Corvinus University of Budapest

Doctoral School of Economics, Business and Informatics

Essays on the Theory of Two-Sided Markets

Ph.D Dissertation

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Contents

List of Figures

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Introduction[1]

Several markets have emerged in which consumers and sellers interact and make transactions through an intermediary or platform. Examples include smart phones, bank cards, game consoles, shopping centers but even airports. The peculiarity of these markets is that the actors join them because the platforms have a large number of members of either their own or the other segment. Such markets are referred to in the literature as two-sided markets, which, through the development of technology, have now appeared in many forms in our daily lives. Although the analysis of two-sided markets is already extensive, it still has unexplored areas. In addition, due to their different functioning from traditional markets, they are also of great interest from a regulatory point of view, whereas the impact of the regulatory tools used may be different and may be particularly harmful in some cases. The chapters in this thesis contribute to a better understanding of two-sided markets.

In the dissertation, first, two-sided markets are presented with the help of the literature. In this context, the characteristics of those are described that distinguish them from traditional markets. The means are also summarized used to analyze them and the key findings are presented. Next, models will be described that focus on neglected areas in two-sided markets, place issues that have already been examined in a different context, or offer an explanation for current phenomena.

The results presented in the different chapters are not closely related, so they can be interpreted independently. Therefore, at the beginning of each chapter, the analyzed problem, its justification, as well as a summary of the relevant literature are covered. In each chapter, duopolistic models are presented to determine the impact of platforms' product differentiation decisions, the use of public and private contracts, and the entry of the state in the market on optimal pricing. Because consumers typically do not consider when purchasing a platform's product or service that they will later purchase compatible products, they do not internalize the benefits of their future consumption, so the models

[1]The present dissertation is the outcome of the project „From Talent to Young Researcher project aimed at activities supporting the research career model in higher education", identifier EFOP-3.6.3-VEKOP-16-2017-00007 co-supported by the European Union, Hungary and the European Social Fund

presented are sequential in nature. To analyze these and determine their equilibrium, the tools of game theory are used. Depending on the type of model, the aim is to determine the subgame-perfect Nash equilibrium or the symmetric perfect Bayesian equilibrium.

The aim of Chapter 1 is to define two-sided markets, present their importance, and highlight their distinctive features from traditional markets. In this chapter, the theory of externalities and multi-product pricing are briefly summarized, as these form the basis of the analysis of two-sided markets. However, a review of the literature reveals that none of the theories can be applied independently in the study of two-sided markets, as the pricing of platforms and the behavior of players are different from those observed in traditional markets. In the case of platforms, most of the controversy has been triggered by their pricing. In this chapter, the main features of this phenomenon are reviewed and the results of empirical studies are presented that examined the pricing of the platforms in the most typical two-sided markets. Finally, examples are provided of why it is still a challenge to regulate platforms to this day.

In Chapter 2, the platforms' decision on product differentiation and its impact on pricing are examined. When it comes to products, one of the most important issues which companies have to decide is how to differentiate their products. The more differentiated a product is, the better it meets consumer tastes, and the higher is the demand for it. In the literature, product differentiation is typically determined by the location decision of the companies, one can think of models of Hotelling (1929) or Salop (1979). However, this is not captured by the usual location decision, but, according to von Ungern-Sternberg (1988), by the ability to influence travel cost. The idea behind this is that, in practice, product differentiation is not achieved through a well-chosen location. Rather, by designing the product or service in such a way that it can satisfy as many needs as possible, it can also meet a more specific goal. Thus, if products are differentiated, the consumer suffers a much smaller loss of utility than if they serve a more general purpose. Furthermore, instead of symmetric network effect, an asymmetric network effect is assumed. That is, on the consumer side, their own segment, while on the sellers' side, the size of the other segment increases the amount of realizable utility. It is concluded that profit-maximizing platforms offer either full customizability to their consumers, but therefore charge a positive price, or limited customizability but at a zero price. An example of this can be found in everyday life, such as anti-virus software used on personal computers. If the consumer is unwilling to pay for the anti-virus software, the free version provides basic protection. While subscribing to its use, it provides complete protection and entitles to additional services from the manufacturer. In the light of the above, it is argued that in two-sided markets, it is not necessarily a problem for a platform to have a large market share in one segment, provided that it has to compete for subscribers on the other side. Based on the results, the competition on one side will automatically spill over to the other side, and if not in the prices charged, it will feel its impact in a different dimension.

Next, in Chapter 3, the impact of observable and unobservable contracts applied in two-sided markets are examined. The literature typically assumes public contracts in the analysis, the examination of private contracts rather neglected. These appear only as an alternative strategy, but their effects have not been incorporated into the models until the paper of Llanes and Ruiz-Aliseda (2015). Under the assumption of a monopolistic platform, the authors analyzed the effect of the above two contract types on equilibrium. However, to the best of our knowledge, a similar attempt has not yet been made for competing platforms. Thus, in the framework of this chapter, the use of public and private contracts are analyzed in a duopolistic environment, their impact on pricing, and sellers' decision to join. On the one hand, it is confirmed that platforms change their optimal strategy even in the event of competition, as long as they have the opportunity to offer private contracts to sellers and set a high price for the previously supported segment. As a result of private contracts, sellers set a collusive price for their products. This is consistent with the findings of Armstrong and Wright (2007) and Llanes and Ruiz-Aliseda (2015). On the consumer side, on the other hand, in contrast to the results of the above two papers, the platforms do not offer discounts but continue to set a positive subscription fee. However, this is lower for private contracts than for public contracts, and the increase in network effect reduces the subscription fee charged to consumers, while it increases it for public contracts. The results also highlight that the use of public contracts is preferred for platforms, while for consumers, a different outcome may occur depending on the travel cost. It is also shown that platforms offer sellers contracts that they can attract as many of them as possible.

In many markets, it is common for the state to intervene by setting up a company. Two-sided markets are no exception: the most typical example is the media market. In Chapter 4, two-sided markets operating as a mixed duopoly are the subject of this study. The answer to the question of how the product differentiation and pricing will be decided in the case of competition between a public firm and a privately-owned platform is looked for. This is justified by the fact that there have already been several attempts in the European Union to ban advertising on state TV broadcasts. However, this makes the state platform inaccessible to one side, and thus essentially ceases to be a platform and continues to operate as a normal company. The results show that if the state appears with a company in a two-sided market, it does not influence its competitor's decision to differentiate products. Conversely, on the side of the segment in which the public firm and the private platform compete, the platform approximates the price charged to that of its competitor, while it imposes a monopolistic price on the other segment. Based on the results, the regulation of such markets can be achieved either by applying regulatory tools (tax, price regulation, competition law) or by establishing a state-owned platform.

Summarizing the results of the dissertation, it was found that as a result of product differentiation, in the case of two-sided markets, the competition on one side spills over to the other side, and if not in prices, it has an effect in another dimension. So it is not necessarily a problem if the platforms do not compete with each other in one segment. In the case of competition, the use of private contracts does not result in a change in pricing strategy on the part of the platforms on the consumer side, but on the seller side. Overall, based on the results, the platforms are encouraged to use public contracts, and the use of private contracts may be encouraged by factors not examined in the model (such as product differentiation, increasing market power). The state can act effectively in a two-sided market if it creates a state platform: if one side is banned from a state platform, the state must resort to other tools of regulation to protect the interests of consumers.

Chapter 1

Two-sided markets

1.1 Introduction

With the development of technology and the spread of the Internet, a new type of market has become the focus of economic research. In these markets, two well-separable segments, typically sellers and buyers, could meet and interact with each other through one or more intermediaries or platforms. The interesting thing about these platforms is that they only attribute value to users if another type of consumer also uses them.

For example, one can think of an online auction portal that is only attractive to buyers if sellers are also present on that portal. However, sellers are only willing to join a given portal if that is able to attract potential buyers. If a portal fails for one segment, it has no value to the other. Credit cards can also be used as an example. The consumer is willing to use a particular type of credit card if it is accepted by a large number of stores, but it is only worthwhile for stores to accept credit cards that are used by many consumers. In addition to the above, there are many other examples of products and services, the consumption of which will only bring any benefits to consumers if it is used by two separate consumer groups at the same time. These are, without claiming to be exhaustive: game consoles (players – game developers), social media (users – advertisers), newspapers (readers – advertisers), even malls (buyers – sellers), entertainment venues (men – women) but also airports (passengers – airlines). The market of such products and services is generally called two-sided markets.

Two-sided markets, as the examples above show, are not necessarily new, but there is no doubt that, as a result of technical progress, a number of new products and services are emerging to this day for which the service provider acts as an intermediary and the market is two-sided.

One of the characteristics of two-sided markets, also known as platforms, is that they serve two well-separable consumer segments. While this is a necessary but not sufficient condition for defining two-sided markets, as buyers and sellers are present in each market. Tirole and Rochet (2004) pointed out that in the case of two-sided markets, there is a non-internalized externality between the two segments, and that elements of multi-product pricing theory also emerge in their operation. In other words, in two-sided markets, the demand of one segment depends on the size of the other segment. Let us look again at the example of online auction portals. Buyers of a given portal benefit from finding themselves with a large number of sellers on the platform, while sellers are more attracted to the portal's service if they can interact with more potential buyers there. Magazines are typically mentioned for negative externalities. Readers buy the magazine because of the content, so the more ads placed in them, the more harmful it is to them. In contrast, the more readers the magazine has, the more attractive it is to the advertiser side. The theory of multi-product pricing is reflected in the price structure. In the case of two-sided markets, the price structure is less distorted by market forces than by price levels. However, in multi-product pricing, externalities are internalized in the purchase, so the case of two-sided markets cannot be modeled purely using this theory.

In the following, first, the theory of externalities, as well as multi-product pricing, are reviewed, and then the pricing characteristics of two-sided markets are described. Then some empirical research is presented that has examined the most typical two-sided markets. At the end of the chapter, examples of the regulation of two-sided markets are provided from recent years, highlighting that there is currently no uniform methodology for regulating two-sided markets.

1.2 Externalities, network effects, and network externalities

An externality or external economic effect exists in a given market if the activity of one actor influences the decision of another actor and these effects are not internalized under normal market conditions.[1]

Externalities can be grouped in two ways: according to whether the activity affected the activity of a consumer (consumption) or a company (production), and according to whether it had a positive or negative effect. So if externalities prevail in the market, then market mechanisms do not result in a Pareto-efficient distribution.[2] The problem is that ownership rights are poorly defined, so the Coase theorem, that is, if ownership rights are completely clear and enforceable and transaction costs are absent or negligible, then then the negotiations of the contracting parties lead to the same allocation result, regardless

[1] Varian (2010, p. 644.)
[2] Varian (2010, p. 645.)

of the original assignment of ownership rights, therefore, the problems of externalities can be solved by voluntarily changing property rights[3], is damaged. The internalization of externalities requires intervention in the functioning of the market: for example, a Pigouvian tax may be introduced by the state (the most typical example is emissions taxation), or redistribution of property rights should be allowed (such as mergers, state settlement of property rights).[4]

In connection with the theory of externalities, the phenomenon of the network effect and network externality must also be addressed. These are often used as synonyms, although the underlying concept is different.

A network effect is a phenomenon where an increase in the number of participants increases or occasionally decreases the value of a particular product or service. The network effect, depending on its nature, therefore increases or decreases, on the one hand, the benefits of those already on the market, while for other consumers it increases or decreases the willingness to join. The most typical example of a positive network effect is social media: the more members a social site has, the higher the willingness to join of a new user, while those already in it benefit from expanding content due to the growing number of users. But phones can also be mentioned, especially smartphones, which can be considered platforms in two ways. On the one hand, in terms of the call origination and call reception segment, and on the other hand, in terms of the user and the programmer. The more people have a smartphone, the more people can call each other, and with the same service provider, they can do so at a discount. While the more applications can be downloaded to a phone, the more popular it is with customers, and the more people buy the phone, the more programmers will create compatible applications with them.

There are two types of network effects in the literature[5]: direct and indirect network effects. The direct network effect arises from the possession of the given product, while the source of the indirect network effect can be, for example, easier availability or lower price of additional products or an increase in the number of users. Staying with the example above, the direct network effect for the customer stems from owning the phone, while the phone case, headset, and also, as explained above, how many acquaintances you can call through it generate an indirect network effect.[6]

Thus, a network effect is when market participants are able to internalize in some way their additional benefits or costs generated by the activity of the other player. If a network effect cannot be internalized by any of the actors, then we can talk about network

[3] Coase (1960)

[4] Varian (2010, pp. 644-666)

[5] See for example Liebowitz and Margolis (1998)

[6] Liebowitz and Margolis (1998) mention fax as an example. Owning the fax machine itself generates benefits (direct) while increasing the number of users and the number of ancillary products such as the toner cartridge generates additional benefits (indirect).

externality.

However, with the emergence of two-sided markets, a special network effect emerged that differed from those identified by previous theory. The paper by Weitzel et al. (2000), in which the problem of positive network effect appears for the first time, is noteworthy[7]. The authors start from the anomaly that in some markets, contrary to the conclusions of the previous theory, it is not the consumer's purchasing decision that determines others, but how many people have already bought a given product. They state that in some markets, demand-side economies of scale can be identified, stemming from the need for product compatibility. As a result, markets also emerge where

1. despite the strong network effect, several different products are available, while according to the previously developed theory, a monopolistic situation would be optimal in this case;

2. even in a competitive market, small but stable consumer groups are created that use a particular solution;

3. in the case of communication networks, strong actors force other actors to use a particular solution.

The theory of network effect did not provide a proper explanation for the phenomena listed above.

The authors review the previous theory of network effect and reveal several shortcomings that may lie behind them:

1. **Direct and indirect network effect:** The direct and indirect network effect is evaluated differently by the actors, and it is also influenced by the nature of the product generating the network effect. In contrast, this difference does not appear in the models.

