus with free-to-air and with pay-tv is

$$CS_F^* = (v_m - \gamma\varphi_F^*) + Z(\varphi_F^*),$$

$$CS_P^* = (v_m - \gamma\varphi_P^* - \frac{13}{12}t_s) + Z(\varphi_P^*),$$

The consumer surplus derived from the product market is always lower with pay-tv competition in the symmetric equilibrium, i.e. $Z(\varphi_P^*) < Z(\varphi_F^*)$. This can be verified by looking at the sign of the derivatives of $Z(\varphi_n^*)$ with respect to the outreach probability and product prices in equilibrium: $\frac{\partial Z(\varphi_n^*)}{\partial G(\varphi_n^*)} > 0$ and $\frac{\partial Z(\varphi_n^*)}{\partial p_n^*} < 0$. In the proof of Proposition 2.4 we established that $\varphi_F^* > \varphi_P^*$ and $p_F^* < p_P^*$, it follows that $Z(\varphi_P^*) < Z(\varphi_F^*)$.

The only way that consumers could obtain a higher surplus is if the surplus generated on the media market was higher with pay-tv. This is the case when $CS_P^{media} > CS_F^{media}$, that is when $\frac{t_m}{\gamma} < \frac{12}{13}(\varphi_F^* - \varphi_P^*)$. At the same time both platforms and producers need to have an incentive to participate in the market in the symmetric equilibrium. For platforms this is always the case, as long as the fixed operation costs are not too high. For producers on the other hand, in addition to low cost of production, the premium they pay to platforms in equilibrium must not be too high. Producer profits will not be positive with either business model if the following condition does not hold: $1 - \frac{\gamma\varphi_F^*}{t_m} > 0$. Rewriting this yields $\frac{t_m}{\gamma} > \varphi_F^*$. However, this is in contradiction with $CS_P^{media} > CS_F^{media}$ and therefore consumer surplus with pay-tv will always be lower than with free-to-air.

Total welfare with free-to-air and pay-tv is

$$W_F^* = t_p[2 - G(\varphi_F^*)]^2 - 2(f + k) + v_m - \gamma\varphi_F^* + Z(\varphi_F^*),$$

$$W_P^* = t_p[2 - G(\varphi_P^*)]^2 - 2(f + k) + v_m - \gamma\varphi_P^* - \frac{1}{12}t_m + Z(\varphi_P^*).$$

Switching to pay-tv only produces a higher total welfare than with free-to-air if the benefits for the platforms and producers outweigh the negative impact on consumer surplus. This is the case when $W_F^* - W_P^* > 0$, that is when $\Delta W^* = 12t_m - \gamma(\varphi_F^* - \varphi_P^*) + 2(v_p - \frac{7}{3}t_p)[G(\varphi_F^*) - G(\varphi_P^*) - (v_p - \frac{19}{12}t_p)[G(\varphi_F^*)^2 - G(\varphi_P^*)^2] + p_P^* G(\varphi_P^*)[2 - G(\varphi_P^*)] - p_F^* G(\varphi_F^*)[2 - G(\varphi_F^*)] > 0$ and this is the case as long as $G(\varphi_F^*) \leq 0.5$ and $c < t_p < \frac{12}{37}v_p$. $\square$

Proof of Proposition 2.6. We denote the platforms' bargaining power by $\beta \in [0, 1]$. The producers' bargaining power is denoted by $1 - \beta$.

The Nash bargaining solution maximizes the product of the gains from a bargaining agreement of both parties over the negotiated advertising rate a_i^j:

$$\max_{a_i^j} \; (\Pi_j - \Pi_j^{-i})^\beta (\pi_i - \pi_i^{-j})^{1-\beta}.$$

Free-to-air. The Nash bargaining solution with asymmetric bargaining power is

$$a_i^j \varphi_i^j = \beta(p_i - c)\left(X^j D_i^j + \frac{\gamma\varphi_i^j D_i^r}{2t_m}\right).$$

Advertising intensities in equilibrium are

$$\varphi_F^{asy} = T_{asy}^{-1}\left(\frac{\gamma\beta}{t_m}\right).$$

where, $T_{asy}(\varphi) = \frac{G'(\varphi)}{G(\varphi)} - \frac{\beta}{\varphi}$. Equilibrium product prices are

$$p_F^{asy} - c = \frac{t_p[2 - G(\varphi_F^{asy})]}{G(\varphi_F^{asy})}.$$

This results in the following payoffs for both platforms and producers in the symmetric equilibrium:

$$\Pi_F^{asy} = \frac{\beta t_p[2 - G(\varphi_F^{asy})]^2}{2}\left(1 + \frac{\gamma\varphi_F^{asy}}{t_m}\right) - f,$$

$$\pi_F^{asy} = \frac{t_p[2 - G(\varphi_F^{asy})]^2}{2}\left(1 - \beta\Big(1 + \frac{\gamma\varphi_F^{asy}}{t_m}\Big)\right) - k.$$

Pay-tv. The Nash bargaining solution with asymmetric bargaining power is

$$a_i^j\varphi_i^j = \beta(p_i - c)\left(X^j D_i^j + \frac{\gamma\varphi_i^j D_i^r}{2t_m}\right) + (1-\beta)\frac{\gamma\varphi_i^j}{2t_m}s_j.$$

Advertising intensities in equilibrium are

$$\varphi_T^{asy} = T_{asy}^{-1}\left(\frac{\gamma\beta}{t_m} + \frac{2(1-\beta)\gamma}{t_p[2 - G(\varphi_T^{asy})]^2}\right).$$

Equilibrium product prices are

$$p_T^{asy} - c = \frac{t_p[2 - G(\varphi_T^{asy})]}{G(\varphi_T^{asy})}.$$

This results in the following payoffs for both platforms and producers in the symmetric equilibrium:

$$\Pi_T^{asy} = \frac{\beta t_p[2 - G(\varphi_T^{asy})]^2}{2}\left(1 + \frac{\gamma\varphi_T^{asy}}{t_m}\right) + (1-\beta)\gamma\varphi_T^{asy} + \frac{t_m}{2} - f,$$

$$\pi_T^{asy} = \frac{t_p[2 - G(\varphi_T^{asy})]^2}{2}\left(1 - \beta\Big(1 + \frac{\gamma\varphi_T^{asy}}{t_m}\Big)\right) - (1-\beta)\gamma\varphi_T^{asy} - k.$$

□

Pay-per-view equilibrium results. In the following we derive the equilibrium results with pay-per-view.

Consumers. Consumers maximize their utility with respect to $\lambda(x)$, where q_j is the price per unit of time spent on a given platform j.

$$\max_{\lambda(x)} U(x) = v_m - t_m\Big\{1 - \lambda(x) - x\Big\}^2 - \gamma\Big\{\lambda(x)\Big(\Big(\varphi_A^0 + \varphi_B^0\Big) - q_0\Big) + [1 - \lambda(x)]\Big(\Big(\varphi_A^1 + \varphi_B^1\Big) - q_1\Big)\Big\},$$

$$\lambda(x) = \begin{cases} 1 & \text{if } x \leq -R^{'} \\ 1 - x - R' & \text{if } -R^{'} < x \leq 1 - R^{'} \\ 0 & \text{if } x > 1 - R^{'} \end{cases}$$

where, $R^{'} = \frac{\gamma\left(\left(\varphi_A^0 + \varphi_B^0\right) - \left(\varphi_A^1 + \varphi_B^1\right)\right)}{2t_m} + \frac{(q_0 - q_1)}{2t_m}$.The market shares are $X^0 = \frac{1}{2} - R'$ and $X^1 = \frac{1}{2} + R'$.

Producers and platforms. Platforms maximize their profits with respect to q_j and simultaneously bargain with producers over advertising prices. Platform profits are

$$\Pi_0 = a_A^0 \varphi_A^0 + a_B^0 \varphi_B^0 + q_0(\frac{1}{2} - R^{'}) - f,$$

$$\Pi_1 = a_A^1 \varphi_A^1 + a_B^1 \varphi_B^1 + q_1(\frac{1}{2} + R^{'}) - f,$$

$$\Pi_0^{-i} = a_l^0 r_l^0 + q_0 \left(\frac{1}{2} - R^{'} + \frac{\gamma \varphi_i^0}{2t_m} \right) - f,$$

$$\Pi_1^{-i} = a_l^1 r_l^1 + q_1 \left(\frac{1}{2} + R^{'} + \frac{\gamma \varphi_i^1}{2t_m} \right) - f.$$

Maximizing platform profits with respect to q_j yields prices that are identical to the ones specified in equation 2.14 with pay-tv. Furthermore, producer profits are identical to the ones specified in equations 2.7 and 2.8. Producers maximization problems are almost identical to the ones specified in Lemma 2.2, except that s_j needs to be replaced with q_j. The same holds true for the bargaining solution which is almost identical to the one specified in equation 2.12.

Equilibrium. In equilibrium product prices, the number of advertising messages and the amount charged by platforms to viewers are identical to the ones identified in Proposition 2.3. The same holds true for platform and producer profits.

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Chapter 3

Drip Pricing: An Experimental Analysis

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3.1 Introduction

It is now widely accepted that (consumer) behavior is often boundedly rational. In the context of consumers' purchasing behavior, models of limited attention demonstrate that the way in which information is presented or choices are framed can have a significant influence on consumer decisions. For example, Gabaix and Laibson (2006) show that firms can use the shrouding of prices for additional services or products (e.g., parking, Internet access) to benefit from boundedly rational consumer behavior. They may be able to increase their profits even if competition is, in principle (i.e. with only fully rational consumers), fierce.

One type of pricing strategy, which is based on consumers' limited attention, is drip pricing. Under drip pricing, the product price consists of several components, but firms advertise only (one single) part of a product's price (bait price), when consumers first learn about the product. The other price components (drip prices) are revealed at later stages of the purchasing process. Since going back to search for alternatives may be costly, this can lead to a lock-in of consumers.[1] Under drip pricing, consumers may therefore underestimate the total price and search too little. Examples are manifold and can be found in many industries (particularly in online trade): flight-ticket prices, online admission tickets, tourism fees, ATM fees, cleaning and service fees on Airbnb.[2] First experimental evidence suggests that consumers indeed strongly and systematically underestimate the total price under drip pricing and make mistakes when searching (Huck and Wallace, 2015; Robbert, 2014; see the literature review below).

These observations already indicate the importance of gaining a better understanding of the mechanisms at work both from a competition policy and a consumer perspective. This is also reflected in the current political discussion and the actions taken by competition authorities around the world. Many of the regulatory interventions are aimed at reducing the practice of drip pricing. For example, the European Commission in its Directive 2011/83/EU on Consumer Rights and the Australian Competition and Consumer Commission have recently investigated pricing in the airline sector. Before the investigations and the subsequent prohibition of certain pricing techniques, airlines kept adding charges (fuel surcharges, payment by credit

[1] Note that under add-on pricing, firms typically offer additional products or services which consumers may or may not buy (i.e., they can avoid additional charges for minibars etc.), whereas under drip pricing, they must pay all price components if they want to buy the product.

Another related pricing strategy, which also aims to exploit consumers' limited attention, is partitioned pricing. There, the product price also consists of several components, but all parts are known from the start.

[2] In 2015 the Australian Competition and Consumer Commission found this pricing strategy to be breaching consumer law. Airbnb now includes all cleaning and service fees in its headline prices.

card, etc.) during the online purchasing procedure. The European Commission now requires airlines to include all applicable taxes, charges, and surcharges in the final flight price and that any surcharges must reflect the cost.[3]

Nevertheless, drip pricing is still an important issue in the airline industry, as companies come up with new charges and techniques to increase their flight prices. Some fees for cabin baggage and seat allocation procedures are such that consumers may be forced into paying for additional services. For example, this is the case when a family traveling on a reservation with a (young) child is required to pay extra in order to sit in a seat adjacent to their offspring.[4]

In this paper, we conduct an experimental analysis to evaluate the effects of drip pricing on market participants. Our experimental market consists of one buyer and two sellers. Sellers set two prices: a base price and a drip price. At first, buyers only observe the base prices and make a tentative purchase decision. Revealing the sellers' drip prices, however, comes at a cost. The experiment allows us to address five key issues which have turned out to be highly relevant in the competition policy debate. First, we analyze whether drip pricing hampers competition. We find that firms fiercely compete in base prices, but not in drip prices. Compared to the standard Bertrand setup, the total price (slightly) increases when firms use drip pricing. Second, we are interested in how drip pricing affects consumers' search behavior. Our experimental study shows that given costly search, consumer search is mostly optimal from an ex-post perspective. Third, we investigate the implications of drip pricing for consumer surplus and firm profits. We find that when firms use drip pricing, consumers are worse off, whereas firms benefit. This leads us to the fourth aspect we analyze: the effects of regulating drip pricing on consumer surplus. We analyze the case in which there is a cap on the drip size and show that this may have a negative effect on consumer surplus. Finally, we examine a case where buyers face uncertainty regarding the drip price limit of the sellers. These situations are relevant in practice as in many markets (in particular those where consumers buy infrequently) consumers are unaware whether or not a firm is using a drip price strategy. We capture this by randomly varying the drip price limit a firm may charge. Our experiments show that this affects competition in drip prices for sellers with a high drip price limit. Moreover, buyers increasingly fail to identify the cheapest seller.

Our study adds to the growing body of literature examining firm incentives and consumer behavior when faced with complex pricing strategies (see, e.g., Greenleaf

[3]Similarly, the U.S. Department of Transportation requires airlines to include all applicable non-optional fees and taxes in its price displays. The former Office of Fair Trading (OFT) recommended to ban excessive debit and credit card surcharges.

[4]In 2016 Congress addressed this problem by passing a bill aimed at making it easier for parents to sit next to their child during a flight.

et al., 2016 and Ahmetoglu *et al.*, 2014 for an extensive review). In theory, complex prices can lead to search frictions which make it harder for consumers to compare offers and which can induce monopoly pricing (Diamond, 1971, Stahl, 1989). Especially a lack of consumer sophistication can incentivize firms to use complex pricing strategies, as only sophisticated consumers know how to avoid additional charges or correctly anticipate hidden costs (Gabaix and Laibson, 2006, Heidhues *et al.*, 2016, Shulman and Geng, 2013).

In particular these behavioral aspects of complex pricing have sparked a growing experimental literature analyzing the topic. Primarily the practices where sellers set multiple prices for a single product (partitioned pricing) or shroud the price of an add-on product have received increasing research attention (Carlson and Weathers, 2008, Morwitz *et al.*, 1998). An important result from this literature is that with multiple price components, the price perceived by consumers is generally lower and that this effect increases with the number of price components (Morwitz *et al.*, 1998). On the seller side, there exist incentives to shroud prices or deliberately confuse consumers, especially when consumers are susceptible to this type of confusion (Kalayci and Potters, 2011 and Kalayci, 2015). Often, not even competitive market conditions can keep sellers from exploiting consumer limitations via complex prices (Kalayci, 2016, Normann and Wenzel, 2015, Crosetto and Gaudeul, 2016).