2. **Network effect and network externality:** In many cases, the creators of the models do not take into account that although the actor connected to the network does not internalize the benefits it generates, the owner of the network can do so. Thus, the existence of a network effect does not necessarily lead to market failure.

3. **The bigger the better:** The existence of an indefinitely increasing positive network effect, according to the literature, results in the formation of natural monopolies. Conversely, if the network effect can be exhausted, multiple networks can coexist.

[7] The authors mention the information and communication market as an example, which in many cases can be considered a two-sided market, however, the actual emergence of two-sided markets did not take place until years later, here they only appeared tangentially.

4. **Homogeneous network effect:** A common simplification in modeling is that actors evaluate the network as well as the resulting network effect in the same way.

5. **Cost due to network size:** The basic hypothesis that, in addition to network externalities, the optimal network is monopolistic, is only valid if a new member is involved at a constant or decreasing (average) cost.

6. **The problem of centralized or decentralized decision-making:** Different institutional backgrounds may lead to different standardization cases, which affects the results obtained.

7. **Normative implications:** The purpose of the models is to be able to draw normative conclusions from them, which has resulted in differing views in the literature as to whether or not there is a need for state intervention in markets characterized by network effects.

Weitzel et al. (2000) believe that the solution may be to develop models that

- are able to handle knowledge and uncertainty / limited rationality;
- follow evolutionary system dynamics (using empirical and simulation approaches);
- display system components and connections;
- reject the conditions of convexity and divisibility;
- intermediaries appear in them.

With the emergence of the theory of two-sided markets, more and more researchers have undertaken to develop models that meet the above criteria.

Another grouping of network effects has also emerged with two-sided markets[8]: the phenomenon of symmetric and asymmetric network effects. In the case of the former, the benefit of both sides is influenced by the number of members of the other segment, i.e. an inter-group network effect prevails. In contrast, in the case of the latter, the benefit of one segment depends on the number of members in its own segment, i.e. on one side, there is an intra-group network effect.

1.3 Multi-product pricing, price structures

Closely related to externalities is the problem of pricing for multi-product companies. In this case, a company manufactures and sells two or more types of products, but this

[8] See for example, Bakó and Fátay (2018)

also includes the case where one company manufactures a particular basic product, while other companies produce accessories that can be used for that basic product. In these cases, it is not the price of a particular product that the company needs to determine, but the appropriate structure of relative prices to achieve maximum profit. The peculiarity of these products is that the price of one product affects the demand for the other product. Products can be complements or substitutes, and the effect of prices on demand varies depending on the relationship.

The principles of optimal pricing of multi-product monopolies were first described by Ramsey (1927). Although the paper is basically about optimal taxation, the generalization of the results reported in it is in line with the trends observed in the practice of multi-product pricing. Ramsey's basic idea was that, with increasing returns, pricing based on the marginal cost will generate a loss, since the marginal cost, in this case, is less than the average cost. The above phenomenon justifies the practice of applying a margin, however, the optimal distribution of this margin among products depends on the price elasticity of their demand. This relationship is described by the inverse elasticity rule, which states that the Lerner index of a given product, i.e. the difference between price and marginal cost on price, is inversely proportional to the price elasticity of demand for products. In the case of multi-product pricing, this correlation is supplemented by an adjustment term that embodies the relationship between the two products.

Two typical textbook cases of multi-product pricing (see Tirole , 1994 or Belleflamme and Peitz , 2015) when demand is related but costs are separable, and when demand is independent, costs are, on the other hand, related. In the first case, as a result of the company's profit maximization, the following relationship is obtained for the Lerner index in the optimum:

$$L_i \equiv \frac{p_i - C_i^{'}}{p_i} = \frac{1}{\eta_i} + \frac{p_j - C_j^{'}}{p_i} \frac{\partial Q_j / \partial p_i}{-\partial Q_i / \partial p_i},$$

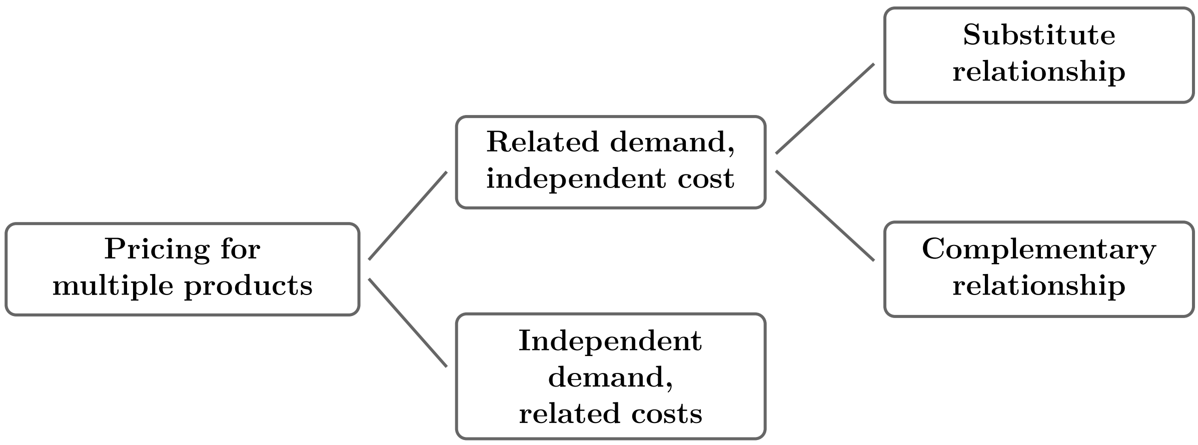
where p_i, p_j are the prices of the two products, $C_i^{'}$, $C_j^{'}$ are the marginal costs of the two products, η_i is the own-price elasticity of product i, and $\frac{\partial Q_j / \partial p_i}{-\partial Q_i / \partial p_i}$ is the additional term. Based on the latter, the first case can be divided into further cases. For substitute products, the value of the Lerner index is greater than the inverse of the price elasticity of demand, i.e., the additional term is positive ($\frac{\partial Q_j}{\partial p_i} > 0$). This means that a multi-product monopoly sets a higher price than if the products were produced by separate divisions. That is, the monopolist internalizes the effect of competition in prices, thereby reducing the incentive to reduce prices that exists for individual firms. If the products are complementary, then the opposite is true: the Lerner index is smaller than the inverse of the price elasticity of demand, i.e. the additional term takes on a negative value ($\frac{\partial Q_j}{\partial p_i} < 0$).

In this case, the positive effect on the demand for the two products is internalized by the multi-product monopolist, resulting in lower prices than if the two products were produced separately in the market. With regard to this sub-case, it is important to highlight that for one product, the Lerner index may be less than or equal to zero. This means that for this product, the monopoly sets a price below the marginal cost to fully benefit from the complementary nature of the products on the other side. A similar phenomenon can be observed for two-sided markets, which is discussed in detail in the next subsection.

In the second case, i.e. when demand is independent but costs are related, the Ramsey formula is modified to the extent that the value of the Lerner index for product i is affected by the level of production of the other product (j) through marginal cost. That is, formally, profit maximization results in the following relationship:

$$L_i \equiv \frac{p_i - C_i^{'}(q_i, q_j)}{p_i} = \frac{1}{\eta_i}.$$

Figure 1.3.1: Cases of multi-product pricing



One of the typical reasons for this is the phenomenon of economies of scale, i.e. when increasing the production of one product reduces the cost of producing another product. In this case, the multi-product monopolist increases the volume sold by reducing the price of product j, which reduces the marginal cost of product i, i.e. the margin of product i will increase. Overall, therefore, if the phenomenon of economies of scale exists, the multi-product monopolist will charge lower prices than if the two products were produced by two separate companies.

In their paper, Armstrong and Vickers (2018) also extended the above theory to the case of symmetric Cournot duopoly. In the model they prescribed, the consumer surplus was a function of quantities and not prices. The authors have shown, on the one hand, that this approach returns the classical profit maximization problem for the multi-product monopolist, or, more generally, the Ramsey problem for welfare maximization, where the constrain is the profit. In the case of an oligopoly, they came to the conclusion that, by properly weighting profit and consumer surplus, the Ramsey quantities correspond to the equilibrium quantities of the Cournot model and vice versa.

1.4 On the pricing characteristics of two-sided markets

The main goal of the platforms is therefore to attract as many buyers and sellers as possible, which they try to achieve by creating the right price structure. The problem, as explained above, is somewhat similar to the problem of multi-product pricing, but in two-sided markets, the consumer does not internalize the benefits that members of the other segment derive from her entry. Thus, when examining two-sided markets, we cannot confine ourselves to the theory of multi-product pricing described above, we are faced with a much more specific case.

The theory of two-sided markets was developed by Tirole and Rochet (2003; 2004) and Armstrong (2006). In these papers, the authors pointed out that the application of basic, previously known pricing principles does not lead to profit-maximizing results in two-sided markets.

In their paper, Tirole and Rochet (2003) analyzed the credit card market, but their results can be generalized. In their model, the two segments were customers and stores for whom two types of credit cards were available. These credit cards were distinguished by the transaction cost incurred in using them. Stores could choose to accept only the cheaper credit card (single-homing) or the more expensive one (multi-homing)[9]. If only the cheaper card could be used for payment, then buyers had to decide whether to use this card, i.e. to enter the platform or pay in cash, i.e. to stay away from the market. If, on the other hand, both cards were accepted by that store, the customer used the card of their choice. However, this did not necessarily coincide with the store's preference. Platforms have been able to reduce the fees charged to stores to accept the credit card they sell in more places. The authors have come to the conclusion that with symmetrical equilibrium, it is possible to pay with both cards in stores, and customers will use the preferred credit card. The fee paid by the two segments was affected by the substitution relationship between the credit cards. Based on this, two types of customer groups were

[9]In the literature, the term "single-homing" is used to describe consumption on one platform, while the term "multi-homing" is used to describe consumption on multiple platforms.

distinguished: those for whom the two cards were close substitutes and those who were less willing to substitute the two cards for each other. The former group generated a higher surplus for the stores, so if they were typically present in the market, the fee to be paid by the stores increased and the fee charged to customers decreased. In the case of the second group, the opposite happened: customers were forced to pay a higher price, while shops paid a lower price. Based on the above results, several conclusions were also drawn. On the one hand, it was pointed out that the total price is determined according to the Lerner index, while the charges imposed on customers and shops are determined by the platforms in proportion to the elasticities. If the latter finding is met by Ramsey prices, then the price structure imposed results in maximum social welfare at a given total price. However, the structure of Ramsey prices does not correspond to a fair cost allocation, the aim is rather to lure both segments to the platform. The main difference between the uniform pricing structure used by both the monopolist and the competing platform and the Ramsey pricing is that the latter takes into account the net surplus on the other side of the market when another consumer from one side joins the platform. However, when uniform pricing is applied, there is no clear distortion in the price structure[10]. It was also argued that the more buyers enter each platform, the more favorable will be the resulting price structure for sellers, which is essentially a manifestation of the network effect typical of two-sided markets.

In their 2004 paper, Tirole and Rochet have already sought to analyze two-sided markets in general. In their view, a sharp distinction should be made between the externalities of use and the benefits of membership. In the case of purely usage externalities, based on their results, the market can be considered two-sided if the number of transactions can be increased by raising the price of one segment while lowering the price of the other proportionately. On this basis, it was recognized that a necessary but not sufficient condition for two-sided markets is that the Coase theorem fails in relation to market transactions. That is, the benefit of the transaction between the two segments does not depend on the total fee charged by the platform, but on the price structure defined by it. Thus, the price structure in the market is not neutral, as the Coase theorem assumes. The authors concluded that if only the benefits of use differ, the benefits of membership do not, and the platform consciously determines the optimal prices, then the total price is determined according to the Lerner index, while for the optimal price structure the elasticities calculated for each segment must be the same. If the utility of consumers after the connection is different and the platform charges membership fees, the total price level can still be given based on the Lerner index, but in the case of the price structure, the price charged to each segment, the transaction benefits they generate for the other segment and

[10]If demand is linear, then all price structures are optimal Ramsey price structures.

the elasticity calculated in their case are decisive. If the two segments have the opportunity to pay each other, based on the authors' results, some of the platform's variable costs will be passed on to segment members following the Coasian bargaining. Where prices are set with asymmetric information for two-sided markets, platforms should provide support to consumers in bargaining. Finally, they also address the fact that platforms not only create an equilibrium between the two segments through the price structure but often also regulate the terms of transactions, protect their entrants with non-price means, and monitor competition between sellers. By using these means, they sacrifice a portion of their profits to limit one side in order to increase their attractiveness so that they can recoup their generated losses on the other side.

The pricing peculiarities of two-sided markets were formally highlighted by Armstrong (2006). In the paper, the author analyzed the case of monopolistic and duopolistic platforms within the framework of the Hotelling model. In a monopolistic model framework, Armstrong examined how it works if the platform is able to increase the size of the market by increasing consumer benefits. In the case of duopolistic platforms, he analyzed consumers' choices about single-homing and multi-homing. The author also paid special attention to the study of the network effect in the case of two-sided markets. Armstrong concluded that three factors determine the pricing structure imposed on the two segments:

1. **The relative magnitude of network effect between segments:** as the network effect increases, the price charged to each segment decreases. And if the utility generated by one side is higher in a transaction with the other side than vice versa, then the platforms will charge a lower price to members of that segment than to the high-profit side.

2. **Type of pricing used by the platforms:** the use of a fixed entry fee is preferred when the willingness to pay of one segment is not affected by the performance of the platform for the other segment, while the application of transaction-by-transaction pricing is more appropriate when the network effect between the two segments is strong.

3. **Do members of the served segments access one or more platforms:** if members of one segment only access the platform they prefer, members of the other segment will join multiple platforms in order to interact with as many consumers in the other segment as possible. In this case, however, the platforms will have a monopolistic power in terms of access to the players that only join them, so they will set a monopolistic price for the players on the side forced to multi-home.