Only little research focuses on the practice of drip pricing. The few, primarily experimental studies, that do, find that also with drip pricing consumers systematically underestimate the total price and perceptions of fairness are weakened, as consumers feel deceived by the sellers (Robbert and Roth, 2014, Robbert, 2014). Furthermore, in an experimental comparison of different price frames, Huck and Wallace (2015) find that drip pricing has the largest negative effect on consumer surplus out of all frames. The reason for this is that drip pricing discourages consumers from searching for cheaper offers which leads to fewer optimal purchase decisions.

Our analysis differs from those studies in that we focus on both market sides (i.e., buyers and sellers), whereas previous studies focus solely on one side of the market, namely the consumer side. In Huck and Wallace (2015), the size of the drip prices is determined randomly by a computer. As a result, it is often optimal for consumers to invest in comparing product prices, which few participants of the experiment did. This approach, however, may lead to biased results, since possible pricing incentives of the sellers are neglected. In our experiment sellers did not choose the size of their drips randomly but rather set the highest possible drip price and only competed in base prices. Participants of the experiment in the role of the buyers anticipated this and—instead of searching for the lowest price—based their purchase decision exclusively on the base price. As in Huck and Wallace (2015), this led to low levels of consumer search. Contrary to them, not searching was often the optimal choice in our experiment as a result of sellers' drip-price strategies and did not lead to large drops in consumer surplus. This changed only once uncertainty over the drip price limit on the buyer side was introduced.

To our knowledge, we are the first to experimentally study the complete market when drip pricing is possible and analyze not only consumers' reactions but also sellers' incentives. In addition to this, our experiment is novel in that we test whether lowering the upper limit of the drip size is a suitable remedy to reduce possibly negative effects of drip pricing.

The remainder of the paper is organized as follows. In Section 3.2, we describe the model that guides our experimental setup. Section 3.3 specifies the design of the experiment and derives our main hypotheses. In Section 3.4 we report the results of the experimental study. Section 3.5 concludes.

3.2 Theoretical background

To guide our experiment we develop a simple model of drip pricing. In this model, due to its sequential price presentation, drip pricing introduces a search friction. While buyers can observe all sellers' base prices, they can compare drip prices only at a cost.

We consider a market with two sellers offering a homogeneous product.[5] The two sellers are identical and have the same constant per-unit production cost of $c > 0$. There is a unit mass of buyers. Buyers are identical and have a valuation of $v > 0$ for one unit of the product.

When sellers can employ drip pricing, the total price consists of two components: the base price p_1 and the drip price p_2 such that the total price a buyer has to pay is $p_T = p_1 + p_2$. We assume that there is an upper limit $\bar{p}$ on the drip price. This upper limit might, for instance, represent a legal restriction. Similar assumptions are imposed in related papers (e.g., Gabaix and Laibson, 2006; Heidhues *et al.*, 2016). There are no restrictions on base prices. This implies that sellers can also charge below cost or even negative base prices.

All buyers can perfectly observe each seller's base price, but there is a search friction regarding the drip price. The drip price is only revealed during the purchase process. Upon observing both sellers' base prices, the buyer tentatively chooses one seller. During further inspection, the drip price of this seller is revealed. If a buyer also wants to learn the other seller's drip price, a search cost of $s > 0$ has

[5] We note that the equilibrium predictions also hold for any number of sellers exceeding two. However, as we only consider duopoly markets in our experiments we present all theoretical results for the two-firm case.

to be incurred. This search cost s might represent any real costs of going through the inspection process again.[6] Alternatively, the search cost might also represent a psychological cost to the buyer because she might have already become attached to a product during the purchase process (e.g., Ahmetoglu *et al.*, 2014; Huck and Wallace, 2015).

We consider the following sequence of events. In the first stage, sellers simultaneously choose both price components. In stage 2, base prices are revealed to buyers. Buyers tentatively decide for one seller. In stage 3, upon observing the drip price of the tentatively chosen seller, buyers can decide whether to purchase from that seller or invest into search. In stage 4, provided a buyer has chosen to search in stage 3, the buyer is now informed about the other seller's drip price. The buyer now makes the final purchase decision.

The following proposition presents the equilibrium behavior of sellers and buyers:

Proposition 3.1. *In equilibrium, sellers charge* $p_1^* = c - \bar{p}$ *and* $p_2^* = \bar{p}$. *The total price is* $p_T^* = c$ *and sellers earn zero profits. Buyers inspect only one product and do not invest into the inspection of further products.*

The intuition of the equilibrium strategies is as follows. Given that both sellers charge the same drip price at its maximum level, buyers, anticipating these drip prices, have no incentive to invest into costly search for a second drip price. On the other hand, as buyers do not compare drip prices, sellers set the drip price at its maximum level $\bar{p}$. Competition between sellers then takes place on the observable base price. In a Bertrand fashion, sellers undercut each other's base prices until all profits from the drip price are depleted. As a result sellers earn zero profits in equilibrium.

This has several implications. Even though there is a search friction in the market and buyers only inspect one product, the market outcome coincides with the competitive benchmark of Bertrand competition. The total price equals marginal cost, sellers earn zero profits and all surplus goes to the buyers. This result is independent of the magnitude of the search friction as measured by the search cost s. In essence, this is the reverse of the Diamond paradox (Diamond, 1971). In Diamond (1971) there is only one price element and buyers have to incur a search cost to compare prices. The paper shows that, independent of the magnitude of the search cost, prices are at the monopoly level and there is no search. In contrast, when there is a search friction only on the drip price component, competition works via the transparent base price and all profits from the drip price are competed away via the base price. In this sense, drip pricing is more competitive.

[6] With this interpretation, it is assumed that the first search of a drip price is costless.

The equilibrium price structure is closely related to models where firms compete in two price dimensions and (at least) some consumers are naive such as in Gabaix and Laibson (2006) and Heidhues *et al.* (2016). In those models, naive consumers only decide according to a transparent base price and ignore an add-on product or an additional price element. In both models, prices for the add-on are high and profit is competed away on the base price.[7] In contrast, in our model buyers are rational and forward-looking, but there is a search friction to compare drip prices. However, as buyers anticipate that sellers set identical drip prices, they do not search in equilibrium.

We can use Proposition 3.1 to evaluate the effects of a policy measure that reduces the maximum permissible drip price $\bar{p}$:

Corollary 3.1. *Lowering the drip price limit $\bar{p}$ decreases the drip price, but increases the base price by the same amount. The total price as well as seller profits and buyer surplus remain unaffected.*

Corollary 3.1 states that a reduction of sellers' drip price limits does not alter market outcomes. The composition of the two price components changes, but the total price buyers are paying remains the same. This finding is an immediate consequence of the equilibrium pricing strategies stated in Proposition 3.1. Thus, the model suggests that policies aimed at reducing drip prices are not an effective tool in order to improve the market outcome.

So far, we considered situations where all buyers were informed about the drip and the drip price limit. In practice, in many situations buyers may be unsure about whether a firm charges a drip price or not. In our experiment we take such considerations into account by considering a setting where the drip price limit is a random variable whose outcome is unknown to buyers.

To be concrete, suppose there are two possible drip price limits $\bar{p}_H$ and $\bar{p}_L$, where $\bar{p}_H > \bar{p}_L$. The different limits can also be thought of as different seller types, where a seller with the high drip price limit is referred to as type H and a seller with the low drip price limit is referred to as type L. Furthermore, suppose that each limit applies to a seller with probability 0.5 (which is the value we use in the experiment) and it is independent across sellers such that sellers may end up with either identical limits (either both $\bar{p}_H$ or both $\bar{p}_L$) or different limits (one seller with $\bar{p}_H$ and one seller with $\bar{p}_L$). The outcome of this random draw is private information of each seller.

[7] Heidhues *et al.* (2016) mostly focus on the case where there is a lower bound on the base price such that not all profits are competed away.

Otherwise, the game coincides with the base game described earlier. The following proposition details the equilibrium behavior of sellers (as type H and as type L) as well as the buyers purchase and search strategy. The equilibrium concept is the Bayesian Nash equilibrium.

Proposition 3.2. *Suppose $\bar{p}_H > \bar{p}_L + 2s$. Then, in equilibrium, both types of sellers charge the same base price of $p_1^L = p_1^H = c - \bar{p}_L$. A seller of type L charges a drip price of $p_2^L = \bar{p}_L$ while a seller of type H charges a drip of $p_2^H = \bar{p}_L + 2s$. Seller L earns zero profit while Seller H's expected profit is equal to s. Buyers inspect only one product and do not invest into further search.*

The proposition provides the following main implications for seller behavior. In equilibrium, both seller types charge identical base prices, but differ in the drip price. Type L charges a drip equal to the upper bound while type H charges a higher drip with the difference equal to $2s$. In this sense, unlike the previous case, uncertainty over the drip price limit restricts the maximum drip price a seller of type H can charge.

While type L prices at marginal cost, the total price by type H exceeds cost and allows a positive profit. Seller H can make a positive profit due to mimicking type L on the base price making both sellers indistinguishable to the buyer in the inspection phase. Upon discovering the higher drip price a buyer does find it worthwhile to search for a lower drip price due to the search cost. Yet, the extent of the search cost limits type H to charge a higher drip.

One immediate implication is that with uncertainty over drip prices buyers indeed may be harmed. In contrast to the treatment with all-inclusive prices or with certain and identical drip price limits the total price at which buyers make a purchase can be above marginal cost. More precisely, while a seller of type $\bar{p}_L$ charges a total price equal to c the total price of seller $\bar{p}_H$ exceeds marginal cost. As in the inspection phase a buyer cannot distinguish seller types (due to identical base prices) a buyer may end up purchasing at a price above cost. This finding suggest that drip pricing per se cannot lead to detrimental outcomes for consumers, except when it is accompanied by buyer uncertainty over the use of it.

3.3 Experimental design and hypotheses

3.3.1 Experimental design

Our main goal is to analyze the effects of drip pricing. Therefore, we ran sessions where sellers could employ a drip pricing strategy and sessions where sellers could only charge an all-inclusive price.

We consider experimental markets with two sellers and one buyer. We chose the following parametrization. A seller's per-unit cost of production amounted to 10 experimental currency units (ECUs). A buyer's valuation of the good offered by the two sellers was 35 ECUs. The buyer could not refrain from making a purchase but in every period had to buy one unit from one of the two sellers. In each treatment, the maximum total price a seller could set was 30, the minimum 10 ECUs. Sellers could only choose integer values.[8]

At the beginning of a session all participants were randomly assigned the role of a seller or a buyer and sorted into matching groups each consisting of 9 players. Participants kept their assigned roles throughout the entire experiment. At the beginning of every period participants were randomly sorted into markets. To mimic the static nature of our model in Section 3.2 we employed a random matching protocol such that within the matching groups participants were re-matched every period. Each matching group therefore represents an independent observation.

Every period of the experiment was structured in three stages. In the first stage, sellers choose their prices. Depending on the treatment, this could either be an all-inclusive price or a drip pricing strategy with two prices, a base and a drip price. In the second stage, buyers made their purchase decisions. In the treatment with drip pricing, buyers could also decide whether to invest into receiving information on drip prices. We provide more detail on buyers' decisions when describing the various treatment below. In the third and final stage, sellers were informed about the price choices of their competitor and the buyer's decision. Both, buyers and sellers received information on their earnings in that period as well as on their cumulative earnings up until that period. The experiment was repeated for 20 rounds.

There were four treatments. 54 subjects participated in each treatment which amounted to 6 independent observations per treatment. All four treatments are summarized in Table 3.1.

In the first treatment (BERTRAND) participants in the role of a seller competed in prices for the buyer in their market by charging an all-inclusive price which was

[8]Parameters were chosen such that in all treatments neither of the participants could make a loss.

Treatment	# Prices	Price range: Base price	Drip price	Total price	Particip. (Indep. obs.)
Bertrand	one price	[10;30]	-	[10;30]	54 (6)
Drip	two prices	[0;20]	[0;10]	[10;30]	54 (6)
Big drip	two prices	[-10;10]	[0;20]	[10;30]	54 (6)
Random drip	two prices	[-10;10] or [0;20]	[0;20] or [0;10]	[10;30]	54 (6)

Table 3.1: Summary of the treatments

fully transparent to buyers. Sellers set a single price, which could range from 10 to 30 ECUs. Upon observing both prices, the buyer made a purchase decision. This treatment served as the benchmark to evaluate the effects of drip pricing.

In the second treatment (Drip) sellers were able to set two prices: a base price and an additional price (or drip price). The base price ranged from 0 to 20 ECUs. The drip price ranged from 0 to 10 ECUs. Both prices together made up the total price. We further imposed the restriction that the total price had to be at least 10 ECUs (the unit production cost). Treatment Drip was designed such that the range of the total price coincides with the price range in Bertrand. The buyer was at first only confronted with the base prices of the two sellers, without knowing the size of the additional price. The buyer could then decide whether she would like to learn the additional price of seller 1 or seller 2. After observing the additional price of the chosen seller, the buyer could again decide whether to stick with her choice and purchase from the seller whose total price had been revealed to her or instead also learn the additional price of the respective other seller. Choosing to learn more about the other seller's drip price came at a cost of two ECUs and, having learned both total prices, was followed by a final purchase decision. Did the buyer instead decide to stick with her initial choice, there were no costs and the period ended.

The third treatment (Big drip) only differed from the second treatment with respect to the range of price components the sellers could choose from: the base price ranged from -10 to 10 ECUs, while the additional price ranged from 0 to 20 ECUs. Thus, this treatment allowed sellers to charge higher drip prices, but was designed such that the total price a seller would charge, was in the same range as in the first two treatments (Bertrand and Drip). In all other respects the third treatment was identical to the second treatment. The comparison of the treatments Big drip and Drip could be used to assess the effects of policies that restrict the maximum drip price a seller may charge.

In the fourth treatment (Random drip) buyers were faced with uncertainty regarding the limit of the drip price of the sellers. With a probability of 50% sellers could set a maximum drip price of 20 ECUs. With a probability of 50% they could only set a maximum drip price of 10 ECUs. Base prices were adapted, such that for both cases the total price could not exceed 30 ECUs but was at least equal to the marginal costs of 10 ECUs. The maximum drip price was private information of the sellers and was drawn anew and independently every period. Otherwise the fourth treatment did not differ from the previous three treatments.

3.3.2 Procedures

All sessions were run at the DICElab for Experimental Economics at Heinrich-Heine-University in Düsseldorf. Participants were drawn from a pool of mostly undergraduate students from different disciplines via email solicitations using the ORSEE system. The procedure used during the experiments was the same throughout all sessions and each session was computerized. The experiment was programmed and conducted with the software z-Tree by Fischbacher (2007).