Thus, based on the literature, it can be concluded that whether it is a monopolistic or a competing platform, it is typically worthwhile for their operator to charge a zero or sometimes negative price for a segment connected to their platform. This is because they can attract more members of that segment, which makes them more attractive to the other side, and they can benefit from this with suitably chosen pricing. To understand the intuition behind these results, consider a platform that faces positive demand for both consumer groups. If this platform were to operate as a traditional profit-maximizing company and set profit-maximizing prices based on specific demand, positive prices would be charged for each segment, provided that the service has a level on both sides for which the marginal cost of a given quantity is lower than the corresponding reservation price. This pricing strategy, on the other hand, is not necessarily optimal for two-sided markets, as if demand on each side is influenced by the size of the other side of the market, higher profits may be obtained if margins are close to or below marginal costs. If, as a result of such a price, the demand of the other segment increases substantially due to the increase in the size of the other side, the profit can be further increased by applying a price determined with respect to higher demand compared to the traditional pricing strategy with a positive price above marginal cost on both sides.

Wright (2004) summarized the characteristics of behavior observed in and significantly different from traditional markets in relation to two-sided markets. The optimal behavior of two-sided markets, based on the logic typical of classical (one-sided) markets, can sometimes lead to incomprehensible and sometimes explicitly misleading, and even incorrect conclusions from a regulatory point of view. Wright also concluded that the pricing applied by the platforms depends fundamentally not only on the cost structure but also on the externalities between segments. The resulting high margin is not necessarily the embodiment of market power, just as pricing below cost does not necessarily mean predatory pricing in the market. The author also highlighted that market competition in two-sided markets does not necessarily result in a more efficient, more balanced price structure between segments compared to a monopoly.

1.5 The empirical analysis of two-sided markets

There have been many empirical studies on the pricing of two-sided markets that have examined the pricing method in the most typical areas, such as newspaper, telephone, internet, or even airport. In these studies, the authors were typically interested in whether firms in a given market operate as a two-sided market.

Argentesi and Filistrucchi (2007) attempted to determine the market power of the four largest Italian newspapers (Corriere della Sera, La Repubblica, La Stampa, Il Giornale) using an empirical model on the Italian newsprint market. To this end, a database was set up containing data between 1976 and 2003 on turnover, advertising, revenue, costs, nominal prices, reader characteristics, and additional information, such as data on promotions for the period under review, the time of introduction of regular supplements to newspapers, the time of editorial changes and the date of launch of the newspaper website. As this is a two-sided market, several factors have been taken into account in determining market power, not just price elasticity of demand. The authors presented a model containing two demand functions (for readers and advertisers), while for publishers they assumed that they would maximize profits. Their analysis also assumed that readers' demand was not affected by the number of ads. Two alternatives have been formulated in connection with their study: newspapers are in oligopolistic competition with each other or maximize their collective profit, i.e., they have examined competing and collusive behavior. Based on the empirical results, on the one hand, their assumption about readers was supported, and on the other hand, they came to the conclusion that the pricing of newspapers is characterized by the maximization of collective profit, while the market of advertisers is closer to competition. This result is interesting because liberalization took place in the Italian newspaper market during the period under review, which resulted in tacit collusion rather than a competitive environment in terms of results.

Another empirical study can be linked to Armstrong and Wright (2008), which examined the landline and mobile phone markets in the UK. Analyzing the model under different specifications, they came to the conclusion that a competitive edge emerges in the case of the fixed network, resulting in too high, monopolistic prices. In contrast, prices for the mobile phone network will be too low to reduce competition between service providers. On the other hand, this situation is unsustainable in the long run, whereas, as a result of supply-side substitution, monopoly prices on fixed networks are not optimal in the long run. Based on the above, if the price is determined in a competitive situation, it will always be above cost, while in the case of collusion, an inefficient, high price can only emerge if calling on fixed networks becomes sufficiently important in the eyes of users. Armstrong and Wright also looked at the issue of demand-side substitution, i.e., the case where consumers may choose to use a cell phone instead of a landline to avoid higher per-minute charges. Under the assumption of a uniform tariff, this can occur when the parties call each other within a given service provider: then the service providers charge low prices to their customers to protect them from the harmful effects of the high tariff. Thus, the importance of the profit realized on the fixed network decreases, while due to the network effect, the competition between the service providers becomes more intense. Overall, for both supply- and demand-side substitution, the incentive for service providers to charge above cost is reduced, but does not disappear completely. Another solution proposed by the authors is to improve bargaining positions, as, in the basic model, mobile networks have the full bargaining position, while fixed networks are in a vulnerable position.

In their paper, Economides and Tåg (2012) examined the Internet market. A model was built to examine the benefits of "net neutrality," meaning that an ISP is unable to charge a positive fee to content and application developers. In contrast, the monopolistic or duopolistic model was in which service providers were free to price their products. The authors concluded that, in addition to the above conditions and reasonable parameter constraints, the regulator charges negative prices to the content provider, while monopolistic and duopolistic platforms charge positive fees. At some values of the parameters, the welfare of society increased with the introduction of net neutrality, however, the opposite can also be said for other parameter values.

Frishammar et al. (2018) analyzed the challenges of shopping malls due to digitization in an interpretive case study focusing on shopping malls in Denmark, Finland, Norway, and Sweden. Data were collected in the form of workshops, interviews, and questionnaires by the authors between November 2014 and November 2015. When analyzing the data, three digitization channels were identified, which were named digital awaiter, digital data gatherer, and digital embracer. The grouping was based on the center of gravity used by the malls (sellers or sellers and buyers alike are in focus) and the role of digital technologies in the case of the mall (significant or insignificant). Digital awaiters are characterized by the use of generally accepted, mature digital technologies, i.e. they offer only simple services such as free Wi-Fi or a website. Thus, in their case, the use of digital technologies is secondary, they do not have a critical impact on their operation, they are most typically seen as a means of communication. The focus of value creation on digital awaiters may be solely the seller segment, but there have also been those who have considered both the seller and the buyer side. Although there is a kind of negative attitude on their part based on the above, based on the interviews conducted, the authors concluded that this is not necessarily the case for the shopping malls examined. Digital data gatherers have included shopping malls that use increasingly sophisticated and complex technologies to collect large amounts of data about their customers. This data is then used, for example, to optimize the location of the stores, to facilitate the inflow and outflow of customers, or, most typically, to pass on to sellers to increase the number of visitors by suiting consumer needs. As a result, digital data gatherers typically focus on the seller side, i.e. data collected from one side of the market (in this case consumers) is passed on directly or indirectly to the other side of the market (sellers). Finally, a digital embracer strategy is followed by shopping malls that, like digital data gatherers, use increasingly sophisticated and complex digital technologies, but not only use them to obtain information and pass it on to sellers but also to develop their own digital services. In other words, in their case, digital technologies play a major role in their operation, they are an integral part of their business strategy. The focus of these shopping malls is on both sides, actively providing value to both sellers and buyers. They will therefore develop mechanisms to encourage participation on both sides and to coordinate the interactions between the actors on both sides so that they serve the interests of each party.

1.6 Regulation of two-sided markets

The way in which two-sided markets are regulated is still a matter of debate today. Due to the specificities reviewed in previous subsections, best practices for traditional markets are not applicable to two-sided markets. Due to the peculiarities ignored, they do not necessarily lead to the desired result, and in some cases may even lead to a detrimental outcome from a welfare point of view. Nevertheless, there is a consensus on the need for regulation, but the development of the right instruments, or even the right combination of existing ones, is still ongoing.

In his paper, Wright (2004) collected and inspect eight “fallacies” that arise when regulators want to apply the logic applied in traditional markets to two-sided markets:

1. *"An efficient price structure should be set to reflect relative costs (user-pays)."*: In order to develop an efficient pricing structure, the platforms need to take into account not only the relative costs of the two consumer sides but also the additional benefits that arise when a new member from the other segment enters the market. That is they need to consider the relative magnitude of the network effect.

2. *"A high price-cost margin indicates market power."*: The idea is that increased competition will lower prices to cost. However, in the case of two-sided markets, the platform sets the price above cost for one segment and below cost for the other group in the optimum. The price above cost thus shows nothing about the market power of the given platform, as the price permanently above cost on one side shows the difference in the magnitude of the network effect on the two sides in the case of two-sided markets.[11]

3. *"A price below marginal cost indicates predation."*: In the case of two-sided markets, the existence of market power does not necessarily imply output limitation, anti-competitive ability, market failure, or deviation from a perfectly competitive market. The problem of predatory pricing in the case of platforms arose precisely because of this – falsely. Platforms set a price below cost for the segment that generates higher

[11] Depending on the definition of market power, platforms may have market power. According to Wright (2004), if we define the existence of market power as the ability of a firm to profitably charge and maintain a price above marginal cost, then each platform has significant market power in one segment. If, on the other hand, we define it as the ability to profitably set and maintain a price above the competitive price, then neither platform has market power.

benefits for the other segment. As this is a practice to gain higher market share in traditional markets, regulators may suspect predatory pricing. The literature, on the other hand, has recognized that this logic does not apply to platforms.

4. *"An increase in competition necessarily results in a more efficient structure of prices."*: In the case of two-sided markets, even a monopolistic platform is encouraged to reduce prices on one side and thereby attract the other. Therefore, a priori, it cannot be assumed that competition will lead to a more efficient price structure. Although competition reduces the overall price level, it can even remove the price structure from the efficient one.

5. *"An increase in competition necessarily results in a more balanced price structure."*: It follows from the previous fallacy but it can be seen that it depends on the specification of demand and the interaction between competition and consumer demand. If one segment is loyal to the platform, then it is worth for the platforms to decrease the price of the other side. If the segment that pays a higher price in the equilibrium is loyal to the platform, then the price of the other, the supported segment, decreases further, which removes the price structure from the efficient one. The opposite – that is, a shift towards a balanced price structure – can happen if one segment opts for multi-homing, which is basically facing a price below cost. Then the price of the other segment will decrease, that is, the segment that faces a price above cost in equilibrium.

6. *"In mature markets (or networks), price structures that do not reflect costs are no longer justified."*: In the initial stage, the price below the cost charged to one segment may be justified by the chicken-and-egg problem, namely that the platform can attract one segment so that no one from the other segment has joined it yet. This will also increase the demand for the platform in the other segment. However, in the future, the platform will not substantially change its pricing: it will continue to charge the segment generating the higher network benefit below cost, while the other segment will be charged above cost. Thus, the chicken-and-egg problem does not necessarily explain the application of prices below and above cost.

7. *"Where one side of a two-sided market receives services below marginal cost, it must be receiving a cross-subsidy from users on the other side."*: The statement can be attacked along with two logics. On the one hand, the idea ignores the fact that the service provided to one segment depends on the service provided to the other segment. If the platform were to exclude one segment, the other segment would also exit from the platform. The revenue from the service provided to the two segments

provides the platform's total revenue so that the revenue generated by consumers covers their additional costs ample. That is, there is no cross-financing. On the other hand, the existence of cross-financing would mean that the segment that pays a price above cost would be better off banning the other segment from the platform. In addition, a platform could be created that would serve exclusively the high-paying side and be able to profitably crowd out the other platform. However, by excluding one segment, for the other segment, the platform would be able to impose only a fraction of the price or nothing at all, which would not be profitable. Changing the pricing structure – imposing a high price on the previously subsidized segment and a low price on the non-subsidized segment – may also result in a worse outcome if demand is reduced.

8. *"Regulating prices set by a platform in a two-sided market is competitively neutral."*: Regulation is competitively neutral if it does not provide a competitive advantage to unregulated companies. This is conditional on the market being sufficiently competitive. This would be the case if a price reduction on one platform due to regulation would force the other platform to reduce prices accordingly. However, a non-regulated platform typically has no interest in introducing a sub-optimal price structure, thereby gaining a competitive advantage over the regulated platform, so regulation is not competitively neutral.[12]

Wright's paper thus highlights that traditional logic is violated in the case of two-sided markets, as both sides of the market need to be considered in these. A similar idea is expressed by Rysman (2009), who analyzes antitrust investigations in his paper.

As a result of the network effect, trends in two-sided markets in many cases point to the emergence of a monopolistic platform, which is often examined by competition authorities. As one of the means for evaluating mergers, Rysmann cites simulations for them, in which their effects on prices and outcomes are examined. In the case of two-sided markets, however, when two platforms merge, complex two-sided issues should be taken into account, such as the interaction between the two sides when setting prices. In a merger, market power and the cost reductions resulting from the merger are considered. In the case of two-sided markets, if costs fall on one side, the price charged on the other side will also be affected. In addition, the merger may increase the market power of the platform on both sides while reducing prices on one side.

Another means for assessing mergers that Rysmann addresses are regression analysis, where, for example, prices are regressed on the number of firms present in the market.

[12] It should be noted that it is not necessarily true in the case of traditional markets that a non-regulated company also reduced its price as a result of the regulation.

However, in the case of two-sided markets, several prices need to be taken into account, as well as different measures of competition for each side.

Antitrust investigations are based on the definition of the relevant market, to which cross-price elasticity is typically applied. If, in the case of two-sided markets, regulators seek to define the relevant market according to a similar methodology, they should take into account endogenous changes in other prices at any price.

And when collusion took place, it is often necessary to set theoretical prices for quantifying the damages, as would have been the case, for example, if the companies had not colluded. Rysmann points out that such calculations are significantly affected by the two-sided nature of the market, but may also have a similar effect on the design of remedies for antitrust infringements.

Rysman (2009) already emphasizes the difficulty of defining the relevant market, while Szilágyi (2012) analyzes in detail the difficulties involved and the differences with traditional markets.