Before the start of each session, all participants were provided with written instructions.[9] For the duration of the experiments, participants were not allowed to communicate and were only able to see their own computer screen. After each period, all participants were informed about their payoffs from that period in addition to their cumulative payoff up until that period. Furthermore, after every period participants in the role of a seller were informed about the price choice of their competitor in that period.

A total of 216 students participated in 9 different sessions (two sessions per treatment and additional one for the treatment Big drip). No subject participated in more than one session. A session including the instruction phase lasted between 45 and 75 minutes. After the last period the cumulative payoffs of each of the players were converted into euros at an exchange rate of 25 ECUs to 1 EUR. Participants were paid a show-up fee of 4 EUR in addition to their cumulative earnings. Including the show-up fee, average earnings of a participant amounted to 18.50 EUR per session if in the role of a buyer and 7 EUR per session if in the role of a seller.

3.3.3 Hypotheses

We now develop hypotheses about market outcomes in the three treatments using the theoretical considerations from Section 3.2. When sellers can employ drip pricing, Proposition 3.1 generates the following two predictions about seller and buyer behavior.[10]

[9]Sample instructions are included in the Appendix.

[10]The following hypotheses are based on the results in Section 3.2 where sellers set continuous prices. In the experiment, however, sellers' choice sets were restricted to discrete prices. As a result,

Hypothesis 3.1. *In treatment* DRIP*, sellers choose a skewed pricing scheme with a drip price at 10 ECUs and a base price of 0 ECUs. The total price equals marginal cost of 10 ECUs and sellers make no profits.*

Hypothesis 3.2. *In treatment* DRIP*, if buyers anticipate high drip prices, they do not invest in search.*

As Proposition 3.1 predicts a Bertrand-like outcome with drip pricing, the overall outcomes in DRIP and BERTRAND should coincide.

Hypothesis 3.3. *In treatments* BERTRAND *and* DRIP *total prices are equal and sellers earn no profits.*

Regarding treatments DRIP and BIG DRIP Proposition 3.1 and Corollary 3.1 immediately provide the following hypothesis.

Hypothesis 3.4. *Compared to* DRIP*, in treatment* BIG DRIP *the drip price rises to 20 ECUs and the base price decreases to -10 ECUs. The total price remains constant at marginal cost of 10 ECUs.*

Regarding treatment RANDOM DRIP Proposition 3.2 provides the following predictions:

Hypothesis 3.5. *In treatment* RANDOM DRIP*, both sellers charge an identical base price of 0 ECUs. A seller of type H chooses a higher drip price than a seller of type L (14 ECUs vs 10 ECUs). A seller of type H earns higher profits than a seller of type L.*

Hypothesis 3.6. *In treatment* RANDOM DRIP *buyers choose the seller with the lower base price and do not invest in search as the difference in drip prices does not warrant the additional search costs.*

with discrete prices, there exists an additional equilibrium in treatments DRIP and BERTRAND where both sellers choose a (base) price equal to 1 ECU. In this case expected seller profits are equal to 0.5 EUCs. The same holds true for BIG DRIP, where there exists another equilibrium in which sellers choose a base price of -9 ECUs.

3.4 Results

Table 3.2 provides a summary of the main results. All comparisons and tests are based on all 20 periods. Throughout the paper we employ non-parametric tests where the number of independent observations corresponds to the number of matching groups.

				Random drip		
Treatment	Bertrand	Drip	Big drip	10	20	Total
Base price		8.06	-2.37	6.41	2.88	4.69
Drip price		8.89	17.82	9.12	14.34	11.66
Total price	15.37	16.96	15.50	15.53	17.21	16.35
Selling price	14.52	16.26	14.77	14.76	15.56	15.18
Seller profits	2.25	3.13	2.42	2.25	2.95	2.59
Buyer surplus	20.49	18.49	19.83			19.45
Search probability		0.13	0.16			0.19
Search efforts		0.26	0.32			0.38

Table 3.2: Summary of the experimental results

In the first part we describe the results of the Drip treatment where sellers employ drip pricing. In the second part we compare these results to those of standard Bertrand competition where sellers can only charge one (perfectly observable) price. Afterwards we analyze the effect of an increase in the drip size. Finally, we examine the impact of buyer uncertainty regarding the drip price limit.

3.4.1 Drip pricing

In the following we report the findings of the Drip Treatment, analyzing both buyer and seller behavior separately.

Seller behavior

Table 3.2 shows that sellers choose a skewed pricing scheme: the drip price is high and its average of 8.89 ECUs is close to the imposed upper limit of 10 ECUs. By contrast, with 8.06 ECUs, the base price is low relative to the imposed upper limit of 20 ECUs. Interestingly, this implies that the average base price is not sufficient

to cover the production cost of 10 ECUs.
Figure 3.1 reveals how both price components evolve over time. Here we can observe two opposing trends. While the base price is continuously decreasing, the drip price is constantly rising, gradually converging to the imposed limit of 10 ECUs.

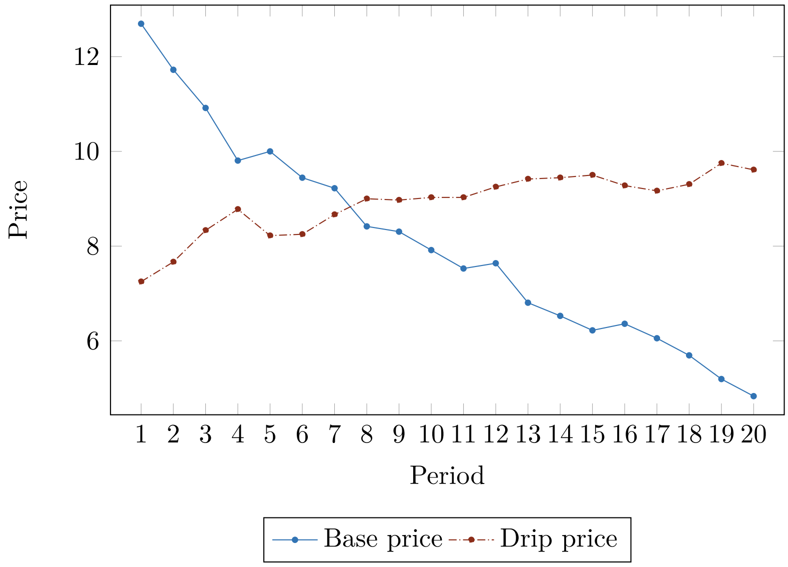


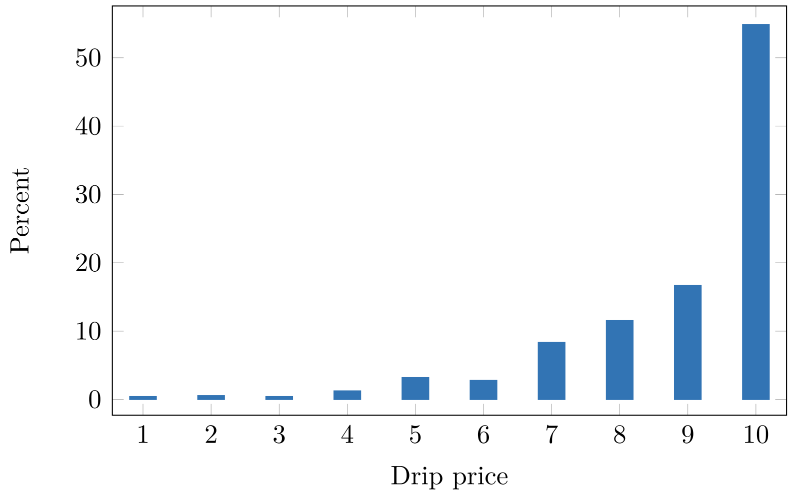
Figure 3.1: Evolution of price components under drip pricing (DRIP).

One important implication of theses findings is that sellers primarily compete in the base price but not in the drip price. Panel a) of Figure 3.2 corroborates this finding. The highest possible drip price of 10 ECUs is chosen in more than 50% of all cases, and the two highest values together exceed 70% of cases.[11] Smaller drips (less than 7) are almost never observed.

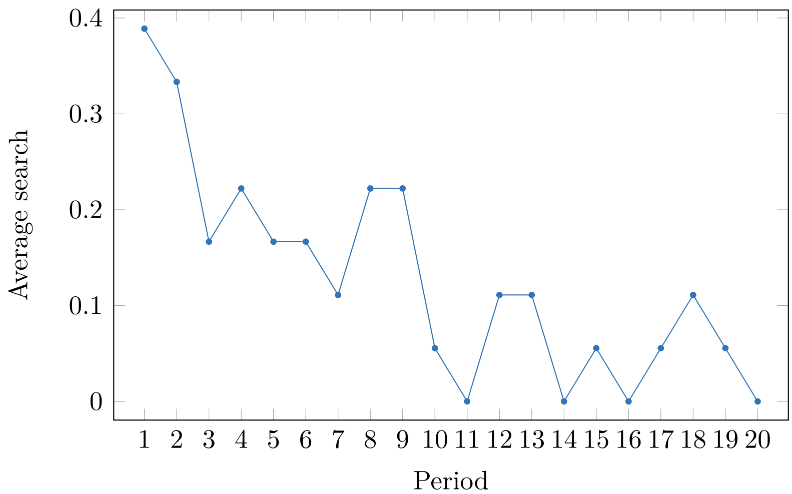
Competition in the base prices, however, is not strong enough to completely erode seller profits. Consequently, the total average price, consisting of both price components, exceeds marginal cost. We observe an average total price of 16.96 ECUs which is higher than the production cost of 10 ECUs. Thus, firms are still earning positive profits. This holds true even for the last periods of the experiment, where base prices have reached their lowest levels. Sellers' pricing strategies are summarized in the following result:

RESULT 3.1. *With drip pricing, sellers choose a skewed pricing scheme with low base prices and high drip prices. In particular, sellers do generally not compete in drip prices but tend towards choosing the highest possible drip price.*

[11]When only the last 10 periods of the experiment are considered these values increase to 70% and 85%, respectively.



(a) Frequency distribution of drip prices.



(b) Evolution of buyers' search decision.

Figure 3.2: Distribution of drip prices and search effort in treatment DRIP.

Result 3.1 is generally in line with Hypothesis 3.1. As predicted by the theory, the pricing scheme is highly skewed. However, we do observe a deviation in the magnitude of the observed effects. Base price competition is not as strong as predicted by theory and sellers earn positive profits. However, the finding that in duopoly markets sellers earn positive profits can be found in many experimental studies (e.g., Dufwenberg and Gneezy, 2000; Huck *et al.*, 2007).

Buyer behavior

One striking finding is that buyers rarely search for lower drip prices. On average, the search rate is as low as 13%. In addition, panel b) of Figure 3.2 shows that the search rate is sharply decreasing over the course of the experiment. While almost half of the buyers decide to invest in the comparison of total prices, only very few keep searching towards the last periods of the experiment.

This behavior is consistent with sellers' pricing strategies. The search efforts of the first periods and increasing competition in base prices lead buyers to anticipate drip prices close to their maximum value. As a result, a large number of buyers select sellers according to the lowest base price (on average 94.5%). While this result is in consonance with the related literature, it should be noted that here, unlike in the related literature, buyers' reluctance to search does not lower their surplus. This, again, is owed to the fact that drip prices are equally high, which makes the base price a reliable indicator as to which total price will be lower. Hence, in our setting buyer decisions are indeed mostly optimal and buyer purchase from the seller with the lower total price (on average 87.2% of cases). This is summarized in the following result:

RESULT 3.2. *In the presence of drip pricing, buyers rarely search for lower drip prices. Nevertheless, buyer mistakes are scarce from an ex-post perspective and buyers tend to purchase from the seller with the lowest price in the majority of cases.*

In summary, in the DRIP treatment, sellers strongly compete in base prices but prefer to set the highest possible drip price. Buyers anticipate this and make their purchase decision only taking into account base prices instead of engaging in costly search. This is in line with Hypothesis 3.2.

3.4.2 Comparison with Bertrand competition

To examine whether drip pricing increases sellers' market power and leads to higher prices, we now compare the outcomes of DRIP with the outcomes under standard Bertrand pricing (BERTRAND) where buyers are perfectly informed about sellers' total prices.

In line with existing studies we find that with an all-inclusive price the observed prices exceed the theoretical benchmark of marginal cost prices (e.g., Dufwenberg and Gneezy, 2000). More importantly, Table 3.2 shows that with drip pricing, prices are indeed significantly higher than with Bertrand competition (Mann-Whitney

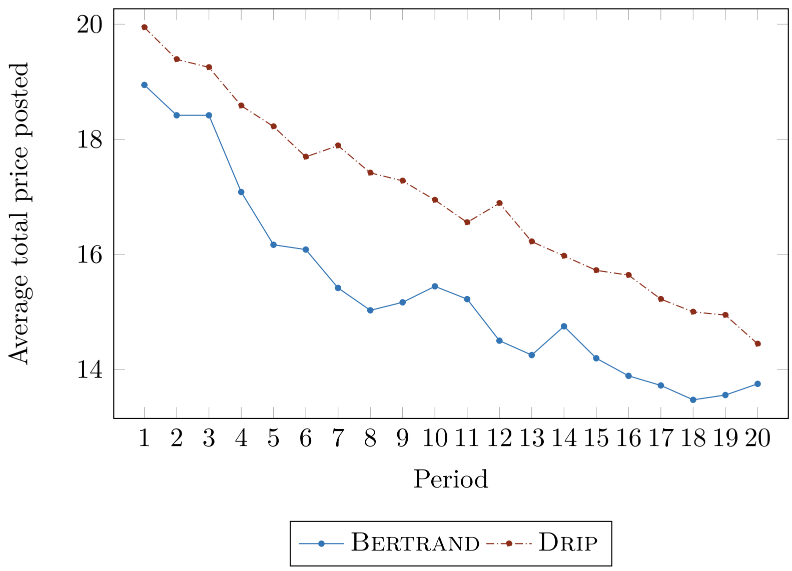


Figure 3.3: Evolution of total prices: Comparison of BERTRAND and DRIP.

rank-sum test, $p = 0.025$).[12] On average, the total price a seller charges rises from 15.37 ECUs to 16.96 ECUs if drip pricing is employed. Figure 3.3 confirms that this effect remains robust over time. While total prices in both treatments are decreasing over time, with drip pricing the total price is consistently higher than with Bertrand competition.

Consistent with higher total prices, we find that seller profits increase whereas consumer surplus declines with drip pricing (Mann-Whitney rank-sum test, $p = 0.037$ and $p = 0.01$, respectively). Profits increase from 2.25 to 3.13 ECUs and consumer surplus decreases from 20.49 to 18.49 ECUs. Thus, to the buyers' detriment, sellers have an incentive to employ drip pricing as it increases their profits.

We note, however, that even though we observe some anti-competitive effects of drip pricing, the magnitude of these effects does not appear to be particularly large. This result is in contrast to existing studies who report sizable welfare effects due to drip pricing (Huck and Wallace, 2015). The main driver of this result is that sellers tend to charge the highest possible drip. Consequently, even if buyers are reluctant to engage in costly search in order to compare different drip prices, there is no welfare loss. The results of the comparison between drip pricing and Bertrand competition are summarized in the following result:

RESULT 3.3. *Compared to Bertrand competition, drip pricing leads to higher total prices, higher seller profits and lower buyer surplus. The magnitude of these effects, however, is not very large.*

[12] Alternatively, selling prices are also higher under drip pricing ($p = 0.037$).

In contrast to Hypothesis 3.3 we find that treatments DRIP and BERTRAND differ in total price and seller profits. The reason for this deviation from the theoretical benchmark seems to lie in the fact that in treatment DRIP sellers are more reluctant to compete away the revenues they earn from charging the high drip component. This finding raises the question whether sellers can also benefit from charging a drip price that exceeds the imposed limit of 10 ECUs.

3.4.3 The effect of the drip size

Our previous results suggest that drip pricing has a small, but nevertheless anti-competitive effect on market outcomes. Here, we elaborate on this finding by examining the effect of an increase in the size of the drip price. To do so we compare the treatment DRIP to the treatment BIG DRIP where sellers are allowed to set a maximum drip price of 20 ECUs, instead of 10 ECUs. The question is whether higher permissible drips can increase sellers' market power, or whether this could spark competition in the drip price.

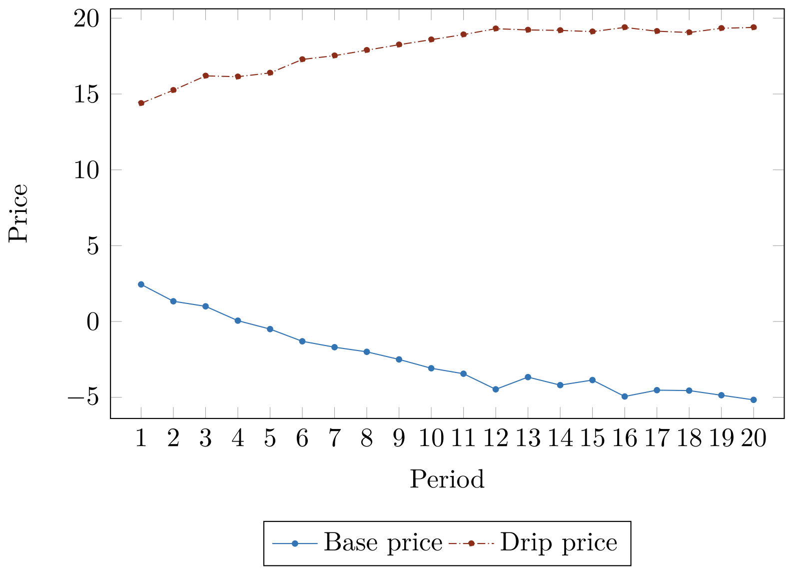
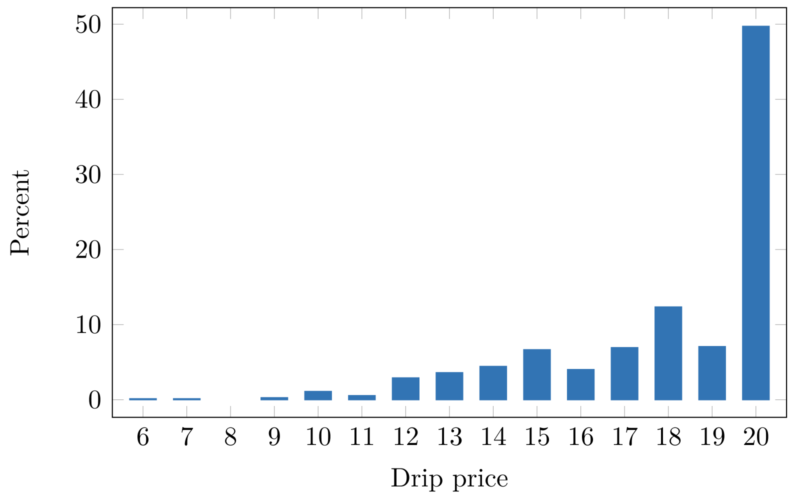
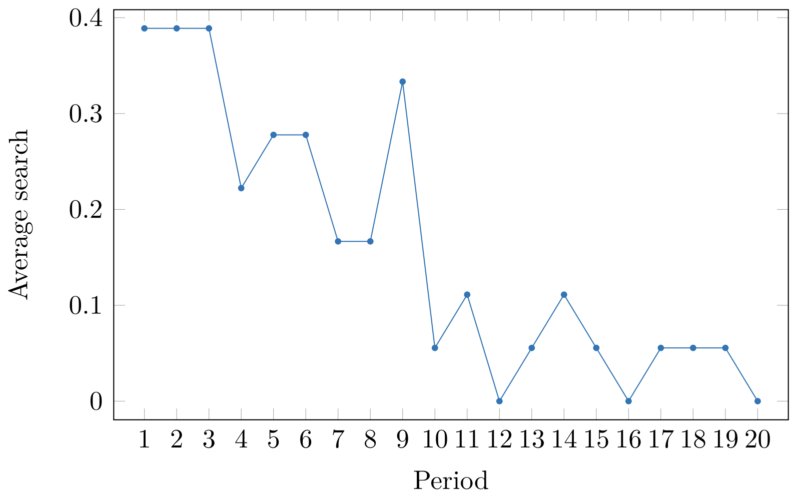


Figure 3.4: Evolution of price components in treatment BIG DRIP.

With the increased drip price limit, we find the same price pattern as in the DRIP treatment. Sellers are charging drip prices at (or close) to the upper limit and only compete in base prices. Figure 3.4 shows that as sellers become more experienced, the average drip price converges toward the upper limit of 20 ECUs. By contrast, the base price decreases, taking negative values as the number of periods increases. Panel a) of Figure 3.5 shows the distribution of drip prices for the BIG DRIP treatment. It is apparent that the upper limit is chosen in the majority of cases. Low drip prices (that is, less than 10 ECUs) are never observed. Thus, as in the base treatment,



(a) Frequency distribution of drip prices.

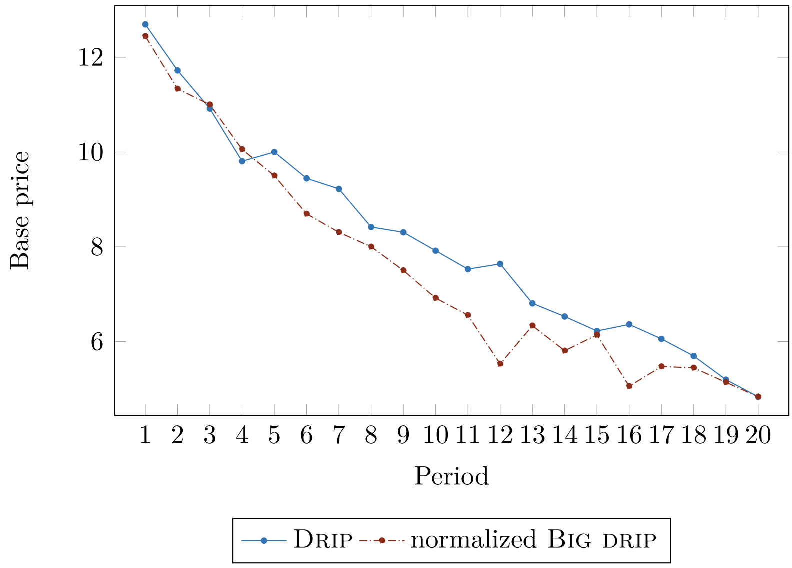


(b) Evolution of buyers' search decision.

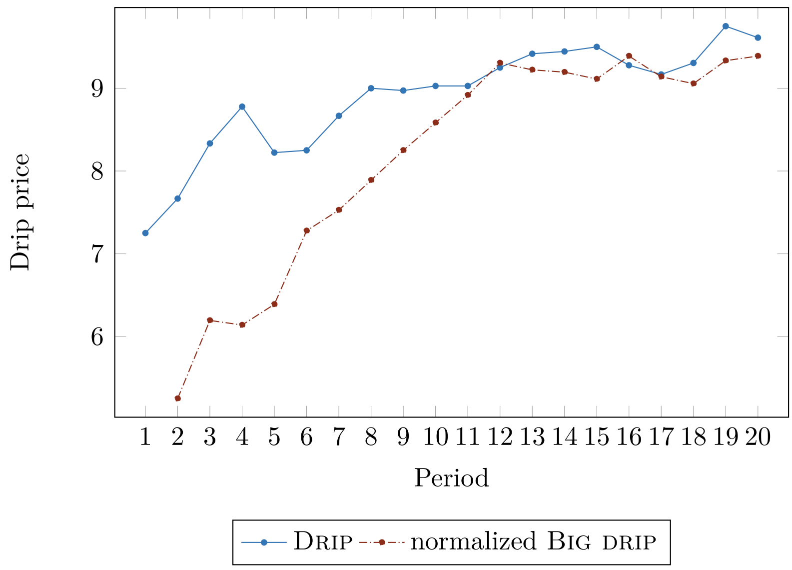
Figure 3.5: Distribution of drip prices and search effort in treatment Big drip.

sellers do not compete in drip prices. Also here, buyer experience drives down search rates (panel b) of Figure 3.5) and we again observe buyers identifying the cheapest offer in the majority of cases. Only in 13.7% of the cases do buyers purchase from the seller charging the higher total price.

Figure 3.6 represents an alternative way of highlighting similarities between the two treatments. In the figure, prices of the Big drip treatment are normalized by adding 10 ECUs to the base price and subtracting 10 ECUs from the drip price. Overall, pricing components in the two treatments follow similar time trends, but learning effects for drip prices in the Big drip treatment appear to be slower (panel b) of Figure 3.6).



(a) Base price.



(b) Drip price.

Figure 3.6: Comparison of price components: Drip and normalized Big drip.

However, overall total prices seem to be slightly smaller with the higher drip (see Figure 3.6 and 3.7), but this difference becomes smaller as time progresses. Thus, regulating drips does not seem to be an effective policy here. This is confirmed when statistically comparing the two treatments. Allowing for a larger drip leads to lower base prices but higher drip prices (Mann-Whitney rank-sum test, $p = 0.004$ and $p = 0.004$, respectively). Both total prices offered and total prices paid are lower. These differences are statistically significant, but economically small (Mann-Whitney rank-sum test, $p = 0.078$ and $p = 0.055$). Although this leads to comparably lower firm profits and higher consumer surplus, these differences are again small (Mann-Whitney rank-sum test, $p = 0.078$ and $p = 0.109$). In fact, if only the last 10 periods of the experiment are considered, the differences in offered and total prices, as well as the differences in firm profits and consumer surplus, become insignificant (Mann-Whitney rank-sum test, $p = 0.337$, $p = 0.262$, $p = 0.262$ and $p = 0.262$, respectively). Put differently, in the long run when taking learning effects into account, a drip price regulation seems to have no effect. Finally, with a larger drip, total prices are not statistically different from those under Bertrand competition (Mann-Whitney rank-sum test, $p = 0.810$). These effects are summarized in the following result:

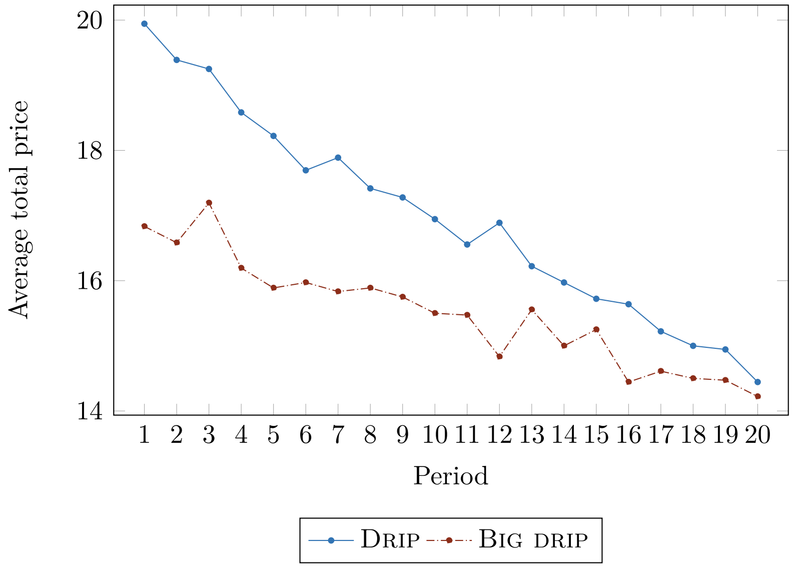


Figure 3.7: Comparison of total prices in Drip and Big drip.

Result 3.4. *Regulating the drip leads to a lower drip price but a higher base price. Over all periods the total price is higher after regulation, but this effect vanishes when taking learning effects into account.*

Surprisingly, this implies that allowing for a larger drips eliminates the small profit advantage that sellers benefit from under drip pricing in comparison with Bertrand competition. Put differently, efforts to counter the anti-competitive effects of drip pricing by capping its size may be to no avail, as lower drips lead to higher total prices and sellers enjoy higher profit margins. Though profit levels and total prices are higher than predicted, the finding is in line with Hypothesis 3.4.

3.4.4 Buyer uncertainty regarding the drip price limit

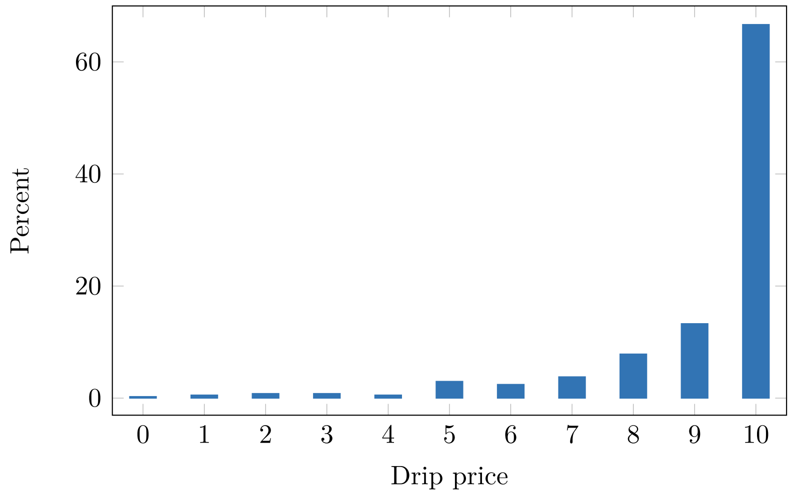
In order to account for the observation that buyers typically face uncertainty regarding sellers' drip price limit, in the treatment RANDOM DRIP we randomize the maximum drip price size. With a probability of 50% a seller is faced with a drip price limit of 20 ECUs. With a probability of 50% she is faced with a limit of 10 ECUs. Regardless of the maximum drip price, the total price could not exceed 30 nor fall below 10 ECUs. Drip price limits were assigned anew every period.