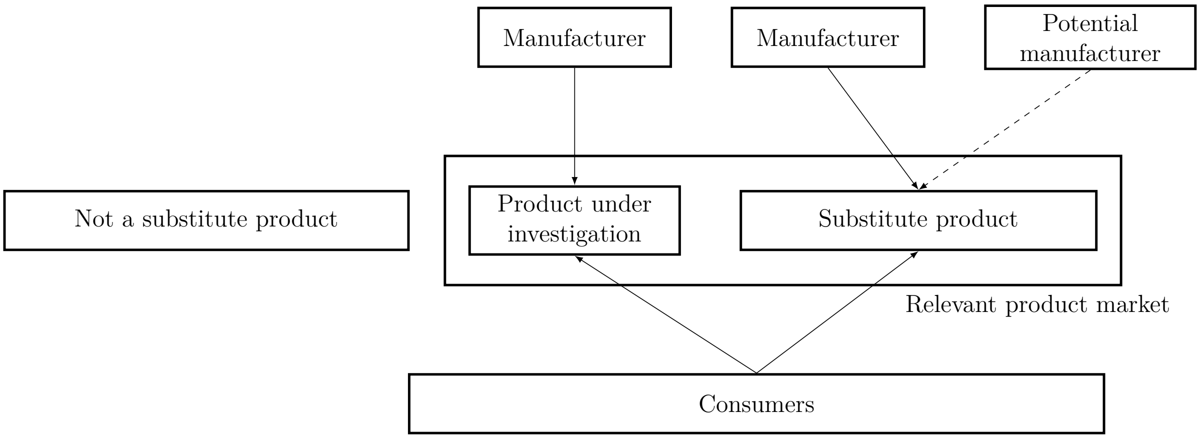
Szilágyi (2012) analyzed the applicability and challenges of competition law in two-sided markets. As they have characteristics that traditional markets do not, it has been seen that the previous practice cannot be applied without modification.

In each case, competition law analyzes are based on the delimitation of the relevant market. In Hungary, Act LVII of 1996 on the Prohibition of Unfair Market Conduct and Restriction of Competition[13] provides for the method of delimiting the relevant market. Under Section 14 of the Act, "the relevant market shall be determined by reference to the goods and the geographical area covered by the agreement." It is also necessary to take into account the products with which the product under investigation can be substituted (demand-side substitutability) and to consider supply-side substitutability. Once the relevant market has been defined, the market share of the company under investigation can be calculated, thus eliminating anti-competitive behavior.

Demand-side substitutability uses theoretical and/or empirical studies to determine the range of products that consumers will buy instead of the product under investigation as a result of a small but significant price increase. According to the author, one can talk about a distorting force if such products cannot be identified. The latter finding, as it will be shown later, is a serious source of conflict for two-sided markets. In the case of supply-side substitutability, competition authorities examine which manufacturers would be able to enter the relevant market in the short term with substitute products, i.e. which companies would be able to quickly switch their production capacities. In this step, therefore, potential competitors are mapped.

[13]Source: Act LVII, Jogtár (2020, November 03)

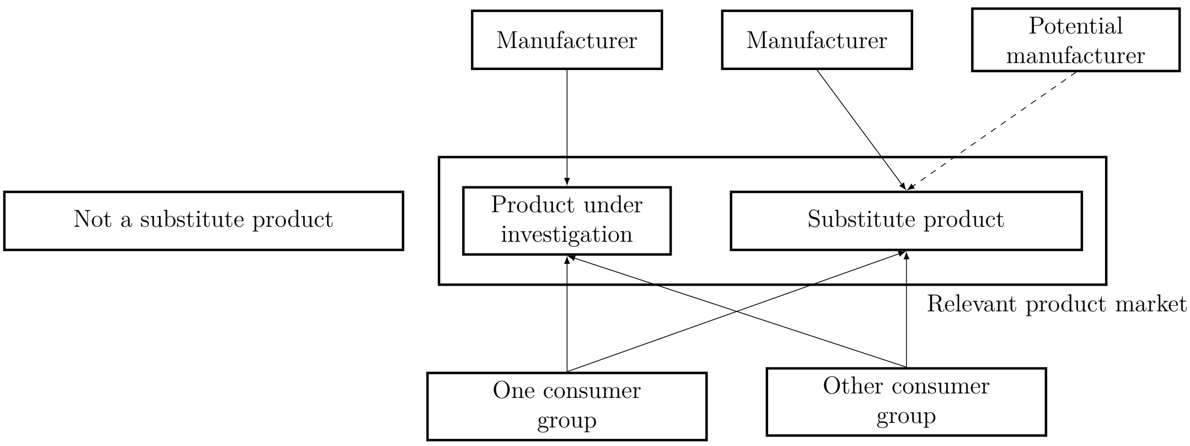
Figure 1.6.1: Delimitation of the relevant market in classical markets



Source: Szilágyi (2012, p.83.)

In the case of two-sided markets, the need to identify demand-side substitutes for two distinct consumer groups, as well as the externalities between the two segments, nuances the picture. In addition to positive externalities, as it has been shown earlier, the number of members of the other segment present on the platform increases the demand for the product or service provided by the platform.

Figure 1.6.2: Delimitation of the relevant market in the case of two-sided markets



Source: Szilágyi (2012, p.84.)

The author pointed out that in the case of a platform-specific practice, i.e. that one of the segments is admitted free of charge, the above methodology cannot be applied without modifications. This is because, for some platforms, the value of the product is given by the connected consumers. He also emphasized that non-price effects were often more pronounced in two-sided markets than in traditional markets, and that price effects should take into account the benefits on the other consumer side. Furthermore, he noted that there is stronger competition with multi-homing than with single-homing and that the focus of the cost structure analysis should be on the whole service because the component-based analysis can be misleading.

In the light of the above, the standard definition of market power, i.e. the ability to price permanently above marginal cost, persists permanently in one consumer segment of two-sided markets, while it cannot be interpreted in the case of the other. Thus, if the authorities examine the existence of market power on a segment-by-segment basis, this may lead to a detrimental outcome for consumer groups. As in the case of two-sided markets, with the conquest of one of the consumer groups, the operation of the platform is endangered or the given platform even ceases to exist, so the competition is reflected in the fight for consumers. In the light of the above, Szilágyi argued that the selection of effective solutions should be left to the market and that timely but only necessary interventions should be sought.

However, there is still no uniform practice for determining the right time and the necessary intervention. The reason for this is well illustrated by Szabó (2017), who examined the possibility of applying data protection regulations in the case of two-sided markets in connection with the "Google judgment"[14], which ended in 2014. The lawsuit was based on the easy availability of personal data and the fact that the user could not have had access to the availability of this data. The case highlighted that the search engine market is not properly regulated and that the issue of jurisdiction for third-country companies also creates uncertainty.

During the review of the case, the author also highlighted the peculiarities of the search engine market and the resulting incentives for circumvention. He assumes that by understanding the entry threshold and network effect typical of two-sided markets, legislation can be effectively enforced.

Szabó followed Szilágyi's (2012) line of thought during the analysis. He identified the search engine market as a relevant market, which is a basic service for internet users, so there is no product to replace it. Search engines also access the number of searches, the content they are looking for, and the geographical location of the person who started the search. That is, although users use the service for free, their behavior represents value to the platform. Based on the above data, search results, but also the advertisements displayed, can be tailored to the tastes of consumers. On the consumer side, according to Szabó, the network effect appears in the case of customizability, as they prefer the services that can better satisfy their needs. And this is made possible by the availability of the right amount and quality of data available on the more popular search engines. This gives them a competitive advantage in making it easier to identify the improvements needed. On the other hand, search engines that do not save the IP address (privacy-friendly),

[14]Source: EUR-Lex (2020, November 03)

for example, are at a competitive disadvantage because they cannot meet consumers' need for convenience. Szabó also emphasized that if they had to comply with strict data protection rules, they would not be able to continue the above practice on the consumer side, which would deprive them of a significant source of revenue. This is what gives service providers a reluctance to regulate. Because the other side is the advertisers, where search engines realize a significant portion of their profits, and they deliver advertisements to consumers by setting their parameters. The more consumers they can reach with a given search engine, the more effectively advertisers will be able to work, so their demand for the platform will increase. However, the necessary condition for this is the existence of personal data, which is why the advertiser side is also against strict data protection regulations.

Finally, from a data protection legal point of view, the barrier to market entry also deserves increased attention, according to Szabó. This is because, for a search engine to work profitably, it requires the proper knowledge of the users as it becomes popular on the other side by attracting them. Thus, Szabó pointed out that the barrier to entry is given by this knowledge in the market, but there is no information available on the extent to which this prevents entry. In the author's view, the restriction of competition in such markets reduces the chances of a competitive situation where users would also take into account their privacy performance when choosing a search engine.

In assessing the lawsuit, Szabó emphasized that according to the court decision, the platforms, whether they operate globally or locally, must comply with the rules of the Member State in which they operate. So the geographical aspect is also important from a data protection point of view.

The above judgment provided the basis for the General Data Protection Regulation (GDPR)[15], adopted in 2016 and entered into force in May 2018, which unifies data protection requirements at the level of the European Union. Szabó emphasized that this regulation was intended to make it easier to monitor the market, as it also applied to companies established outside the Union. It will make it easier for EU citizens to enforce their rights and will also make it easier for service providers to comply. In other words, the protection of privacy is no longer merely a market advantage, but a minimum expectation for service providers. Following the Google lawsuit and the commencement of the regulation, the author considered it worthwhile to apply the experience to the examination of platforms operating on a similar principle and to take into account the peculiarities of the two-sided markets.

It is important to briefly summarize the GDPR as it covers several two-sided markets such as Google, Facebook, but also telephone service providers and credit card issuers.

[15]Source: GDPR, EUR-Lex (2020, November 03)

The new data protection regulation is binding on all companies operating or providing services within the EU that process personal data, regardless of where they are established. Personal data is any data on the basis of which a natural person can be directly or indirectly identified. The regulation distinguishes between the data controller and the data processor: the former merely deals with the collection of the data and forwards it to the latter, another company that processes it. Both the data controller and the data processor are obliged to prepare a data management information sheet, and the former is obliged to indicate the processor in it as well. The information sheet must be clear and unambiguous as well as it should cover the purpose for which the data collected will be used, the method of data collection, and the conditions and timing of processing. In the case of online service, users must also be informed about the cookies[16] used, and in the case of cookies that are not required for the operation of the site, their approval must also be requested. If unauthorized persons have access to the personal data processed, the company must report the case to the National Data Protection and Freedom of Information Authority (NAIH) in Hungary.[17]

The reviewed literature highlights the need to regulate two-sided markets, but it is challenging to take their specificities into account. There is no uniform methodology developed for this, so countries regulate the operation of the platforms according to their own laws and discretion. Although the General Data Protection Regulation adopted by the European Union provides the necessary basis for consumer protection, it is only one of the areas covered by the regulation.

There are many examples of different regulations from recent years. In August 2014, in Hungary, with the entry into force of Act XXII on the Advertising Tax[18], the publishers of advertisements and their customers were also required to pay taxes. Although the range of taxpayers is quite wide, it should be mentioned here as it also affects platforms like Google. In the case of advertisers, the tax is based on the net turnover from the taxable activity, which needs to be adjusted by a number of items. The tax rate payable was 0 percent until June 2017 and then rose to 7.5 percent until July 2019. In the case of customers, the part of the monthly fee paid for the publication of advertisements in excess of HUF 2.5 million was the tax base, and the tax rate was 5 percent. Failure to pay the tax resulted in a fine.

In January 2017, the National Tax and Customs Administration imposed a significant default fine on Google, which eventually led to a lawsuit between Google and the Hungari-

[16]Cookies are small files stored on the computer that allow us to browse the Internet in a personalized way. They store personal information such as login information or previous purchases. Because they store personal information, they allow criminals to abuse. Source: http://www.whatarecookies.com/ (2021, February 28)

[17]Source: GDPR, EUR-Lex (2020, November 03)

[18]Source: Act XXII, Jogtár (2020, November 02)

an Government. Google argued that the tax imposed was discriminatory because foreign-based companies were subject to higher penalties and that the tax violated the principle of freedom to provide services. The lawsuit ended in March 2020 with the conclusion that the advertising tax itself is not contrary to European Union law, but the system of sanctions applied is objectionable.[19]

Another Hungarian precedent is the case of Uber. Uber was launched in Hungary in November 2014 using a ride-sharing application. In contrast to taxi operators, Uber drivers were subject to fewer regulations (for example, they did not have to apply the statutorily fixed tariff, did not have to paint their vehicle yellow, were not subject to a minimum luggage requirement, etc.), which caused outrage on the part of taxi drivers. In this spirit, the Government has continuously made provisions to alleviate the competitive disadvantage of taxi drivers (for example, the issuance of e-invoices and the application of passenger permits has been made mandatory).

Finally, Uber announced that it would withdraw from Hungary on 24 July 2016 by enacting the Act LXXV of 2016 on the legal consequences of unauthorized passenger transport services by car[20]. The law made it mandatory to operate a dispatch service in accordance with the regulations. If this is not available and therefore a penalty is imposed, websites that provide the illegal service will be blocked for 365 days. Those who engage in illegal passenger transport services can be fined and their vehicle is taken out of service. According to the European Commission's resolution, Uber and other platforms operating along similar principles should also be given special treatment, as their services are provided on an ad hoc basis and are based on a sharing economy model, thus operating differently from professional service providers. They also see the need to harmonize regulations, and a total ban is proposed only as a last resort.[21]

The idea also arose in the UK's capital not to renew Uber's taxi service license, meaning to ban the operator from the city. In November 2019, Transport for London (TfL), the City Hall organization that manages public transport in London, refused to grant the permit because Uber did not meet the required conditions. Finally, following Uber's appeal, in September 2020, the Westminster Magistrates' Court in London issued an order allowing Uber to continue operating in London[22]. Mention should also be made of California, where a referendum decided whether to ban Uber and Lyft from the state.[23]

The practice of the above countries is contrasted with the case of Estonia, where

[19]Source: Digital giants cannot avoid paying taxes either (Hungarian), Website of the Hungarian Government (2020, November 02)

[20]Source: Act LXXV, Jogtár (2020, November 03)

[21]Source: European Parliament (2020, November 21)

[22]Source: Uber can stay in London (Hungarian), MTI, 2020, September 28. (2020, November 21)

[23]Lyft also provides passenger services in the United States and Canada. Source: Lyft (2020, November 03)

Uber and Taxify were first legalized in November 2017.[24] The new transport law no longer separates ride sharing from the taxi service, while at the same time easing the requirements for the latter. The taxi service is divided into 4 categories in the law:

1. Classic taxis with an illuminated sign and a taximeter;
2. Cars that can be ordered through a mobile application and for which payment will be made through the help of the mobile application;
3. Cars with a taximeter but with no illuminated sign;
4. Cars with an illuminated sign but with no taximeter.

Separate rights have been defined for each category. For example, anyone who has a taximeter is not required to serve their customer through a mobile app. Cars with an illuminated sign can also use public transport lanes, while cars without an illuminated sign and a taximeter cannot, and they must issue all invoices through the mobile app. Those who provide their service through the mobile app can install an illuminated sign on their car, but the vehicle and driver must have all the necessary permits to do so. As an exception, the case of ride-sharing also appears in the law, when passengers join a planned trip and thus the driver does not earn income.

To become a Uber driver in Estonia, you only have to meet a few requirements[25]:

1. You must register online on the website;
2. You must upload the required documents (identity card, driving license, copy of car insurance, bank statement, profile picture) to the system;
3. You must obtain the service license and vehicle license required for the Uber;
4. You must have a car;
5. Finally, you need to activate your registration.

Thus, it can be seen that countries reacted differently to the emergence of Uber with different regulations. Judging which country is on the right track is extremely difficult. In the absence of uniform rules, the harmonization outlined in the European Commission's resolution cannot take place. The paper by Szilágyi (2012) and Szabó (2017) illustrates why it is difficult to create a uniform and, above all, workable regulation for two-sided markets.

[24] Source: Uber and Taxify will be legal in Estonia, BTN (2020, November 03)
[25] Source: Uber (2020, November 03)

Chapter 2

Product differentiation in two-sided markets[1]

2.1 Product differentiation and two-sided markets

The basic model of product differentiation can be linked to Hotelling (1929). The Hotelling model is based on a linear line on which consumers are evenly distributed and companies decide on their spatial location. A point in space actually indicates the differentiation of a product, so companies determine the characteristics of their products through their location decision, while the location of consumers represents the ideal product for them. The discrepancy between the product offered and the product to be consumed, i.e. the incomplete customization of the product, represents a negative benefit or cost for consumers. This discrepancy in the characteristics of the product is captured by the travel cost in the Hotelling model. Further development of the Hotelling model is the district model of Salop (1979), which eliminates the problems of the previous model[2] and is also suitable for the analysis of multi-player markets. Similarly, in this case, the product differentiation is determined by the spatial location of the companies.

The above two models have resulted in several papers focusing on the effect of product differentiation on pricing[3], but in these, the parameter expressing the degree of product differentiation is an exogenous variable and is not influenced by companies. The first paper in which companies directly defined the differentiation of their product can

[1]Based on Bakó and Horváth (2020).

[2]For example, d'Aspremont et al. (1979) have proved that with linear transportation costs the Principle of Minimum Differentiation is invalid.

[3]See. for example, Hobbs (1986), who analyzed the effect of the appearance of spatiality in the case of Bertrand and Cournot competition, while Thisse and Vives (1988) examined the decision between the unit price and price discrimination. In both papers, the authors concluded that product differentiation increases competition and that the dominant strategy on the part of companies is to apply price discrimination.

be attributed to von Ungern-Sternberg (1988). The author examined the incentives of companies to produce general purpose products within the framework of the Salop model, i.e. how product differentiation affects the market share and profit of companies. In his model, he approached product differentiation, in contrast to conventional approaches, not by choosing a location or determining the number of companies entering, but by the ability to influence travel costs. This was justified by the fact that in practice, product differentiation is best captured not by the right choice of location, but by the ability to influence transport costs. As an example, he cited the IBM 360 series, which was the first computer family to be used in many areas, from business use to scientific application. Based on these, the basic assumption of the author's model was that the lower the travel cost, the more general purpose the product. He found that companies are motivated by consumer preferences to produce products for more general purposes, that is, to reduce product differentiation, and as a result, they set travel costs below the social optimum.

The shortcoming of the above paper, according to Hendel and de Figueiredo (1997), is that companies decide first on location and then on product differentiation, and is therefore not suitable for examining the effect of the latter decision on pricing. This is why Hendel and de Figueiredo examined a three-period game where companies set their prices after deciding on location and product differentiation. They concluded that if companies produce general purpose products free of charge, optimally only two companies will enter the market and offer fully customized products. If it is costly for companies to produce a general-purpose product, the customization of the products will decrease, price competition between companies will decrease, and more than two companies will be present in the market at optimum.

A different approach was taken by the paper by Ferreira and Thisse (1996), in which the impact of different transportation technologies on firms' pricing and market share was analyzed within the framework of the Launhardt model. As the two companies had different transport costs, their products could be considered differentiated. If companies can decide on the transport technology used and are located at two endpoints of the market, it is advisable to differentiate their products minimally. This result is consistent with von Ungern-Sternberg's (1988) result.

In two-sided markets, the ability to differentiate products has received little attention. In their paper, Armstrong and Wright (2007) examined the effect of the product differentiation and network effect on prices and users' platform choice, however, in this paper, product differentiation as a decision factor did not appear. They concluded that as the network effect increases, the connection fee payable decreases, while it increases as product differentiation increases. The authors also noted that with significant product differentiation across both sides, actors will only enter one platform, i.e., they will strictly prefer single-homing behavior. In contrast, if product differentiation is specific to only one side, actors in the other segment want to be active on multiple platforms. However, platforms can and want to prevent this by introducing exclusive contracts.

In the case of two-sided markets, the decision on product differentiation is examined below. However, the presented model differs in two aspects from the standard models used in the literature. First, in the model presented below, asymmetric platforms are considered instead of symmetric platforms. Similar to Bakó and Fátay (2018), this model has an intra-group effect on one side and an inter-group effect on the other.

There are a number of examples of asymmetric network effects instead of symmetric network effects in two-sided markets. Consider, for example, a social media provider where the company provides a platform for user-advertiser interaction. However, in this relationship system, the classic symmetric network effect does not prevail, as it was seen in the examples mentioned in the previous chapter because in most cases users do not benefit from interactions with advertisers, but from the ability to interact with other users using the platform. That is, in their view, there is an intra-group network effect. On the other hand, it is still true for the advertiser side that the larger the group of users they access using the platform, the more valuable its service will be to them. So for the advertiser side, a positive inter-group network effect, which is considered classic, prevails.

The other aspect in which the model differs from the models presented in the literature is that platforms are able to determine the extent to which they want to differentiate their products. By this, it becomes a decision factor how much customizability they provide to the actors joining the platform.

There are several examples of this practice. On most platforms, it is possible to define a user-level interface and make it customizable by the user. For example, one can think about the customizability of the Google, Facebook, Twitter, and Instagram accounts, but even the types of feeds one can choose for news providers.

Consider a less obvious example, the Netflix online media service platform: the more subscribers Netflix has, the more accurate the referral system is, as the more likely it is that the recommended show will suit the viewer's taste. As a result, the more people use Netflix, the more useful it will be for a user. Furthermore, the more Netflix subscribers, the more attractive it becomes to production offices and content providers. Another feature of Netflix is that it provides users with a personalized profile, meaning that subscribers receive a differentiated service in exchange for a monthly subscription fee. Overall, therefore, Netflix is not only an example of asymmetric two-sided markets but also fits into the concept of platforms using product differentiation.

The possibility of customization can be important because it also makes the service of the platform more attractive to users who would not otherwise connect to the platform.

The model outlined below seeks to answer the question of how asymmetric two-sided markets price their products and services, and how this pricing decision depends on the degree of customizability. For example, one can think of the multitude of products and services available online. Generally speaking, most of these are available in two forms: a form that provides a limited user experience but is available for free, or at a positive price in the form of a product or service that provides several customizability options, even additional services. The aim of the model described below is to better understand this phenomenon.

2.2 The model

Consider a classic Hotelling market and suppose that two platforms, 1 and 2, operate in the market. They face two types of consumer groups, users (k) and advertisers (l).[4] It is assumed that both consumer groups are evenly distributed over the unit interval representing the market and that the platforms are located at the two endpoints, with platform 1 at 0 and platform 2 at 1. This is illustrated in Figure 2.2.1. For simplicity, it is assumed that the platforms will operate at zero cost.

Figure 2.2.1: Location of platforms

Consumers are assumed to realize v_i ($i = k, l$) benefits from joining a platform, however, they have to pay a non-negative price, $p_{i,j}$, for entering ($j = 1, 2$). There is a further reduction in utility for consumers if they are not joining a platform with an ideal location for them, which is embodied in the transportation cost, $t_{i,j}$, expressed as a linear function of the distance between the consumer's location and the platform of her choice. More specifically, the consumer of type i, when entering a platform j at a distance d, suffers a utility loss of magnitude $t_{i,j}d$, and it is assumed that $t_{i,j} \geq 0$ for all $i = k, l$ and $j = 1, 2$. Because the aim is to examine the customizability provided to the user side, the transportation cost of the advertiser side will be kept constant for future traceability and it is assumed that $t_{l,j} = 1$.

[4]Hereinafter, the actors that demand the service of the platform are generally referred to as consumers. However, if it is important to differentiate consumers by segment, they will be called users and advertisers.

The specificity of two-sided markets, as explained above, is the effect of the network effect between the two segments. As a result, it is assumed that consumers connecting to the platform will benefit more from connecting to a larger platform than if they choose a platform on which fewer users are active. However, instead of assuming classic platforms, the performance of asymmetric platforms[5] is examined and it is assumed that advertisers benefit from the increase in the number of users connected to the platform. Users do not have an inter-group network effect like this but have a classic intra-group network effect. Based on this, the more users connect to a given platform, the greater the benefits to users of logging in to the platform. Hereinafter, the number of k-type consumers connected to platform j is denoted by $n_{k,j}$ and it is assumed that the additional benefit of the i-type consumer connected to the platform from interactions can be expressed by $b_i n_{k,j}$, where $0 < b_i < 1$ $(i = k,\, l)$ expresses the magnitude of the network effect.[6]

Following the literature on asymmetric platforms, it is assumed that users will connect to only one platform, while advertisers, if interested, will advertise on both platforms. For the sake of simplicity, it is also assumed that users realize some positive utility from the connection as a result of the basic service provided by the platform, even if no other user has joined it[7], whereas advertisers only realize positive utility if users enter the platform.

Based on the above, the benefit of a k-type consumer (user) with x location, if she choose platform 1, can be given by the following utility function:

$$u_{k,1}\left(x\right) = v_k + b_k n_{k,1} - p_{k,1} - t_{k,1} x, \tag{2.2.1}$$

while if she connects to the other platform, the benefits will be

$$u_{k,2}\left(x\right) = v_k + b_k n_{k,2} - p_{k,2} - t_{k,2}\left(1 - x\right) \tag{2.2.2}$$

The benefit of the type l consumer (advertiser) when entering platform 1 will be

$$u_{l,1}\left(x\right) = b_l n_{k,1} - p_{l,1} - x, \tag{2.2.3}$$

while

$$u_{l,2}\left(x\right) = b_l n_{k,2} - p_{l,2} - \left(1 - x\right) \tag{2.2.4}$$

[5] See Bakó and Fátay (2018)

[6] Note that there is no difference between transactions that occur on the platform and transactions that potentially occur on the platform. In practice, it is assumed that there is exactly one transaction between each of the different types of consumers connected to the platform. The use of this assumption is widespread in the literature. See, for example, Armstrong and Wright (2007).

[7] Thus, it is assumed that there is a direct network effect on the users, i.e. the ownership of the platform's product or service also generates benefits for the players of the segment.

will be the realized benefit if she chooses the other platform. If she advertises on both platforms, the realized benefit can be specified with the following function:

$$u_{l,1,2}(x) = b_l n_{k,1} - p_{l,1} - x + b_l n_{k,2} - p_{l,2} - (1 - x), \tag{2.2.5}$$

in which case the advertiser's payment will be independent by the location.

The profit function of the platforms can be written in the following form:

$$\pi_j = \sum_i p_{i,j} D_{i,j}(\mathbf{p}), \tag{2.2.6}$$

where $D_{i,j}(\mathbf{p})$ is the demand of type i consumers for the service of platform j as a function of $\mathbf{p} = (p_{k,1}, p_{k,2}, p_{l,1}, p_{l,2})$, i.e. the vector of prices determined by the platforms.

The game is as follows: In the first period, the platforms decide simultaneously on the differentiation of their service, which is expressed in terms of the transportation cost on the user side, and then in the second period they determine the subscription fees. Finally, the players on both sides, observing these decisions, decide which platform to join, and eventually, the market clears up.

Transportation cost, as a decision variable, aims to capture the incentives of platforms to differentiate products. For most information products, consumers have the opportunity to use the service they use in a personalized way, within certain limits. This customizability is intended to be captured by the size of the transportation cost. The greater the consumer's room for maneuver in shaping the given service according to his own idea, the lower the transportation cost she will face when consuming it, while the more limited the possibilities of customization, the higher the transportation cost of using the platform's service.

The solution to the game is given by its subgame-perfect Nash equilibrium, which can be obtained by backward induction due to the sequential nature of the game.

Two cases are examined: when platforms compete with each other for consumers, and when they behave as a local monopoly.