In Table 3.2 the results of treatment RANDOM DRIP are shown separately. Next to the total average results of the treatments, the table also shows the results for each of the two drip price limits.

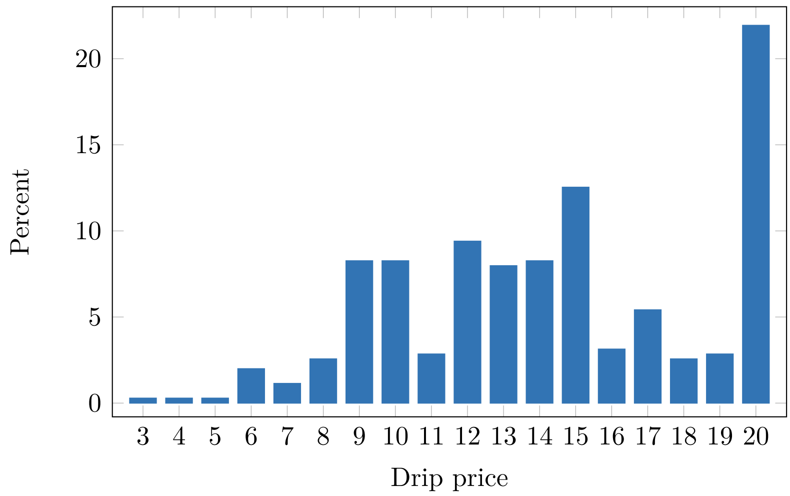
Seller behavior

Table 3.2 shows that despite the random drip price limit assignment, sellers still choose a skewed pricing scheme. Overall, sellers choose an average drip price of 4.69 ECUs and an average drip price of 11.66 ECUs. Looking at each type's pricing strategy separately reveals that those sellers whose maximum drip price equals 10 ECUs, choose significantly lower base prices and drip prices similar to those in the DRIP treatment (Mann-Whitney rank-sum test, $p = 0.010$ and $p = 0.337$, respectively). By contrast, sellers with a maximum drip price of 20 ECUs choose significantly higher base prices but significantly lower drip prices than their counterparts in the BIG DRIP treatment (Mann-Whitney rank-sum test, $p = 0.007$ and $p = 0.010$, respectively). Taking a closer look at the drip price frequencies further shows that while sellers with a drip price limit of 10 ECUs still mostly choose 10 as their drip price, there is now visibly more variation in drip prices of sellers with a drip price limit of 20 ECUs, as shown in Figure 3.8. The frequencies of the drip prices in Figure 3.8 suggest that, in contrast to the previous treatments, there is now also some competition in the drip price, at least among those sellers who were assigned a maximum drip price of 20 ECUs. The average drip price has dropped to 14.34 ECUs.

Interestingly, as Table 3.2 also shows, sellers who were assigned the high drip price limit charge a lower base price and higher drip price (Wilcoxon signed-rank test: $p = 0.028$ and $p = 0.028$, respectively) than their counterparts with a limit of 10. Moreover, sellers who were assigned the high drip price limit charge significantly higher total prices and earn higher profits (Wilcoxon signed-rank test: $p = 0.028$ and $p = 0.046$, respectively). As a result, despite the observation that there is now also competition in the drip price when the drip price limit is high, sellers seem to be better off with the maximum drip price of 20. We note that this advantage of



(a) Sellers with a maximum drip price of 10.



(b) Sellers with a maximum drip price of 20.

Figure 3.8: Frequency of drip prices in treatment Random drip.

sellers with the high drip price limit also extends to the comparison with standard Bertrand pricing ($p = 0.010$ and $p = 0.025$, respectively).

These findings mainly accord with our theoretical predictions. As hypothesized, sellers are no longer able to charge drip prices up to the maximum, but due to the presence of low limit sellers are forced to lower it. Nevertheless, high drip price limit sellers benefit by charging higher total prices and earn higher profits. In contrast to the theory, however, sellers with a high drip price limit charge lower base prices and do not fully mimic the behavior of the low limit sellers. Yet, buyers do not seem to take this fully into account as profits are higher. In the next subsection, we will explore buyer behavior in more detail.

We summarize the main findings regarding seller behavior in the following result:

RESULT 3.5. *With random drip price limits,*

i) sellers still choose a skewed pricing scheme with a low base price and a high drip price. However, now there is also some competition in drip prices, which only affects those sellers with a high maximum drip price,

ii) high drip price limit sellers charge a lower base price and a higher drip price than their low limit counterparts, and

iii) high drip price limit sellers charge a higher total price and earn higher profits both compared to their low limit counterparts and standard Bertrand pricing.

Buyer behavior

One striking observation is that, although the pattern of the drip price frequencies in Figure 3.8(b) has changed considerably, buyers' search behavior has not. On average, buyer search has only increased slightly (but not significantly) to 19% as compared to the treatments DRIP and BIG DRIP, where search probabilities amounted to 13% and 15%, respectively.

Another striking observation is that in the first stage buyers predominantly choose according to a lower base price. In the treatment RANDOM DRIP in 79% of observations participants chose the seller offering the lower base price. Looking only at cases where a seller with a high drip price limit competes against a seller with a low drip limit we still find that in 69% of observations participants chose according to the lower base price. As sellers with a high limit tend to have lower base prices, with a probability of almost 66% did buyers make the seller with the higher drip price their first choice, whenever competing sellers differed in their drip price limits. We interpret this as evidence for the attraction effect of lower base prices (e.g., Ahmetoglu *et al.*, 2014). Buyers seem to be drawn towards lower base prices while somewhat neglecting that exactly those sellers tend to charge higher drip prices.

Due to search friction this implies that buyers may not always end up with the lowest price. As compared to both previous drip pricing treatments ex-post buyer mistakes have increased to 21%. That is, on average, 21% of buyers did not choose the cheapest offer. This difference is also significant with respect to the DRIP treatment, where an even lower search probability leads to only 13% of buyers failing to identify the cheaper seller (Mann-Whitney rank-sum test, $p = 0.0538$). In those instances where two competing sellers were assigned different drip price limits, a situation in which a buyer purchased from the seller with the higher price occurred in even more than 35% of purchase decisions.

Result 3.6. *With random drip price limits,*

i) buyers search more as compared to the previous drip price treatments, though not significantly, and

ii) buyers choose predominantly according to lower base prices, and

iii) from an ex-post perspective buyers end up with higher total prices more frequently compared to the treatments where sellers have identical drip price limits.

Thus, from a policy perspective, situations where buyers are not perfectly informed about the use of drip pricing strategies appear to be worrisome. Buyer search is still at a rather low level and buyers fail to identify the cheapest offer in a large number of cases. This complements the findings in Huck and Wallace (2015) who also report too little search when prices are drawn randomly.

3.5 Conclusion

Sellers often advertise only part of a product's price in order to attract buyers and reveal additional price components at later stages of the purchasing process. Previous studies, mostly focusing on just one side of the market, have found this to be harmful, causing buyer confusion and discouraging price search. In an experimental setting we study this pricing strategy, examining both seller and buyer behavior and find that the effects of drip pricing depend to a large degree on consumer information on the use of drip pricing. When consumers are well informed about the use, we find only little support for these previous findings. In fact, our experiment shows that even when sellers employ drip pricing, competitive market forces drive prices almost down to Bertrand competition levels and buyer search behavior is nearly optimal. To be precise, we find intense competition in base prices, but almost no competition in drip prices. As a result, most buyers correctly anticipate total prices based on the base price and do not invest in search. These results change when uncertainty about the drip price limit on the buyer side is introduced. There, sellers with a high drip price limit also compete in drip prices and post significantly higher total prices than their low limit counterparts, resulting in equally higher profits. In addition to this, buyer search is less optimal and buyers are purchasing from sellers with higher prices more frequently.

From a policy perspective this study has two important implications. First, in contrast to the related literature on the topic, the practice of drip pricing may only have small effects when buyers are well informed about the use of drips. Total prices increase little compared to Bertrand competition and the reduction in buyer surplus is small. Second, when consumers are less experienced about the use of drip pricing strategies, drip pricing may be more detrimental to consumers as the number of mistakes increases. In such situations, policy interventions might be more beneficial for consumers.

3.A Appendix

Theoretical derivations

Derivation of Proposition 3.2. Here we show that a pooling equilibrium exists where both types of sellers charge an identical base price of $c - \bar{p}_L$, but differ in their drip price ($p_2^L = \bar{p}_L$ and $p_2^H = \bar{p}_L + 2s$). Accordingly, with identical base prices buyers cannot identify seller types, a buyer observing a base price $c - \bar{p}_L$ expects each type with equal probability. Consider the following out-of-equilibrium beliefs. For any base price unequal $c - \bar{p}_L$, the buyer believes the seller to be the high type. In the following we show that no player has incentive to deviate from the strategies described in Proposition 3.2.

First note that, given prices and beliefs, a buyer will never search for the second drip. As base prices are identical, a seller type will be revealed only after the buyer inspects the first drip price. There is obviously no reason to search if the buyer discovers a seller of type L. However, there is also no incentive to search if the buyer has tentatively chosen a seller of type H. Search is only worthwhile if the other seller is of type L which happens with probability 0.5 in which case the buyers saves an amount of $2s$. Hence, the benefits from search are $0.5 \cdot 2s = s$. Hence, the benefits coincide with the cost, hence, there is no incentive to search a second seller. Next, note that given identical base prices, a buyer cannot distinguish seller types. Thus, consider that a buyer will choose either seller with equal probability.

Consider the behavior of a seller of type L. Given the proposed pricing strategies, the total price equals marginal cost and the seller is chosen with probability 0.5. The expected profit is zero. Notice that the seller cannot profitably deviate from the proposed strategies. As the seller charges the highest possible drip, he can neither increase his drip price nor profitably deviate to a lower drip price. Increasing the base price is also not profitable as buyers would believe the seller to be type H and abstain from buying from this seller. Decreasing the base price would lead to a total price below cost.

Finally, consider the behavior of a seller of type H. Given the proposed pricing strategies, the total price exceeds marginal cost and the seller is chosen with probability 0.5 due to identical base price as type L. Decreasing the drip would only lead to reduced profit margin, but no additional buyers and is therefore not profitable. Increasing the drip price is also not profitable as it would induce the buyer to search and thus to the loss of the buyer. Finally, charging a lower base price would reveal the seller to be type H and thus a buyer would strictly prefer to chose the other seller. Similarly, increasing the base price is not an attractive option, as buyers would believe the seller to be type H and abstain from buying from this seller.

Instructions

Here we provide a translation of the instructions. The original instructions are in German. We provide the instructions for the treatment Drip.

In this experiment you are either assigned the role of a buyer or a seller. Which role is assigned to you is randomly determined at the start of experiment and communicated to you. You keep your role for the entire experiment.

A market consists of two sellers and one buyer. Before the start of each round of this experiment, two sellers will be randomly matched with one buyer by the computer. This matching takes place every single round. Whether you are matched with entirely new participants or participants you have already been matched with in one of the preceding rounds is determined randomly and cannot be anticipated.

Each seller wants to sell one unit of his product to the buyer. For production of one unit of his product the seller incurs costs of 10 units. Each buyer wants to purchase exactly one unit of the product. In each round the buyer therefore has to decide between the two sellers.

The sellers set two prices for their respective product: a base price and an additional price. The total prices is the sum of both prices:

$$\text{total price} = \text{base price} + \text{additional price}.$$

Each round of the experiment consists of three stages:

Stage 1: The sellers determine their prices. The base price has to range from 0 to 20 units. The additional price has to range from 0 to 10 units. The total price cannot be higher than 30 units and cannot be lower than 10 units.

Stage 2: The buyer first only observes the base prices of the two sellers. The buyer then tentatively decides for one of the sellers.

Stage 3: The buyer now also observes the additional price of the tentatively chosen seller. The buyer then decides whether he wants to stick with his initial choice or observe the additional price of the other seller, too. Does the buyer stick with his initial choice, he makes a purchase at the chosen seller and the round ends. Does he instead want to observe the additional price of the other seller, he has to bear a cost of 2 units. The additional price of the other seller is then revealed and the buyer can now decide where to make his purchase.

At the end of each round you will be informed about your units earned. In each round the earnings of a buyer are equal to:

$$\text{Payoff buyer} = 35 \text{ - total price - cost for second price revelation (if applicable).}$$

In each round the seller receives the total price he set in stage 1 of each round less the cost of production conditional on the buyer choosing his product:

$$\text{Payoff seller} = \text{total price - 10.}$$

If a buyer chooses the product of a seller's competitor, that seller does not incur any cost of production and has no earnings.

The experiment lasts for 20 rounds. At the end of the experiment you will receive your cumulative earnings in addition to a participation reimbursement.

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Chapter 4

Coordination, Reputation and Preannouncements: An Experiment

4.1 Introduction

Especially in high-tech and information based industries it is common for firms to announce new technologies well in advance of market availability. One purpose of these preannouncements is to convince consumers to delay their purchase decision in favor of the announced technology, thereby “freezing” the market until its launch. Examples of preannouncements include video game consoles (Playstation, Xbox, etc.), computer operating systems (Windows, MacOS) and mobile operating systems (Android, iOS, Windows Mobile). There are two important features which these types of industries have in common. Firstly, they are often characterized by network effects which gives rise to coordination problems. Secondly, product cycles are relatively short, that is, consumer demand is fundamentally influenced by the release of new versions of a technology. Consumers therefore often purchase repeatedly.

In markets with network effects the value of a product for a consumer increases in the size of its network, that is, a consumer cannot fully enjoy the benefits of a product unless other consumers use the product as well. This can result in a “lock-in” of consumers who may be unwilling to switch to a competing product with fewer users and create a barrier of entry for other firms, regardless of the product’s quality. In this context consumers can use preannouncements as a means to coordinate and the announcement may therefore critically influence the outcome of competition. To be more precise, preannouncements can both be pro-competitive by securing a new technology’s success over an already existing one and anti-competitive by bringing consumers to excessively delay their purchase decision in favor of a socially less valuable technology (Farell and Saloner, 1986). These effects on competition were also discussed in the 1994-95 licensing court case against Microsoft (see United States vs. Microsoft Civil Action No. 94-1564) but while the judge acknowledged the potential anti-competitive effects of preannouncements, no restrictions where placed on Microsoft in this regard.

Since preannouncements can be used to persuade consumers into waiting for the new technology’s launch, there exists an incentive for firms to exaggerate its quality. This may be particularly tempting when the innovation is incremental rather than radical (Lilly and Walters, 1997). However, exaggerating a technologies quality can come at the cost of future sales, that is, a loss of firm reputation. These reputational concerns are particularly important in dynamic industries where firms continuously develop new products and consumers make repeated purchases. Exaggerated preannouncements can therefore be punished by consumers through the market mechanism, thereby incentivizing firms to be honest (Klein and Leffler, 1981; Fisher *et al.*, 1983; Fisher, 1989).

In this paper these effects of preannouncements on consumer and firm behavior are formalized in a game of strategic information transmission and then tested in a series of laboratory experiments. The experiments are framed as a model of technology adoption in a market with two competing firms, A and B, where both firms develop a sequence of technologies. Consumers choosing firm A's technology benefit from network effects but are faced with quality uncertainty while technology B serves as a safe outside option. Furthermore, firm A can communicate its technology's quality via a cheap talk message to consumers and consumers make repeated purchases. From a theoretical perspective, in the short run, firms have an incentive to distort the truth and exploit the asymmetry in information to some financial advantage. In the long run, however, firms risk losing credibility by being untruthful and have an incentive to build a reputation for being honest. To identify the effects of preannouncements on consumer coordination I vary the size of network effects and compare the results to those of a "silent" version of the game, where the firm cannot make any announcements. I find that the announcement does not have any effect on overall coordination, but significantly increases efficiency. However, the announcement does have an impact on which technology consumers coordinate on, once coordination is achieved. When network effects are strong, the announcement by firm A does not lead to more, but less coordination on technology A. This effect is reversed when network effects are weak. One reason for these results is that honesty is only rewarded in periods in which technology A's quality is high. When low quality is announced it is always optimal for consumers to switch to technology B. Furthermore, with strong network effects fewer firms pursue an honest strategy and consumers are less willing to punish deceptive behavior by the firm. One explanation for this finding is that with strong network effects coordination on technology A is relatively more attractive for consumers than with weak network effects. As a result it may be that consumers are more forgiving with strong network effects and, anticipating this, firms are encouraged to make misleading announcements. Thus, reputational concerns are less pronounced when network effects are strong.

The rest of the paper is organized as follows. Section 4.2 relates this work to the relevant literature. Sections 4.3 and 4.4 describe the basic framework of the model and discuss the experimental design and procedures. Section 4.5 summarizes the results of the experiment, analyzing both the role of announcements and firm reputation in this setup. Section 4.6 concludes.

4.2 Literature Review

This paper is broadly related to the literature on sender-receiver games and more closely related to the economics of network effects and preannouncements. In the literature of sender-receiver games the seminal work by Crawford and Sobel (1982) predicts that when preferences between sender and receiver are not aligned, no information is transmitted in the one-shot equilibrium and receivers ignore the signal by the sender. Experimental tests of this theoretical result have shown, however, that even when incentives are not aligned senders reveal information and receivers include this information in their decision making process (Cai and Wang, 2006; Sánchez-Pagés and Vorsatz, 2007). By contrast, in a field experiment Jin and Kato (2006) analyzed seller claims about baseball card quality on ebay and find that high-claim sellers are most likely to commit fraud and offer low quality. This, however, did not result in punishment by buyers which according to the authors could be attributed to a lack of buyer sophistication and incorrect beliefs about the distribution of quality on the market. This paper differs from the literature on sender-receiver games in two important aspects. First, it assumes that there are multiple receivers who interact strategically via network effects. As a result the announcement, if effective, becomes a more powerful tool, which can have significant implications for competition. Second, the paper analyzes a setting with repeat interaction between senders and receivers to examine the importance of reputation effects when senders can make cheap-talk announcements.

The central insight of the theoretical literature focusing on network effects is that there exist multiple equilibria in which consumer expectations are fulfilled and where consumers coordinate on the product of the firm which they expect to be dominant in the future (Katz and Shapiro, 1985; Suleymanova and Wey, 2012). As argued by David (1985) in his analysis of the typewriter keyboard market, this can also lead to the adoption of an inferior technology despite the availability of better alternatives. In contrast to this, Hossain and Morgan (2009) experimentally show that in a game of platform competition subjects never get stuck on an inferior option.

In the theoretical literature on preannouncements this paper is closest to Choi *et al.* (2010). In a setting very similar to mine they show that even though the announced products may never be launched, a phenomenon also known as vaporware, announcements are still valuable to consumers. In their model consumers have incomplete information about a firm's type and the products quality. Consumers can then choose whether to buy an outside product or postpone their purchase decision until the announced product is available in a later period. Choi *et al.* (2010) show that there exists a partially informative equilibrium in which the announcement is credible with a certain probability when the game is repeated twice. Even though their work is similar to mine, they focus on a purely theoretical analysis of preannouncements and do not consider network effects. Little work focuses on the empirical analysis of announcements in network industries.[1] An empirical study by Dranove and Gandal (2003) examines both network and preannouncement effects in the context of video players. They find that the preannouncement did in fact slow down the adoption of a competing technology, if only temporarily.

This paper is also somewhat related to the extensive literature on coordination games. This literature mostly focuses on the conflict between payoff dominant and risk dominant outcomes. According to Harsanyi and Selten (1988) who defined the term risk dominance, payoff dominance should be the first criterion to be applied to equilibrium selection in case of tensions between the two criteria. Some studies, however, have found that play in coordination games converges to the risk dominant equilibrium rather than the payoff dominant equilibrium (Straub, 1995; Van Huyck *et al.*, 1991). By contrast, Clark *et al.* (2001) have shown that allowing for communication among the players reverses this result and induces a convergence to the payoff dominant equilibrium. Furthermore, Schmidt *et al.* (2003) find that changes in risk dominance significantly affect play while changes in payoff dominance do not. In addition to this, they find that the observed history of play has an important influence on subject behavior. In the context of network effects Keser *et al.* (2012) show theoretically and experimentally that both the payoff dominant and the risk dominant criterion can explain behavior, when subjects face a trade-off between the two. Neither one of those studies has analyzed the effect of announcements on coordination behavior and equilibrium selection.

The present study contributes to this previous literature by examining the impact of preannouncements on consumer choice in the presence of network effects. Furthermore, it analyzes the effect of variations in the size of network effects on firm honesty and consumer choice. Finally, it shows whether the market mechanism is sufficient to prevent fraudulent claims by firms when network effects are present. The results may serve as a guideline for policy makers when facing anti-competitive concerns and can inform them under which market conditions it may be advisable to intervene. To the best of my knowledge this paper is the first to model interaction by receivers via network effects when senders make announcements repeatedly and to analyze the effects of preannouncements with the help of controlled laboratory experiments.

[1] Park (2004) and Gandal *et al.* (2000) focus on network effects only and find that network effects play an important role in the high-tech industry and can be key in determining the success of one firm over another.

4.3 Theoretical Background

Consider the following simple dynamic model of cheap talk, where the state of the world changes over time. In each period $t \geq 1$ of the game a firm A (the sender) privately observes the quality $s_t \in \{H, L\}$ (the state) of the single technology it produces and makes a public announcement $m_t \in \{H, L\}$ about its quality to $n > 1$ identical consumers R_i (the receivers).[2] After having observed the firm's announcement, consumers play a one-period coordination game, whose payoffs depend on the underlying quality. The technology of firm A can either have high or low quality and each consumer $i = 1, ..., n$ has two possible choices: she can either purchase the technology of firm A by taking action a_t or buy the technology from firm A's competitor, firm B, by taking action b_t.[3] We assume that payoffs are observed and the true quality of firm A's technology is revealed after each period, such that consumers can tell whether the message by the firm was truthful or not. Furthermore, successive qualities are independent and the prior probability of firm A supplying a high quality good is $\theta \in (0, 1)$, where θ is common knowledge.

The current quality of firm A's good together with the current actions of the consumers determine their utilities. Consumer i's payoff from choosing action a_t increases in the number of other consumers taking the same action in t. The magnitude of the increase is captured by a constant, $\beta > 0$, reflecting the size of the network effects of technology A. The sum of consumers choosing action a in period t is denoted by n_t^A. In addition, upon purchasing firm A's technology consumer i has a constant payoff x^j whose value depends on the technology's quality such that $j = H, L$ and $x^H > x^L \geq 0$. Consumer i's payoff from buying firm B's technology, however, is constant. The payoffs are summarized in Table 4.1.

		True state	
		H	L
R_i's action	a_t^i	$x^H + \beta(n_t^A - 1)$	$x^L + \beta(n_t^A - 1)$
	b_t^i	c	c

Table 4.1: Receiver i's payoffs by state and action

I make the following assumption with respect to consumer payoffs:

[2]There are as many messages as states.

[3]In the experimental analysis firm B's technology will merely serve as an (computerized) outside option.

$$x^H \geq c > x^L + \beta(n-1).$$

This implies that if the quality of firm A's technology is low, consumers always prefer to purchase technology B, regardless of the other players' choices. If the quality of technology A is high, consumers always prefer A over B. If the consumers do not have any information beyond their prior belief, the static game has at least one pure strategy equilibrium depending on the size of θ:[4]

Proposition 4.1. *In the static game, as long as* $\frac{c-x^L-\beta(n-1)}{x^H-x^L} < \theta < \frac{c-x^L}{x^H-x^L}$ *there are two pure strategy equilibria. One in which (risk-neutral) consumers coordinate on the technology of firm A and one in which they all opt for firm B's technology. In that case there is also one equilibrium in mixed strategies, where consumers choose technology A with probability* $p_A = \frac{c-[\theta x^H+(1-\theta)x^L)]}{\beta(n-1)}$. *If* $\theta < \frac{c-x^L-\beta(n-1)}{x^H-x^L}$ *only the b-equilibrium exists, for* $\theta > \frac{c-x^L}{x^H-x^L}$ *all consumers choosing a is the only equilibrium.*

The size of β has an impact on consumer payoffs and therefore affects the pure strategy equilibria. As β decreases, everything else constant, the lower bound of the size of the two-equilibria interval defined in the proposition above increases and it becomes more likely that there are two equilibria. As the size of network effects approaches zero, the thresholds become one and depending on the size of θ there is either a single equilibrium in which all consumers choose technology A or a single equilibrium in which they coordinate on purchasing technology B. In other words, as network effects increase, the range of θ that allows for multiple equilibria increases which give rise to a coordination problem.

Firm A does not take any payoff-relevant action. Its payoff depends on the actions taken by the receivers and a constant $\rho > 0$, which can be thought of as the price of technology A, such that

$$\pi_t^A = \rho \cdot n_t^A.$$

If none of the consumers buy firm A's technology in a given period t, the firm's payoff in that period will be equal to zero. As a result, regardless of the quality, firm A always prefers consumers to buy its good, whereas consumers always want to "match" the state. When quality is high, preferences between firm A and consumers are therefore perfectly aligned. When quality is low, however, incentives are opposing. As a result, the public announcements made by firm A in the first stage of the game need not credibly transfer information about the true quality of its product. In fact, in the static game all equilibria are babbling equilibria in which the actions taken by the receivers are independent of the message sent by A. A separating

[4]The proof to Proposition 4.1 is included in Appendix A.

equilibrium in which firm A truthfully reveals the state and consumers believe its message cannot exist in the static game as the sender always has an incentive to lie when the quality is low.

Repeated interactions between sender and receivers, however, could allow for equilibria in which A's signal is in fact informative. The underlying mechanism is one where firm A builds a reputation for sending truthful messages and consumers trust the signal. In the model, reputational concerns can be induced by extending the time horizon to infinity, assuming that firm A develops a sequence of new technologies and consumers adopt a trigger strategy. This means that consumers trust the firm's announcement until the first misleading announcement has been made and purchase technology B thereafter. As long as the firm announces truthfully consumers will coordinate on technology A if high quality is signaled. They will switch to firm B's technology after a low quality announcement. Let δ be the discount factor of firm A.[5]

Proposition 4.2. *Under the assumption that $\theta < \frac{c-x^L}{x^H-x^L}$ (i.e. all consumers purchasing B is a Nash equilibrium of the static game) the infinitely repeated game has a subgame perfect Nash equilibrium in which consumers play a trigger strategy and firm A always makes truthful announcements iff $\delta \geq \frac{1}{1+\theta}$.*

This means that with infinitely repeated interaction and for sufficiently high values of δ, firm A will also announce truthfully in the low state, even though consumers buy from the competing firm in that case. As a result, in the honest equilibrium, firm A accepts a profit of zero in a period with low quality in order to guarantee maximum sales in a period with high quality. Firm A enjoys a positive payoff as opposed to the equilibrium in which no information is transmitted and consumers opt for technology B, while consumers earn the highest payoff possible.

In the infinitely repeated game, an increase in the magnitude of the network effects of technology A has no effect on firm A's announcement decision. If the firm chooses to signal its quality truthfully, consumers will match the state regardless of the magnitude of the network effects, just like in the static game. In the babbling equilibrium, the effect of an increase in network effects will be the same as in the static game. If the increase is sufficiently large, choosing technology A becomes an equilibrium action for consumers.

[5]The proof to Proposition 4.2 is included in Appendix A.

4.4 Experiment

4.4.1 Experimental design

The experiments were implemented as a sequence of repeated games, each consisting of an announcement decision stage for the firm, followed by a purchase decision stage for the consumers. Within a stage all purchase decisions were made simultaneously and players stayed in their designated roles for the entire duration of one session. At the beginning of a session one firm was paired with three consumers which constituted one group and due to the fixed matching one independent observation. After 15 rounds of play, the game was continued with a probability of 2/3.[6] The session was over, once the computer determined that there would be no additional round of play. As a result, the number of rounds played varied with each session. At the end of every round all players were informed about their payoffs from this round and their cumulative payoffs. Furthermore, all consumers were informed about the true quality of the firm's product.

There were four treatments which differed in their payoffs for consumers: in the treatments denoted "StrongNE" network effects were strong (i.e. $\beta = 2$) and payoffs from choosing firm A's technology increased a lot in the number of other consumers also choosing A. In the treatments denoted "WeakNE", network effects were weak (i.e. $\beta = 1$), this effect was much smaller. Only in the treatments denoted by "WeakNE/A" and "StrongNE/A" were subjects in the role of firm A able to make announcements about the quality of their technology. In the treatments "StrongNE" and "WeakNE" no announcements were made.[7]

The parameters chosen are presented in Table 4.2. The stand-alone value for the high quality technology x^H was 5, while the stand-alone value for the low quality technology x^L was 0. Since one group consisted of three consumers and one firm, the maximum value n_t^A could take was 3. When network effects were strong the maximum payoff a consumer could reach in one round was 9. When network effects were weak the maximum payoff was 7. The highest payoff could only be achieved when all three consumers chose firm A's technology and its quality was high. Equally, when firm A's technology was low, the maximum payoff from choosing firm A's technology was 4 when network effects were strong and 2 when they were weak. Choosing firm B's technology resulted in a constant payoff of 5, irrespective of state and treatment.

[6]Here, this continuation probability is interpreted as the discount factor. According to the model a probability of 2/3 is sufficient to give firms an incentive to pursue a truthful strategy.