2.2.1 Competition

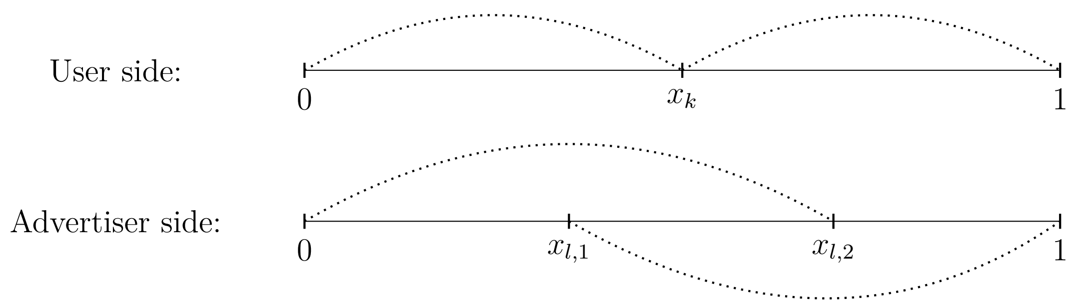
Suppose that platforms have chosen $t_{k,j}$ transportation costs as well as $p_{i,j}$ prices in previous periods. To determine demand, it is needed to specify the consumers, more specifically the location of consumers who are indifferent to which platform to connect to. Consider k-type consumers first. A user with location x for whom $x \leq x_k$, where x_k is the location of the indifferent user, will join platform 1, while everyone else will choose platform 2. It is true for the location of the indifferent user that the utilities given by the terms (2.2.1) and (2.2.2) are the same. From this, the indifferent user is located at the

$$x_k = \frac{b_k\left(n_{k,1} - n_{k,2}\right) + p_{k,2} - p_{k,1} + t_{k,2}}{t_{k,1} + t_{k,2}} \tag{2.2.7}$$

point.

Similarly, in determining an advertiser's demand for platforms, first, the location of advertisers must be determined who are indifferent to whether to enter only one or both platforms. Denote by $x_{l,1}$ the location of the advertiser who is indifferent to joining platform 1 or both, and $x_{l,2}$ by the location of the advertiser who is indifferent to joining platform 2 or both. Figure 2.2.2 is intended to illustrate the situation of indifferent consumers.

Figure 2.2.2: The location of indifferent consumers and the demand for platforms' service



From the equations $u_{l,1}\left(x_{l,1}\right) = u_{l,1,2}\left(x_{l,1}\right)$ and $u_{l,2}\left(x_{l,2}\right) = u_{l,1,2}\left(x_{l,2}\right)$, it follows that the indifferent actors on the advertiser side are located at

$$x_{l,1} = 1 - \left(b_l n_{k,2} - p_{l,2}\right) \tag{2.2.8}$$

and

$$x_{l,2} = b_l n_{k,1} - p_{l,1}, \tag{2.2.9}$$

respectively.

Provided that all consumers realize positive utility at the given prices, that is, that v_k is at least as large as all users connected to a platform in equilibrium, and taking advantage of the fact that $n_{k,1}$ is equal to x_k in equilibrium and $n_{k,2}$ is equal to $1 - x_k$, the demand for the platforms can be given by the following terms:

$$D_{k,1}\left(\mathbf{p}\right) = \frac{p_{k,2} - p_{k,1} + t_{k,2} - b_k}{t_{k,1} + t_{k,2} - 2b_k} \tag{2.2.10}$$

$$D_{k,2}(\mathbf{p}) = 1 - D_{k,1}(\mathbf{p}) \tag{2.2.11}$$

$$D_{l,1}(\mathbf{p}) = 1 + p_{l,2} + \frac{b_l\left(p_{k,2} - p_{k,1} + b_k - t_{k,1}\right)}{t_{k,1} + t_{k,2} - 2b_k}, \tag{2.2.12}$$

and

$$D_{l,2}(\mathbf{p}) = \frac{b_l\left(p_{k,2} - p_{k,1} - b_k + t_{k,2}\right)}{t_{k,1} + t_{k,2} - 2b_k} - p_{l,1}. \tag{2.2.13}$$

Using these terms, platform profits can be defined as follows:

$$\pi_1\left(p_{k,1}, p_{l,1}\right) = p_{k,1}D_{k,1}(\mathbf{p}) + p_{l,1}D_{l,1}(\mathbf{p}), \tag{2.2.14}$$

and

$$\pi_2\left(p_{k,2}, p_{l,2}\right) = p_{k,2}D_{k,2}(\mathbf{p}) + p_{l,2}D_{l,2}(\mathbf{p}). \tag{2.2.15}$$

Platform j defines connection charges for which it is true that

$$\frac{\partial \pi_j}{\partial p_{i,j}} = 0 \;\forall i = k,\, l. \tag{2.2.16}$$

From the solution of the system of equations formed by these first-order conditions, it follows that in equilibrium

$$p_{k,1} = \frac{\left(2t_{k,1} + 2t_{k,2} - b_l^2 - 4b_k\right)\left(2t_{k,1} + 4t_{k,2} - b_l^2 - 6b_k\right)}{2\left(6t_{k,1} + 6t_{k,2} - 2b_l^2 - 12b_k\right)}, \tag{2.2.17}$$

$$p_{k,2} = \frac{\left(2t_{k,1} + 2t_{k,2} - b_l^2 - 4b_k\right)\left(4t_{k,1} + 2t_{k,2} - b_l^2 - 6b_k\right)}{2\left(6t_{k,1} + 6t_{k,2} - 2b_l^2 - 12b_k\right)}, \tag{2.2.18}$$

$$p_{l,1} = \frac{b_l\left(2t_{k,1} + 4t_{k,2} - b_l^2 - 6b_k\right)}{2\left(6t_{k,1} + 6t_{k,2} - 2b_l^2 - 12b_k\right)} \tag{2.2.19}$$

and

$$p_{l,2} = \frac{b_l\left(4t_{k,1} + 2t_{k,2} - b_l^2 - 6b_k\right)}{2\left(6t_{k,1} + 6t_{k,2} - 2b_l^2 - 12b_k\right)}. \tag{2.2.20}$$

In addition to the above prices, the companies' profits are as follows:

$$\pi_1 = \frac{\left(4t_{k,1} + 4t_{k,2} - b_l^2 - 8b_k\right)\left(2t_{k,1} + 4t_{k,2} - b_l^2 - 6b_k\right)^2}{16\left(3t_{k,1} + 3t_{k,2} - b_l^2 - 6b_k\right)^2} \tag{2.2.21}$$

and

$$\pi_2 = \frac{\left(4t_{k,1} + 4t_{k,2} - b_l^2 - 8b_k\right)\left(4t_{k,1} + 2t_{k,2} - b_l^2 - 6b_k\right)^2}{16\left(3t_{k,1} + 3t_{k,2} - b_l^2 - 6b_k\right)^2}. \tag{2.2.22}$$

As a final step, consider decisions about the variables that capture the customizability chosen by the platforms. By maximizing the profit functions given by terms (2.2.21) and (2.2.22) with respect to transportation costs and taking advantage of the symmetry between firms, the following proposition is made.

Proposition 1. *In an asymmetric two-sided market, where two platforms operate at two endpoints in the market, members of the user and advertiser segments are evenly distributed across the market, and platforms compete with each other for subscribers, the following equilibrium emerges if the platforms also decide on product differentiation. Platforms optimally define transportation costs*

$$t_{k,j} = \frac{b_l^2}{4} + b_k \ \forall j = 1.2 \tag{2.2.23}$$

In addition to these transportation costs, prices of $p_{k,j} = 0$ and $p_{l,j} = \frac{b_l}{4}$ are set and a profit of $\pi_j = \frac{b_l^2}{16}$ is realized. In equilibrium, on the user side, the indifferent consumer will be at the midpoint of the interval, while on the advertiser side, advertisers with $x \in \left(\frac{b_l}{4}, 1 - \frac{b_l}{4}\right)$ locations will advertise on both platforms. The other advertisers only enter the platform closest to them.

It can be seen that in the case of competing platforms, as the network effect increases, the customizability of the products offered by companies decreases. As a result, however, the service of the platforms is less valuable to users, so they are only willing to pay a lower price for it. To offset this, companies allow users to join for free and achieve a positive profit at the price charged to advertisers. The greater the benefit to advertisers of being able to transact with users, the higher the price the platform will be able to enforce on the advertiser side, and the profit will increase accordingly. In contrast, as prices rise, a smaller and smaller proportion of advertisers choose to join both platforms.

However, the above result will only be the equilibrium outcome of the game if the basic assumption is true that both sides of the market are fully covered, i.e. that all consumers are willing to enter a platform at given prices. However, this is only the case if the realized utility at the given prices to the consumer realizing the lowest utility after the entry is non-negative. That is, if for the user side

$$v_k - \frac{1}{2}\frac{b_l^2 + 4b_k}{4} + \frac{1}{2}b_k \geq 0 \tag{2.2.24}$$

and the advertiser side

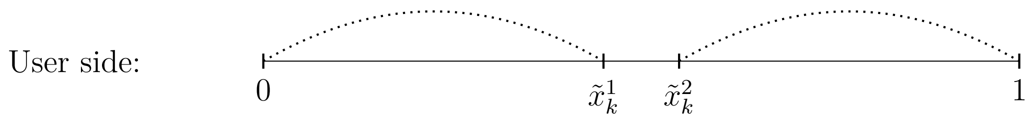
$$\frac{b_l}{2} - \frac{b_l}{4} - \frac{b_l}{4} \geq 0, \tag{2.2.25}$$

hold. These conditions are met for all $v_k \geq \frac{b_l^2}{8}$. However, if the benefit from using the platform is less than $\frac{b_l^2}{8}$, then the behavior of the platforms in the equilibrium of the game differs from that described above.

2.2.2 Local monopolies

With low v_k values, some consumers – those who are far enough away from the platforms – decide that they do not want to connect to any of the platforms at the given prices. Such a case is represented in Figure 2.2.3.

Figure 2.2.3: User demand for platforms in the case of an uncovered market



Thus, the markets of the platforms on the user side do not meet, i.e., companies operate as local monopolies. In this case, in the absence of direct competition for users, the platforms will charge prices so that the net benefits realized by the most distant consumers connected to the platforms will be zero, i.e. $v_k + b_{k,j}n_{k,j} - p_{k,j} - t_{k,j}\tilde{x}_{k,j} = 0$ will be satisfied for all $j = 1, 2$. Proposition 2 is obtained using the methodology used previously.

Proposition 2. *In asymmetric two-sided markets, where two platforms operate at two endpoints, users and advertisers are evenly distributed along the interval, and the platforms act as local monopolies, the following equilibrium emerges if the platforms also decide on product differentiation. Platforms optimally define a transportation cost of*

$$t_{k,j} = 0. \tag{2.2.26}$$

In addition to these transportation costs, prices of $p_{k,j} = \frac{v_k}{2}$ and $p_{l,j} = \frac{b_l}{4}$ are set and a profit of $\pi_j = \frac{v_k}{2} + \frac{b_k}{4} + \frac{b_l}{4}\left(1 - \frac{b_l}{4}\right)$ is realized. In equilibrium, on the user side, the indifferent consumer will be at the midpoint, while on the advertiser side, advertisers with $x \in \left(\frac{b_l}{4}, 1 - \frac{b_l}{4}\right)$ locations will advertise on both platforms. The other advertisers only enter the platform closest to them.

Note that in the above equilibrium, unlike in the previous case, the platforms provide users with maximum customizability characterized by zero transportation costs. Because users reap low benefits from connecting to platforms, companies try to make the platforms more attractive to users and thus more attractive to consumers on the other side, taking full advantage of the possibility of customization. In equilibrium, platforms are priced so that their markets are just separated at the midpoint of the market and can continue to operate as a local monopoly. That is, indifferent users are in the middle of the market, and since at zero prices, users reap positive utility with all non-negative v_k due to the network effect, this provides an opportunity for platforms to set a positive connection fee. Since in equilibrium, platforms can attract the same number of users as in the previous case, it is not surprising that indifferent consumers on the advertiser side will be in points $\frac{b_l}{4}$ and $\frac{4-b_l}{4}$, and there will continue to be advertisers who will advertise on both platforms. As before, the number of these advertisers decreases as their network effect increases: the higher the benefit they realize from interacting with users, the more it is worthwhile for them to join only one or the other platform.

2.3 Summary

In general models of product differentiation, companies are able to influence the differentiation of their products by choosing their location, but while this reduces transportation costs for some consumers, the opposite is true for other consumers. Nowadays, on the other hand, we are consuming more and more information products, for which consumers, to a greater or lesser extent, have the opportunity to consume them in a personalized way, according to their own tastes. This phenomenon is not sufficiently captured by the methodology used in the literature, so we examined von Ungern-Sternberg's (1988) approach to two-sided markets.

The study of customizability is justified by the fact that the platforms can this way reach and attract consumers who would not otherwise join them. To this end, a model was presented in which the platforms customize the products and services they offer by influencing the transportation cost. It was assumed that the lower the transportation cost, the more the product is tailored to the consumer's taste. In addition, instead of assuming symmetric market in the analysis of two-sided markets, this issue has been explored for asymmetric markets, as for many platforms, consumers care about the number of members in their own segment, while sellers benefit from the number of the other segment. Examples include streaming media providers like Netflix or Disney+, or online video sharing sites like YouTube. In the model, the question was examined how product differentiation affects the pricing of the products and services they offer in the case of asymmetric two-sided markets.

The results of the model suggest that profit-maximizing platforms provide users with either maximum customizability at a positive price or somewhat limited customizability at a zero price, depending on the utility from consumption. This is supported by several practical observations. However, the company does all this in order to make its own platform attractive enough to the other side of the market, i.e. to the advertisers. This is because a significant part of the company's profit comes from the consumption of the players on this site.