[7]To ensure the comparability of treatments with and without announcements, the role of firm A was still assigned to participants in the treatments were no announcements were possible.

		True state (StrongNE)		True state (WeakNE)	
		H	L	H	L
R_i's action	a_t^i	$5 + 2(n_t^A - 1)$	$2(n_t^A - 1)$	$5 + (n_t^A - 1)$	$(n_t^A - 1)$
	b_t^i	5	5	5	5

Table 4.2: Receiver i's payoffs by state, action and treatment

At the beginning of each new period subjects in the role of a consumer were uncertain about the true quality of technology A. With $\theta = \frac{1}{2}$, both the low and the high quality state were equally likely. Note that in the StrongNE treatment choosing product A over B was ex-ante only more profitable when all consumers decided to purchase from firm A. That is, for the parameters in the treatment, with a strong network effects, two was the critical mass needed to make coordination on the announced standard more profitable for the third consumer. With the belief that consumers would always coordinate, the expected payoff from choosing technology A was higher than from choosing B when network effects were strong. By contrast, when network effects were weak the expected payoff from purchasing A was always lower. Payoffs for firm A were equal across treatments: $\pi_t^A = 5 \cdot n_t^A$.

4.4.2 Experimental Procedures

Each session was run at the DICE Lab for Experimental Economics at the Heinrich-Heine-University of Düsseldorf in February, May and December 2015 and January and February 2016. Participants were drawn from a pool of mostly undergraduate students from different disciplines via email solicitations. The procedure used during the experiments was the same throughout all sessions and each session was computerized. The experiment was programmed and conducted with the software z-Tree by Fischbacher (2007). For the duration of the experiments, participants were not allowed to communicate and only able to see their own computer screen. Furthermore, written instructions were provided to all participants.[8]

A total of 200 students participated in 8 different sessions. A treatment including the instruction phase lasted no longer than 45 minutes. After the last period the cumulative profits of each of the players were converted into euros at an exchange rate of 20 experimental currency units to 1 EUR. Subjects were paid a show-up fee of 4 EUR in addition to their cumulative earnings. Including the show-up fee, average

[8] Sample instructions are included in Appendix B.

subject earnings were roughly 9 EUR per session. Table 4.3 presents a summary of all treatments:[9]

	StrongNE/A	StrongNE	WeakNE/A	WeakNE
Indep. obs. per treat.	14	11	13	12
Subjects per treat.	56	44	52	48
Av. periods per treat.	18.5	17.5	18	19
Av. earnings in €	10.65	10.25	8.80	8.40

Table 4.3: Summary statistics for each treatment

4.4.3 Hypotheses

According to theory and with the parameter values defined above the following equilibria could be observed. In the case where announcements by the firms were not possible and network effects were strong, there were three Nash equilibria. One in which all three consumers chose technology A, one in which they all chose technology B and one equilibrium in mixed strategies where they chose technology A with probability 0.625.[10] By contrast, with weak network effects there was a unique Nash equilibrium in which all consumers chose technology B.[11]

In the treatments with announcements and a continuation probability of 2/3 firms had an incentive to reveal the true state to the consumers in every period. Moreover, since firm A's incentive to announce truthfully is theoretically independent of consumers' payoff and choosing B was an equilibrium regardless of the magnitude of the network effects, full information revelation was an equilibrium in both treatments with announcements. In this equilibrium consumers then chose firm A's product, when high quality was announced but firm B's product when low quality was announced, regardless of the magnitude of the network effects. That way consumers obtained the highest possible payoff.

As a result of the payoff structure in the treatment with strong network effects also a dishonest firm A could still achieve the highest possible payoff if consumers decided to coordinate on technology A, ignoring the announcement. Since choosing

[9]Each group of four players was counted as an independent observation and all periods were used for the analysis.

[10]With strong network effects the conflict between equilibrium selection criteria exists: the equilibrium in which all consumers coordinate on technology A is payoff dominant, while the one where all consumers purchase technology B is risk dominant.

[11]In this case there is no conflict between payoff and risk dominance.

A was not an equilibrium in the treatment where network effects were weak, there the firm could not obtain a higher payoff pursuing a dishonest strategy.

The model suggests that impatient players in the role of a firm may always announce high quality, while patient players in the role of the firm may always announce truthfully. Similarly, consumers will never trust impatient firms and in that case choose one of the three equilibria of the static game. By contrast, they may trust players who always announce truthfully and purchase technology A when high quality is announced but switch to quality B when low quality is announced. However, the model cannot make a unique prediction about firm or consumer behavior as the repeated stage game has multiple equilibria and it is not clear which one of them will actually be chosen by the players. Therefore, this experiment should not be seen as a precise test of the model's predictions but rather as a guideline as to which strategies and equilibria are selected by the players. Nevertheless, the model provides a theoretical foundation and a reference point for the empirical analysis.

4.5 Results

I will first compare the results between the treatments where firms were able to make announcements with those where firms were not able to make announcements, focusing on the effect of announcements on both coordination and efficiency. Following this I will analyze the reputation mechanism, that is, compare the announcement behavior of firms and the punishment behavior of consumers when network effects are strong and when they are weak. To test for significant differences between treatments I use the two-sided non-parametric Mann-Whitney U test, treating each group of four participants as an independent observation. All periods were used for the analysis. Table 4.4 contains a summary of the results.[12]

[12]The variable "Choice A" indicates the average share of consumers who chose technology A. The variable "Cond. coor. on A" represents the average share of consumer who coordinated on technology A, conditional on having coordinated.

Treatment	StrongNE/A	StrongNE	WeakNE/A	WeakNE
Choice A	0.63	0.75	0.37	0.25
Coordination	0.71	0.61	0.62	0.53
Cond. coor. on A	0.67	0.86	0.31	0.08
Efficiency	0.69	0.48	0.71	0.50
Honesty	0.46		0.75	
Punishment	0.25		0.68	

Table 4.4: Aggregated results

4.5.1 The role of announcements

Figure 4.1 shows the percentage of total coordination for each of the four different treatments and indicates how much of total coordination was on technology A and how much on technology B.[13]

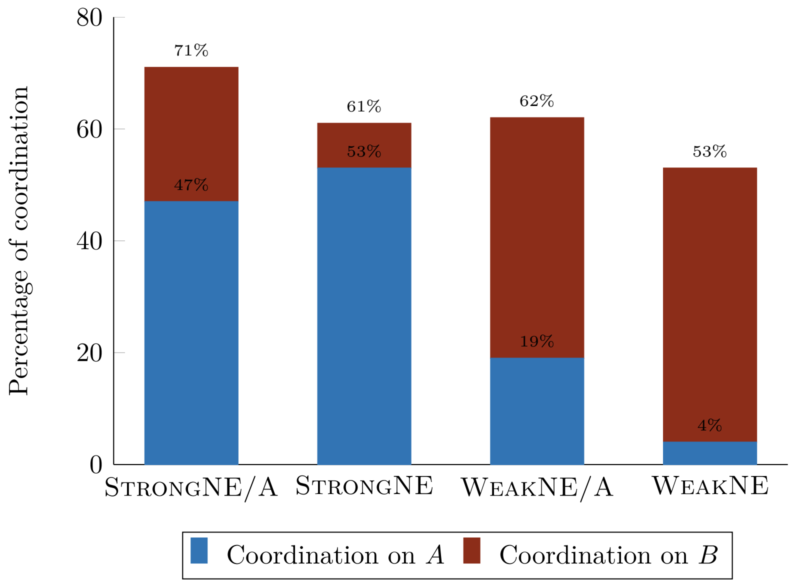

Figure 4.1: Average coordination of consumers on technologies A and B

With 71% total coordination among consumers is highest when network effects are strong and firm A could announce its technology's quality. It is lowest when network effects are weak and firms could not announce their technologies' quality. In the other treatments total coordination is just above 60%. Despite these visible

[13]In Figure 4.1 coordination on A and B are presented in absolute terms, not as percentages of total coordination.

differences in overall coordination between the four treatments, none of them are significant. In particular, the announcement itself does not lead to significantly more coordination, regardless of the size of the network effects.

Result 4.1. *Coordination among consumers is not significantly higher in those treatments were firms were able to make announcements.*

As the announcement makes one of the two technologies more salient, it could have facilitated coordination both in case of honest and dishonest firms. With honest firms all consumers could have coordinated on A when high quality was announced and on B when low quality was announced. Equally, with a dishonest firm A, consumers could have coordinated on technology A. However, this is not the case here as, on average, the announcement has no significant effect on coordination rates.

More importantly, however, there are significant differences in which of the two technologies consumers coordinated on, once coordination was achieved.[14] Here, the announcement does make a significant difference. When announcements were not possible and network effects were strong, 86% of total coordination was on technology A. By comparison, when firms did make announcements, only 67% of total coordination was on technology A, which constitutes a significant decrease ($p = 0.0321$). Reversely, In the treatments where no announcements were possible and network effects were weak, 8% of total coordination was on technology A and increased significantly to 31% when firms did signal consumers ($p = 0.0527$).

Result 4.2. *When network effects are strong, significantly fewer consumers coordinate on the announced technology as compared to the case where firms are not able to make announcements. The reverse is true when network effects are weak.*

It follows from Result 4.2 that when network effects are strong, on average, firms cannot use the announcement to their advantage by making consumers coordinate on the announced technology and stick with it. This also implies that preannouncements do not necessarily have anti-competitive effects in markets with strong network effects, as new competitors entering the market cannot be pushed out by making consumers coordinate on the announced technology. Moreover, while firms earned higher payoffs when they were not able to make announcements this difference is not significant ($p = 0.9563$). On average a firm earned 9.5 experimental currency units each period when announcements were possible which compares to 11.2 units, when they were not. One explanation for Result 4.2 is that in the treat-

[14] For the following significance tests, the percentages of coordination on technology A, conditional on successful coordination were used.

ments with announcements some of the firms decided to pursue an honest strategy, meaning they made truthful announcements when their actual quality was low, and consumers trusted the signal. In case of a low quality announcement it was then optimal for each consumer to switch to the competing technology B.[15] Consequently, in those instances total coordination on technology B was achieved. This may have driven down average coordination on technology A. It could also be the reason why total coordination is higher (though not significantly) in the treatment with announcement and strong network effects.

By contrast, with weak network effects, firms could benefit from the announcement as more consumers coordinated on their technology than would have done so, had there not been any announcements. This had significant implications for average payoffs per period of the announcing firms. On average firms earned 5.6 experimental currency units per period when announcements were possible but only 3.7 when they were not ($p = 0.0039$). This implies that with weak network effects firms are better off when they are able to make announcements than when they are not. The share of firms that pursued a credibly honest strategy could have been the driver for the increased coordination on technology A. There, consumers had a greater incentive to choose technology B as their expected payoff from doing so was higher. As a result, with low network effects, honest announcements could convince some of the consumers to choose technology A who otherwise would have chosen technology B. Summarizing, the effect of the announcement on the announced technology critically depends on the size of the network effects.

Even though the announcement did not help the firms increase their sales, it still increased overall efficiency. Here, an efficient consumer choice is one, where consumers choose technology A when its quality is high but purchase technology B when it is low. As a result, whenever a firm pursued an honest strategy and consumers believed the signal, efficiency was highest. By comparison, whenever a firm pursued a dishonest strategy, but consumers still managed to perfectly coordinate on either one of the two technologies, efficiency was reduced to 50%.

As Figure 4.2 shows, the size of the network effects barely had any effect on the level of efficiency. However, efficiency was always higher in treatments with announcements as compared to their silent counterparts. With strong network effects efficiency was 69% when announcements were made, as opposed to 48% when no announcements were made. This difference is significant ($p = 0.0062$). Similarly, in the treatments with weak network effects, efficiency was 71% when firms made announcements as compared to 50% when they did not. Also this difference is significant ($p = 0.0015$).

[15] All participants but one chose technology B whenever low quality was announced.

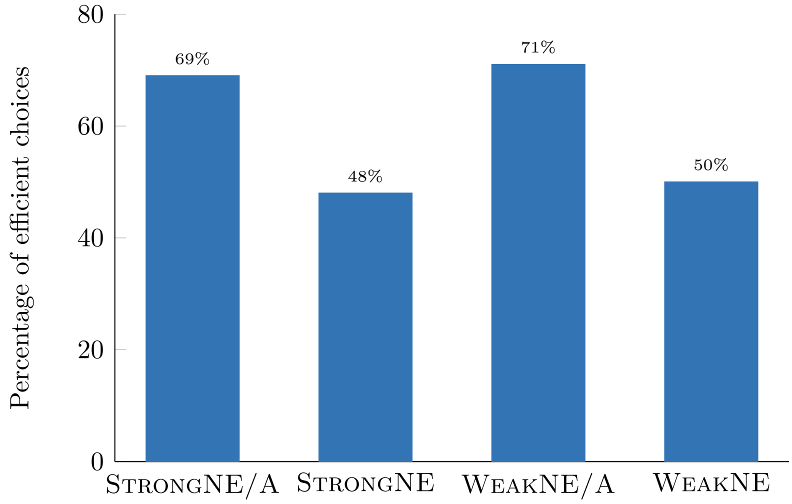

Figure 4.2: Average efficiency of consumer choices

Result 4.3. *Efficiency is significantly higher when firms announce their technology's quality. This is true, both when network effects are strong and when they are weak.*

Although announcements on average do not improve total coordination, consumers still benefit in terms of efficiency, as a higher efficiency translates into higher consumer payoffs. Thus, not only can the announcements not be used to lock consumers in on an inferior technology but consumers, on average, even benefit from the announcement. Furthermore, the magnitude of the network effects is not a significant driver of efficiency. However, also in terms of efficiency firms' announcement behavior seems to play a significant role, as announcements have to be both truthful and credible to increase efficiency.

4.5.2 The role of reputation

According to Proposition 4.2 it is an equilibrium strategy to always announce truthfully. By doing so a firm can build a reputation for being honest and thereby gain consumers' trust. One could argue that, rather than being a result of reputational concerns, truthful announcements can be attributed to a preference for honesty or altruism by the participants. However, there is some indication that this was not the case in this experiment. There were several firms who pursued a predominantly honest strategy throughout the first periods but then changed their behavior towards the end of the game, consistently announcing high quality in later periods. This suggests that the reason for their honest behavior was fear of punishment by the consumers, rather than a preference for honesty.[16] Furthermore, several players in the role of the firm indicated that the motivation for their chosen strategy was to maximize payoffs, as opposed to moral concerns in a short questionnaire conducted at the end of the session. Similarly, several players in the role of a consumer commented on the experiment by describing a strategy consistent with a trigger strategy. These findings suggest that reputation did in fact play a role in both the firms' and the consumers' decision process.