The above results differ from those described in the literature. While von Ungern-Sternberg (1988) has come to the conclusion that companies are encouraged to produce general purpose products, i.e. they will reduce the differentiation of their products, Hendel and de Figueiredo (1997) added that this is only true if companies produce their products free of charge. In contrast, with costly manufacturing, customizability is reduced. And the results from Ferreira and Thisse (1996) suggested that if companies can choose their transportation technology and are located at two endpoints in the market, they will minimally differentiate their products. That is, the effect of product differentiation is just the opposite in the case of two-sided markets as in the case of standard markets, which is a result of the network effect between the two segments.

All these results also provide important lessons from a regulatory point of view. As it has been shown, platforms quite often apply zero, in practice even negative price, in order to make a profit through the services provided to the other side's players. This practice is not necessarily a concern in terms of competition law per se, but requires special attention, as the analysis of Szilágyi (2012) and Szabó (2017) has shown.

Based on the results, the ability of a platform to gain market power is somewhat hampered by the possibility of customization. As it was seen, if platforms act as a local monopoly, they will ultimately provide users with the maximum degree of customizability in equilibrium. This, in turn, spreads competition for advertisers to the other side of the market, even if companies operate in well-separated markets. It can be said that competition on one side of the market in two-sided markets will automatically spread to the other side of the market, and if not in terms of prices, it will have an impact in some other dimension. Therefore, it is not necessarily a problem for a platform to have an exceptionally large market share in the user market, provided that it is forced to compete with other platforms on the other side of the market, the advertising market.

Chapter 3

Public and private contracts in two-sided markets

3.1 Introduction

As in any market, there are many examples for two-sided markets where platforms offer public or even private contracts to sellers entering them. These contracts typically specify a variable and/or a fixed fee to be paid as a result of the transactions.

An example of a public contract is the eBay online auction site, whose rules list the fees to be paid item by item. Examples of both variable and fixed fees can be found in the regulations[1]. Consider the case where books are sold through eBay. After a successful transaction, taking into account the value of the auction and the number of books purchased, the seller will have to pay 12 percent of the final price, but a maximum of \$750. So below a certain final amount and amount of books, this will be the variable fee that arises as a result of the transaction, while once the maximum threshold is reached, the seller will not pay a variable fee for the transaction. In addition, the seller have to pay to list the goods: according to eBay policy, the first 50 listings are free every month, but above that, \$0.35 should be paid for each product listed, regardless of whether it was sold and, if so, for how much and in what quantity, i.e., this item is considered as a fixed fee.

If one is looking for an example of using a private contract, then Netflix, Spotify, and Sony Music, but Apple and Microsoft can be considered, too. In the case of these companies, there is an idea of what business policy they are pursuing, however, it is not possible to say item by item how much they spent or where their revenue came from. Take Spotify, for example. It is basically available for free, although the user encounters many

[1] On http://pages.ebay.com/help/sell/fees.html (2020, October 18) you will find all the fees charged by eBay.

advertisements while listening to music. On the other hand, for 2.5–8 euros, one can also subscribe to the packages offered by the company, which removes advertisements, provides faster access, and even allows offline music listening. This is essentially a set access fee for consumers to the platform. The other side of Spotify is provided by the content creators. The amounts offered to them are typically secret, but it made the dust fly in 2015 when hackers leaked a contract between Spotify and Sony Music.[2] It can be seen from this that, on the one hand, the two companies contracted an advance of $42.5 million in connection with the transfer of the contents, which corresponds to a fixed fee included in the contract. The variable fee is made up of three items under the contract: the ad-supported free tier, online day passes (which no longer exist), and Spotify's premium service. In each case, Sony Music will receive 60 percent of Spotify's revenue multiplied by Sony Music's market share. That is if Spotify earned $100 million in a given month and Sony Music's share of streams was 10 percent, it could claim 10 percent of $60 million, or $6 million. In addition, however, the contract also included a minimum clause calculated on the basis of usage and subscribers. These ensure that if, for example, royalties from usage exceed the amount available under the above formula, Sony will receive the higher amount. Sony Music will get $0.00225 per stream according to the usage-based minimum clauses unless Spotify has not met its growth target in a given month, in which case the fee will increase to $0.0025 per stream. In the case of the minimum condition for premium subscribers, the amount due to Sony Music under the contract is calculated by taking the percentage of use of the Sony Music label (i.e. how much of all the content viewed is attributable to Sony) multiplied by the number of premium subscribers, and by $6.00.

Thus, it can be seen that there are many examples of the use of both public and private contracts, however, the literature analyzing two-sided markets usually assumes public contracts in the market, i.e. all actors have all the information available in the market. One of the earliest papers, which also deals with the application of private contracts, can be linked to Armstrong and Wright (2007). In their paper, however, at the level of modeling, the effect of private contracts on the equilibrium is not yet visible, only their application by platforms emerges as an alternative strategy. The authors point out that if one side – typically sellers – enters both platforms, the platforms will have the opportunity to offer contracts to members of this segment that will deter them from multi-homing in some form. If the platform offers these exclusive contracts, the authors concluded that the platform's previously used strategy will change to the opposite, and a high access fee will be set for the previously supported segment until the previously unsupported segment is subsidized.

For an incumbent and an entrant platform, Doganuglu and Wright (2010) analyzed

[2]Source: The Verge (2021, January 02)

the use of exclusive contracts in two-sided markets: they sought an answer as to when an incumbent platform is worth contracting exclusively with market players. Based on their results, if the incumbent is confronted exclusively with consumers, i.e. the market can still be considered one-sided and therefore can only contract with them, then if consumers join only one platform, full foreclosure will take place in the market using the contracts. Conversely, if the consumer segment can purchase products from more than one company, the incumbent can only partially foreclose the entrant through exclusive contracts. In these types of markets, the use of exclusive contracts thus leads to an anti-competitive and inefficient outcome. In contrast, in the case of two-sided markets, the use of private contracts results in a more favorable outcome for one segment, even if by using them the platform present in the market completely excludes the entrant from the market.

The application of public and private contracts in two-sided markets was first examined by Llanes and Ruiz-Aliseda (2015) in a model framework.[3] Their goal was to examine if a monopolistic platform offers private contracts to multi-homing sellers, how the platform's strategy, as well as sellers' pricing strategy, will change. The authors came to the conclusion that when using private contracts, the platforms reduce the subscription fee for consumers, so much so that they end up attracting them with discounts and gifts. In contrast, contracts offered to sellers include franchise and fixed access fees that ultimately encourage them to set collusive prices. That is, the authors have proved Armstrong and Wright (2007)'s statement that private contracts change the optimal behavior of platforms and have a significant impact on market price structure, as the price charged to the previously unsupported segment decreases while the previously subsidized segment experiences substantial fee increases.

In this chapter, a model is presented where the impact of the above two types of contracts, namely public and private contracts, are examined within the framework of duopolistic two-sided markets. It is examined whether the statement of Armstrong and Wright (2007) that platforms change their optimal strategy in addition to private contracts also exists in the context of the present model, and the finding of Llanes and Ruiz-Aliseda (2015) that the franchise and fixed access fees offered under contracts result in collusive prices for platform-specific products. The question is also addressed whether, in the context of duopolistic two-sided markets, in addition to public and private contracts, single-homing or multi-homing behavior is preferred by sellers.

Section 3.2 describes the model used in the analysis, and then Section 3.3 examines the case of public contracts. The answer to the question of whether, in addition to public contracts, platforms encourage sellers wishing to enter the market for single-homing or

[3]For traditional markets, the analysis of private contracts is more extensive. See, for example, Bakó (2012) or Bakó (2016).

multi-homing, and which output is more favorable for consumers, is looked for.
In Subsection 3.3.1, the model is examined in which sellers subscribe to only one platform, and then in Subsection 3.3.2, the case is analyzed where they enter both platforms. Thereafter, Subsection 3.3.3 compares the results of the two models. In Section 3.4. private contracts are introduced into the model, more specifically in the case of the model described in Subsection 3.3.2, platforms are allowed to enter into private contracts with sellers. This is because, as Armstrong and Wright (2007) have pointed out, it is in the interest of platforms to offer private contracts when sellers are present on more than one platform, as the purpose of these contracts is typically to deter multi-homing. The results of the model are compared with the conclusions of the relevant model of public contracts to determine the impact of private contracts on welfare. Finally, Section 3.5 summarizes the findings of the chapter.

3.2 The base model of contracts

Consider a classic Hotelling market. There are two platforms (1 and 2) in the market. The two companies are located at the two endpoints, with platform 1 at point 0 and platform 2 at point 1, as illustrated in Figure 3.2.1. There are two sellers and a continuum of consumers in the market, the latter are evenly distributed along the unit section. A platform provider provides a product or service to both sellers and consumers (e.g., manufactures a console, telephone, or operates a mall) that is assumed to have zero marginal cost of production. Sellers produce their products for these platforms (for example, they make video games, develop applications, or operate stores where they sell their products). It is assumed that the marginal cost of manufacturing these products is also zero.

Figure 3.2.1: Location of platforms

Consumers buy $q_{i,j}$ quantities of sellers' ($i = 1,\ 2$) platform-specific products after entering each platform ($j = 1,\ 2$). They have to pay a non-negative price of p_i for these products. Consumption of platform-specific products affects the benefits realized by consumers through multiple channels. On the one hand, their consumption directly increases the realizable utility. On the other hand, depending on the relationship between the sellers' products, they can increase, decrease, or even leave the level of utility achieved unchanged. The relationship between the products is represented by a parameter ϕ, which can take a value between -1 and 1 ($\phi \in (-1,1)$). If $\phi < 0$, the products complement each other, and the degree of complementarity decreases as ϕ increases. If there is a complementary relationship between the platform-specific products, the consumer benefit increases by $\phi q_{i,j} q_{-i,j}$ if $q_{i,j}$ quantities were purchased from seller i's product and $q_{-i,j}$ quantities from seller $-i$'s product. If $\phi > 0$, there is a substitution relationship between the products and the degree of substitution increases as ϕ increases. If the products are substitutes, the realized benefit to the consumer is reduced by $\phi q_{i,j} q_{-i,j}$ when purchasing a platform-specific product with $q_{i,j}$ and $q_{-i,j}$ quantities. If $\phi = 0$, then the two platform-specific products are independent of each other, and there is no additional effect through the second channel following the consumption of the platform-specific products.

The third channel through which the consumption of platform-specific products affects the utility of the consumer is the network effect typical of two-sided markets. In the model, this is embodied by a parameter b and is realized in the wake of the purchased platform-specific products. If a consumer has purchased $q_{i,j}$ and $q_{-i,j}$ quantities of a platform-specific product on platform j, then the benefit changes with $b\left(q_{i,j} + q_{-i,j}\right)$. As discussed in the introduction, this network effect can be both positive and negative, depending on the activity of the sellers as well as the preference of the consumers. As a result, the network effect parameter is assumed to be $-1 < b < 1$.

Platforms charge consumers a fee of $p_{0,j}$ for the subscription. However, as it was seen in the literature review, this subscription fee may also cover the provision of discounts, so no restrictions were made on its value. Owning the product of the platforms generates a benefit of $v_k > 0$ for the consumers. It reduces the utility of consumers if they are not connected to a platform with an ideal location for them, which is embodied in the travel cost expressed as a linear function of the distance between the consumer's location and the platform of her choice. Based on these, if a consumer at a distance d chooses platform 1, her utility decreases by td, while if she enters platform 2, $t\left(1-d\right)$ is the extent of utility reduction. Travel cost is assumed to be non-negative.

Based on the above, the benefit of the consumer at point x, if she enters platform 1, can be given by the function

$$U_1\left(p_{0,1}, p_1, q_{1,1}, p_2, q_{2,1}\right) = u\left(p_1, q_{1,1}, p_2, q_{2,1}\right) - tx - p_{0,1}, \tag{3.2.1}$$

while if she prefers platform 2,

$$U_2\left(p_{0,2}, p_1, q_{1,2}, p_2, q_{2,2}\right) = u\left(p_1, q_{1,2}, p_2, q_{2,2}\right) - t(1-x) - p_{0,2} \tag{3.2.2}$$

is the utility function. In both cases,

$$u\left(p_1, q_{1,j}, p_2, q_{2,j}\right) = v_k + q_{1,j} + q_{2,j} - \frac{1}{2}\left(\left(q_{1,j}\right)^2 + \left(q_{2,j}\right)^2 + \phi q_{1,j} q_{2,j}\right) -$$

$$p_1 q_{1,j} - p_2 q_{2,j} + b\left(q_{1,j} + q_{2,j}\right)$$

and $j = 1,\, 2$.[4]

Sellers must sign a contract when joining the platforms. In these contracts offered, the platforms include a two-part tariff. On the one hand, sellers have to pay a franchise fee $w_{i,j}$ for transactions with consumers. If seller i sold $q_{i,j}$ quantities of products to consumers on platform j, she then pays an amount of $w_{i,j} q_{i,j}$ to the platform. On the other hand, the contract also includes a fixed access fee, denoted $f_{i,j}$ in the model, which the seller pays in a lump sum upon connection.

As we are interested in the pricing impact of the offered contracts in this chapter, as well as the incentives of the platforms, no restrictions were made on the location of the sellers, they can be located at any point in the section. That is why the sellers' travel costs were chosen to zero.

Based on the above, the sellers' profit function can be written as follows:

$$\pi_i\left(p_i, q_{i,1}, q_{i,2}, w_{i,1}, w_{i,2}, f_{i,1}, f_{i,2}\right) = \left(p_i - w_{i,1}\right) x_{0,1} q_{i,1} + \left(p_i - w_{i,2}\right) \cdot$$

$$\left(1 - x_{0,2}\right) q_{i,2} - f_{i,1} - f_{i,2}, \tag{3.2.3}$$

where $x_{0,1}$ and $\left(1 - x_{0,2}\right)$ denote the number of subscribers to platforms 1 and 2, respectively.[5]

Note that although two sellers are operating in the market, the market is still two-sided, as the number of consumers entering the platform affects the ability of each seller to generate profit. That is, the network effect occurs not only on the side of consumers but also on the side of sellers.