Figure 4.3 shows the frequencies of truthful announcements by firms for each of the two treatments where announcements were possible.[17] Since firms will always announce truthfully when the quality of their technology is high, I focus on those instances when firms were faced with low quality.[18]

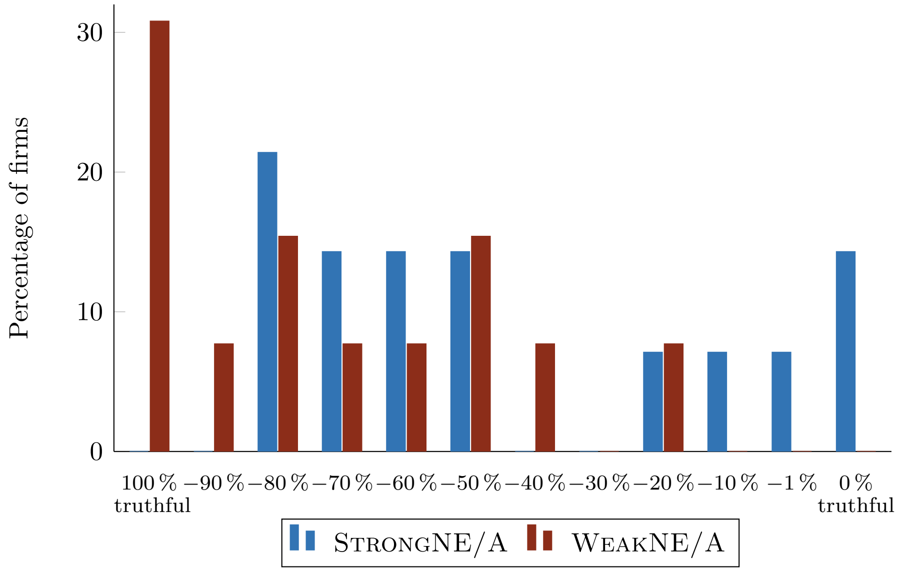

Figure 4.3: Percentage of truthful low quality announcements by firms

When network effects were weak, over 30% of the firms decided to always truthfully announce low quality. Furthermore, none of the firms in the WeakNE/A treatment reported the truth less than 20% of the time. By contrast, when network effects were strong, almost 15% of the firms chose to babble and announced high quality in every single period of the game. None of the firms in the StrongNE/A treatment decided to always report truthfully. To be more precise, the most honest

[16]Due to the random continuation rule participants of the experiments did not know exactly when the game would end, however they were informed in the instructions that the game would last at least 15 periods. 22% of all firms that were able to make announcements changed their behavior as described above.

[17]The percentage values between 100% and 0% reported in Figure 4.3 refer to the lower bound of intervals, that is, 99%-90%, 89%-80%, etc..

[18]During the experiments all but one firm announced high quality throughout, whenever their actual quality was high.

firms only truthfully reported low quality 89% of the time. On average, firms truthfully reported low quality in 75% of the cases when network effects were weak and in 47% of the cases when network effects were strong. This difference is significant ($p = 0.0305$).

Result 4.4. *The firms make truthful announcements significantly more often when network effects are weak as compared to when they are strong.*

This result shows that when network effects are weak, reputation is a stronger force than the temptation to manipulate consumers an announce high quality when it is actually low. A reason for this could be the reduced consumer payoffs for purchasing technology A in case of weak network effects. There, punishing firm A by choosing B after a false announcement is relatively cheaper as compared to the treatment with strong network effects. With weak network effects, choosing technology B when high quality is announced truthfully results in forgone payoffs of at most 2. This compares to a payoff loss of 4 in in the treatment with strong network effects. Anticipating this, with strong network effects firms may be less concerned about consumers playing a trigger strategy because punishment is relatively more expensive.

This is confirmed when looking at the average punishment rates, that is, how often consumers chose technology B in response to a false announcement in the preceding period. When network effects were weak, almost 70% of consumers punished dishonest behavior, whereas, when network effects were strong, only 25% decided to do so. As a result, significantly fewer consumers were willing to punish false announcements in the following period when network effects were strong ($p = 0.0018$).

Result 4.5. *Fewer consumers punish misleading announcements when network effects are strong, as opposed to when they are weak.*

Another reason for Result 4.5 may be that with strong network effects, choosing technology A, in expected terms, is more attractive for consumers, as long as they do so unitedly. Consequently, when network effects are strong consumers may be more forgiving. As a result, with strong network effects, firms may be less honest because they expect to get away with it.

By contrast, with weak network effects, in expected terms, technology B is more attractive. Thus, consumers may be more inclined to choose technology B to begin with but especially so after an untruthful announcement. If the firms anticipate this they will be less reluctant to make truthful announcements when faced with low quality.

4.6 Conclusion

This paper analyzes the effect of product preannouncements in the presence of network effects in a game of strategic information transmission. Since, in this type of setting equilibrium theory cannot make unique predictions about consumer choices and firm behavior I identified the effects of preannouncements using a controlled laboratory experiment. Despite potential anti-competitive effects of preannouncements I find that when network effects are strong, significantly fewer consumers coordinate on the announced technology. This indicates that a preannouncing firm cannot necessarily use the announcement to induce consumers to wait for the launch of its technology, thereby pushing competitors out of the market. In fact, when network effects are strong not announcing leads to higher sales. By contrast, when network effects are weak, the announcement does persuade significantly more consumers to choose the announced technology than would have done so in the silent game. This effect, however, is comparably small. Consumers on the other hand, on average, are always better off when technologies are preannounced. This leads to the conclusion that not only are product preannouncements not a threat to competition in this setting but they can be even beneficial for consumers.

In addition to this, the market mechanism, which incentivizes firms to announce truthfully, works better when network effects are weak. Even though theoretically a firm's incentive for being honest is independent of the magnitude of the network effects, with strong network effects more firms succumb to the temptation of exaggerating their quality, encouraged by more forgiving consumers. As a result, regulations penalizing deceptive preannouncements may be more effective in industries with strong network effects.

4.A Appendix

Proofs of propositions

Proof of Proposition 1. For all consumers to choosing technology A to be a Nash equilibrium it cannot be beneficial for one consumer to choose B while all others purchase A. This is the case whenever $\theta x^H + (1-\theta)x^L + \beta(n-1) > c$ and therefore whenever $\theta > \frac{c-x^L-\beta(n-1)}{x^H-x^L}$. Equally, all consumers choosing B is an equilibrium whenever it is not profitable for one consumer to deviate and choose A while all others choose B. This is the case whenever $\theta x^H + (1-\theta)x^L < c$ and therefore $\theta < \frac{c-x^L}{x^H-x^L}$. Hence, there are two both all consumers choosing A and all consumers choosing B are Nash equilibria when $\frac{c-x^L-\beta(n-1)}{x^H-x^L} < \theta < \frac{c-x^L}{x^H-x^L}$. In this case there is also a symmetric mixed strategy Nash equilibrium in which the consumers are indifferent between choosing technology A and B. A consumer's payoff from choosing A is $\theta x^H + (1-\theta)x^L + \beta p_A(n-1)$ where p_A is the probability that a consumer chooses A. Her payoff from choosing B instead is c. Hence, a consumer is indifferent between both whenever $p_A = \frac{c-[\theta x_H+(1-\theta)x_L)]}{\beta(n-1)}$. □

Proof of Proposition 2. Considering a period in which the quality of firm A's technology is low, there are two possible actions for the firm: it can either decide to deceive consumers and announce high quality or truthfully announce low quality instead. Since it is assumed that all consumers trust the signal until the first misleading announcement, all consumers purchase technology A when high quality is falsely announced but switch to the competing technology in all following periods. As a result the misleading announcement results in a payoff of $\rho \cdot n$ for firm A. If firm A truthfully announces low quality instead it will not make any sales in that period but consumers will keep purchasing technology A in the following periods if high quality is truthfully announced. This results in an expected payoff of $\frac{\delta}{1-\delta} \cdot \theta\rho n$.

In the infinitely repeated game firm A will therefore always announce truthfully, as long as $\rho \cdot n \leq \frac{\delta}{1-\delta} \cdot \theta\rho n$ and consequently $\frac{1}{1+\theta} \leq \delta$. As long as the firm is patient enough, there exists an equilibrium in which announcements are always truthful. This mechanism only works as long as the threat made by the consumers is credible. This, however, is not the case when purchasing technology B is not an equilibrium. Then there cannot be an equilibrium in which firm A always reveals the true quality, i.e. the equilibrium derived above only exists as long as $\theta < \frac{c-x^L}{x^H-x^L}$. □

Instructions

The following is a translation of the instructions of the treatment with large network effects and announcements. The original instructions are in German.

General Rules

This session is part of an experiment in economics of decision making. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of money. All earnings from the experiment will be paid to you in cash at the end of the experiment.

All 24 people in this room are participating in this experiment and are reading the same instructions as you. It is important that you do not talk to any of the other participants in the room until the session is over.

The session will consist of at least 15 periods, in each of which you can earn points. At the end of the experiment you will be paid based on your total point earnings over all periods. Each point is worth 0.05 Euros. The more points you earn, the more cash you will receive.

Description of a Period

At the start of the first period you will be randomly matched with exactly three other participants in the room and will represent either a consumer or a firm. You and these three others form a market which consists of three consumers and two competing firms. Firm A will be represented by a participant while firm B is represented by a computer. During all periods you will be playing with the same three people and retain the same type (either firm or consumer).

Both firms sell the same product. The quality of firm A's product is uncertain and can either be of high or low quality. Only firm A knows the true quality of its product. Consumers only know the quality after having bought the product. Firm B's product always has the same quality which is known to all participants. Independently of the quality, the price for both products is the same.

At the beginning of each period, firm A can announce the quality of its product to the consumers. Notice that the announced quality does not have to be the same as firm A's actual quality. Consumers will then decide between either buying firm A's or firm B's product. At the end of each period all consumers will learn the true quality of firm A's product.

Payoff Calculation

The probability that firm A produces a high quality product is 0.5. The probability that it produces a low quality product is also 0.5. If the high quality is realized, consumers' value of firm A's product is equal to 10. If the low quality is realized, their value is equal to 5. A consumer's valuation of product B is always 10.

Every consumer's payoff when purchasing firm A's product depends on the number of other consumers also choosing A. The higher the number of consumers purchasing A the higher a consumer's payoff from choosing A as well. You will earn net payoffs according to the following table:

Purchase decision	**No. of consumers who bought the same product**	**Resulting payoffs**
A: High quality	0	5
	1	7
	2	9
A: Low quality	0	0
	1	2
	2	4
B	0	5
	1	5
	2	5

The profit of the firms depends on both the number of products sold and the price, such that

Profit= 5 x number of product sold

Number of Periods

The session consists of at least 15 periods. After the 15th period a random draw from the numbers one to three will decide whether the experiment ends. If the number drawn is equal to either one or two, the experiment continues. If the number is equal to 3, the session ends.

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Chapter 5

Conclusion

In this thesis three different advertising and pricing strategies were analyzed that are often found in digital markets: business models of media platforms, price obfuscation and product preannouncements in the presence of network effects.

Chapter 2 analyzed two business models which are widely popular in media markets: free-to-air and pay-tv. The key ingredients of the model are the bargaining process through which platforms and producers determined advertising rates and informative advertising which can increase or reduce competition on the product market. On the consumer side, a setting where consumers can allocate their viewing time on media platforms in order to reach their optimal consumption mix is considered. Chapter 2 finds that with pay-tv, as opposed to free-to-air, mixing by consumers disappears, product prices and advertising rates increase while the number of advertisements declines and media firms' revenues increase. These effects are driven by the improved bargaining position of media firms. As a result, a switch to pay-tv not only gives platforms additional market power but also leads to a loss in consumer surplus. This result is in contrast with related studies which have emphasized the advantages of pay-tv over free-to-air. However, when pay-tv on a pay-per-view basis is considered, this negative effect on consumer vanishes and consumers are still able to consume their ideal content mix. In this sense, pay-tv on a pay-pre-view basis is strictly preferable from a consumer perspective. Regarding the business model choice, Chapter 2 finds that media platforms favor pay-tv if differentiation on the product and on the media market is high and their bargaining power vis-à-vis producers limited. Consequently, factors that might lead to greater bargaining power of advertisers, such as, an increase in retail market or producer concentration may induce platforms to adopt pay-tv in order to mitigate the negative profit effects of their worsened bargaining position.

In a series of laboratory experiments Chapter 3 examined the effects of drip pricing on seller strategies, buyer behavior and total welfare. Sellers set two prices: a base price and a drip price. At first, buyers only observe the base prices and make a tentative purchase decision. Revealing the sellers' drip prices, however, comes at a cost. Chapter 3 finds that sellers only compete in base prices and set the highest possible drip price. This makes the base price a reliable indicator for the lowest total price, few consumers invested in drip price search and choices were mostly optimal. A comparison with Bertrand competition revealed small but significant effects: with drip pricing consumer surplus was lower and seller profits were higher. By contrast, further capping the drip price had no significant implications for either buyers or sellers. This leads to the conclusion that capping the drip size may not be an effective tool to limit the use of drip pricing, when there is certainty among buyers about the size of the drip price. Contrary to this, Chapter 3 also finds that when buyers are uncertain about a sellers' drip price limits and sellers differ in their limits, high type sellers also compete in drip prices and buyers more frequently fail to identify the cheapest offer. Thus, regulatory intervention may be more effective when uncertainty regarding the drip price exists among buyers.

Chapter 4 analyzes the effect of product preannouncements in the presence of network effects in a game of strategic information transmission. In a controlled laboratory experiment Chapter 4 examines a cheap talk setting with one sender and multiple receivers playing a repeated coordination game. The experiment was framed as a model of technology adoption in a market with two competing firms, A and B. Consumers purchasing firm A's technology benefited from network effects but were faced with quality uncertainty while technology B served as a safe outside option. Chapter 4 found that when network effects were strong, coordination on the announced product was lower when firm A could communicate its technology's quality. When network effects were weak, this effect was reversed. As a result, despite potential anti-competitive effects of preannouncements, the signaling firm could not use the announcement to induce consumers to wait for the launch of its technology, thereby pushing competitors out of the market. Consumers on the other hand were always better off when technologies were preannounced. This leads to the conclusion that not only are product preannouncements not a threat to competition in this setting but they can be even beneficial for consumers. In addition to this, the market mechanism, which incentivizes firms to announce truthfully, works better when network effects are weak. Even though theoretically a firm's incentive for being honest is independent of the magnitude of the network effects, with strong network effects more firms succumbed to the temptation of exaggerating their quality, encouraged by more forgiving consumers. As a result, regulations penalizing deceptive preannouncements may be more effective in industries with strong network effects.

Eidesstattliche Versicherung

Ich, Miriam Thöne, versichere an Eides statt, dass die vorliegende Dissertation von mir selbstständig, und ohne unzulässige fremde Hilfe, unter Beachtung der "Grundsätze zur Sicherung guter wissenschaftlicher Praxis an der Heinrich-Heine-Universität Düsseldorf" erstellt worden ist.

Düsseldorf, 14. März 2017

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Unterschrift