The platforms, therefore, generate revenue from the subscription fee charged to consumers and through the contracts offered to sellers. If platform 1 set a subscription fee of $p_{0,1}$ for the connected consumers and offered the sellers contracts containing the $(w_{1,1},\, f_{1,1})$ and $(w_{2,1},\, f_{2,1})$ menus, then its profit function can be written in the form of

$$\pi^1\left(w_{1,1}, f_{1,1}, w_{2,1}, f_{2,1}, p_{0,1}\right) = x_{0,1}\left(p_{0,1} + w_{1,1} q_{1,1} + w_{2,1} q_{2,1}\right) + f_{1,1} + f_{2,1}. \tag{3.2.4}$$

[4] See Vives (2001, pp.143-183.)

[5] Note that for the marginal consumer of the two platforms, a deviation is allowed, i.e., the consumer at point $x_{0,1}$ is not necessarily the same as the consumer at point $x_{0,2}$.

For platform 2, the profit function takes the form

$$\pi^2 (w_{1,2}, f_{1,2}, w_{2,2}, f_{2,2}, p_{0,2}) = (1 - x_{0,2}) (p_{0,2} + w_{1,2}q_{1,2} + w_{2,2}q_{2,2}) + f_{1,2} + f_{2,2}. \quad (3.2.5)$$

In the following, a three-period game is examined. In the first period, sellers decide whether to enter only one platform or join both. In the second period, the platforms will offer a contract to sellers as well as set a subscription fee for consumers. The sellers then decide whether to accept the offered contracts. Then consumers, by observing how many sellers have joined a given platform and what subscription fees have been set, decide whether to enter the market and, if so, to which platform. Finally, in the third period, sellers determine the price of their products and consumers decide how many products they want to buy at those prices.

The structure of the game is justified by the fact that consumers typically use the platform's product over several periods, during which time sellers develop more and more platform-specific products. For example, if a consumer buys a game console, she will purchase compatible games not only when purchasing the game console but also at a later date. And the price of these is not taken into account when buying the console.

Due to its sequential nature, the game is solved by backward induction, thus, in the case of public contracts, the aim is to define the subgame-perfect Nash equilibrium, while in the case of private contracts the aim is to define the symmetric perfect Bayesian equilibrium, taking into account the beliefs formed by the actors regarding behavior other than equilibrium.

3.3 Public contracts

3.3.1 The model of single-homing sellers

Consider first the case where sellers in the first period decided to enter only one platform. Namely, seller 1 joins platform 1, while seller 2 joins platform 2. Consumers will only buy a product from one platform if they are interested.

Suppose platforms charge a subscription fee of $p_{0,j}$ ($j = 1, 2$) and sellers charge a price of p_i for their products ($i = 1, 2$). Consumers connected to the platform have to decide on the quantity of platform-specific products they want to buy at the prices charged. Based on consumer utility maximization, the individual demand for the product of seller i on platform j is given by the function

$$q_{i,j} (p_i) = 1 + b - p_i. \quad (3.3.1)$$

If $x_{0,1}$ consumers signed up for platform 1 and $1-x_{0,2}$ for platform 2, then the total demand for seller 1's product on platform 1 is

$$D_{1,1}\left(p_1\right)=x_{0,1}q_{1,1},$$

while demand for seller 2's product on platform 2 is

$$D_{2,2}\left(p_2\right)=\left(1-x_{0,2}\right)q_{2,2}.$$

In addition to the above demands, the profit function of sellers given in (3.2.3) takes the following form:

$$\pi_1\left(p_1,q_{1,1},w_{1,1},f_{1,1}\right)=\left(p_1-w_{1,1}\right)x_{0,1}q_{1,1}-f_{1,1} \tag{3.3.2}$$

$$\pi_2\left(p_2,q_{2,2},w_{2,2},f_{2,2}\right)=\left(p_2-w_{2,2}\right)\left(1-x_{0,2}\right)q_{2,2}-f_{2,2} \tag{3.3.3}$$

Sellers optimally set a price for which it is true that

$$\frac{\partial \pi_i}{\partial p_i}=0 \qquad \forall i=1,2.$$

As a solution to the above profit maximization problems, equilibrium prices as a function of franchise fees can be written in the form of

$$p_1\left(w_{1,1}\right)=\frac{1+b+w_{1,1}}{2} \tag{3.3.4}$$

and

$$p_2\left(w_{2,2}\right)=\frac{1+b+w_{2,2}}{2}. \tag{3.3.5}$$

Given the prices, individual demands for platform-specific products as a function of franchise fees based on (3.3.1) are:

$$q_{1,1}\left(w_{1,1}\right)=\frac{1+b-w_{1,1}}{2} \tag{3.3.6}$$

$$q_{2,2}\left(w_{2,2}\right)=\frac{1+b-w_{2,2}}{2} \tag{3.3.7}$$

Next, let us turn to the analysis of the second period. Because symmetrical solutions are looked for, and the content of the contracts is known, it is not worthwhile for platforms to set different franchise fees. Suppose platform j sets a higher franchise fee for sellers who want to join it than its competitor. Since the content of the contracts is known to everyone, including the sellers, they will decide to enter a platform with a lower franchise fee. As the sellers thus exit the platform j, consumer demand for its services will also decline. As a result, platform j reduces the franchise fee included in the contract to the same level as that set by its competitor. Now suppose platform j chooses to set a higher franchise fee for the seller i and a lower franchise fee for the seller $-i$. In this case, seller i may choose not to sign the contract offered to him, which would also lead to a reduction in demand on the consumer side. Furthermore, discrimination between the two sellers would be a competition concern. Therefore, it is a rational assumption that for all platforms ($j = 1, 2$) and all sellers ($i = 1, 2$), $w_{i,j} = w$. Considering this, as well as the level of subscription fees charged by the platforms, the utility of the consumer at point x if she subscribes to platform 1 is

$$U_1\left(w, p_{0,1}\right) = v_k + \frac{\left(1+b-w\right)^2}{8} - tx - p_{0,1}, \tag{3.3.8}$$

and if she subscribes to platform 2, then it is

$$U_2\left(w, p_{0,2}\right) = v_k + \frac{\left(1+b-w\right)^2}{8} - t(1-x) - p_{0,2}. \tag{3.3.9}$$

To determine the demand for the platforms' products, it is necessary to specify the location of consumers who are indifferent to connection and absence. Consumers with x locations for whom $x \leq x_{0,1}$ holds, where $x_{0,1}$ is the location of the indifferent consumer who is indifferent to whether or not to join platform 1, will subscribe to platform 1. While consumers for whose location $x \geq x_{0,2}$ holds, where $x_{0,2}$ is the location of the consumer indifferent between platform 2 and the absence, enter platform 2. In the case of indifferent consumers, it is true that their realized utility is zero, i.e., the utilities given in (3.3.8) and (3.3.9) must be equal to zero. Based on these, the marginal consumers are located at points

$$x_{0,1}\left(w, p_{0,1}\right) = \frac{\left(1+b-w\right)^2}{8t} + \frac{v_k}{t} - \frac{p_{0,1}}{t} \tag{3.3.10}$$

and

$$x_{0,2}\left(w, p_{0,2}\right) = 1 - \frac{\left(1+b-w\right)^2}{8t} - \frac{v_k}{t} + \frac{p_{0,2}}{t}. \tag{3.3.11}$$

It is worthwhile for sellers to connect to each platform if the conditions $f_{1,1} \leq x_{0,1}\left(p_1 - w_{1,1}\right) q_{1,1}$ and $f_{2,2} \leq \left(1 - x_{0,2}\right)\left(p_2 - w_{2,2}\right) q_{2,2}$ are met for the fixed access fee to be paid. Because sellers only enter one platform and contracts are public, the platforms set the access fee so that no profit is left to the sellers, i.e., $f_{1,1} = x_{0,1}\left(p_1 - w_{1,1}\right) q_{1,1}$ and $f_{2,2} = \left(1 - x_{0,2}\right)\left(p_2 - w_{2,2}\right) q_{2,2}$ are met. Based on these, the profit functions of the platforms given in (3.2.4) and (3.2.5) can be further simplified and written in the following form:

$$\pi^1 (w, p_{0,1}) = x_{0,1} (w, p_{0,1}) (p_{0,1} + p_1 (w, w) q_{1,1} (w, w)) \tag{3.3.12}$$

$$\pi^2 (w, p_{0,2}) = (1 - x_{0,2} (w, p_{0,2})) (p_{0,2} + p_2 (w, w) q_{2,2} (w, w)) \tag{3.3.13}$$

The platforms set subscription fees and franchise fees for which it is true that

$$\frac{\partial \pi^j}{\partial p_{0,j}} = 0 \ \forall j = 1, 2.$$

and

$$\frac{\partial \pi^j}{\partial w} = 0 \ \forall j = 1, 2,$$

while the condition $x_{0,1} + x_{0,2} \leq 1$ holds.

As a result of the above optimization task, the following equilibrium is obtained with the use of public contracts when sellers are connected to only one platform.

Proposition 3. *In a duopolistic two-sided market where platforms are located at the two endpoints, seller 1 is on platform 1 and seller 2 is on platform 2, while consumers are only present on their preferred platforms and contracts are public, the following equilibrium is established while allowing a market that is not fully covered: the platforms optimally set a franchise fee of*

$$w = \frac{1}{3} \left(1 + b - 4\sqrt{(1 + b)^2} \right) \tag{3.3.14}$$

and a subscription fee of

$$p_{0,j} = \frac{1}{4} \left((1 + b)^2 + 2v_k \right). \tag{3.3.15}$$

Sellers charge a price of

$$p_i = -\frac{2}{3} \left(-1 - b + \sqrt{(1 + b)^2} \right) \tag{3.3.16}$$

for their products, for which they can sell

$$q_{i,j} = \frac{1}{3} \left(1 + b + 2\sqrt{(1 + b)^2} \right) \tag{3.3.17}$$

quantities of platform-specific products.

$$x_{0,1} = \frac{(1 + b)^2 + 8\sqrt{(1 + b)^2} + 8b\sqrt{(1 + b)^2} + 18v_k}{36t}, \tag{3.3.18}$$

consumers will join platform 1, while

$$x_{0,2} = 1 - x_{0,1} \tag{3.3.19}$$

consumers enter platform 2. Then the platforms realize a profit of

$$\pi^j = \frac{\left((1+b)^2 + 8\sqrt{(1+b)^2} + 8b\sqrt{(1+b)^2} + 18v_k\right)^2}{1296t}, \tag{3.3.20}$$

while the consumers realize a surplus of

$$CS = -\frac{1}{1296t}\left(65 + 65b^4 + 16\sqrt{(1+b)^2} + 4b^3\left(65 + 4\sqrt{(1+b)^2}\right) + 648t^2 + \right.$$
$$6b^2\left(65 + 8\sqrt{(1+b)^2} - 12t + 6v_k\right) + 36v_k\left(1 + 8\sqrt{(1+b)^2} + 9v_k\right) -$$
$$72t\left(1 + 8\sqrt{(1+b)^2} + 18v_k\right) - 4b\left(-65 - 12\sqrt{(1+b)^2} + \right.$$
$$\left.\left. 36\left(1 + 4\sqrt{(1+b)^2}\right)t - 18\left(v_k + 4\sqrt{(1+b)^2}v_k\right)\right)\right). \tag{3.3.21}$$

For Proposition 3 to be the equilibrium, the $v_k > \frac{1}{18}\left(7 + 14b + 7b^2\right)$ condition should hold.

In the light of Proposition 3, it can be concluded with the help of comparative statics that as the network effect increases, the franchise fee optimally set by the platforms decreases, which represents a non-positive value for all possible parameter values. That is, the platforms attract sellers with discounts when using public contracts. In contrast, consumer subscription fees provide a positive value that increases as the network effect increases and the utility generated by the platform's product increases. In addition to public contracts, consumers receive platform-specific products for free, and demand for them increases with the increasing network effect.

The number of subscribers shows that while consumers have been allowed to stay away from the market, the platforms set the subscription fee, franchise fee, and access fee in such a way that their markets converge and it is not worthwhile for any consumer to decide not to enter.

The higher the network effect, the more consumers value the platform's product, and the lower the travel cost, the greater the profit that can be realized by the platforms. Deriving the surplus of consumers with respect to the network effect results in

$$\frac{\partial CS}{\partial b} = -\frac{1}{324\sqrt{(1+b)^2}t}(1+b)\left(16 + 16b^3 + 65\sqrt{(1+b)^2} + b^2\left(48 + 65\sqrt{(1+b)^2}\right) - \right.$$
$$\left. 288t + 144v_k + 18\sqrt{(1+b)^2}(-2t + v_k) + 2b\left(24 + 65\sqrt{(1+b)^2} - 144t + 72v_k\right)\right)$$

The increase of the network effect increases the realizable surplus if the conditions

$$t > \frac{(1+b)^2 + 2v_k}{4}$$

and

$$v_k > \frac{14}{9}$$

hold.

The partial derivative of consumer surplus with respect to the realizable benefit of the platform product can be given in the form of

$$\frac{\partial CS}{\partial v_k} = -\frac{(1+b)^2 + 8\sqrt{(1+b)^2} + 8b\sqrt{(1+b)^2} - 36t + 18v_k}{36t}$$

Based on these, the increase of the direct benefit increases the surplus that can be realized by the consumers connected to the platforms if the conditions

$$t > \frac{(1+b)^2 + 2v_k}{4}$$

and

$$v_k > \frac{14}{9}$$

hold.

The partial derivative taken with respect to the travel cost can be given in the form of

$$\frac{\partial CS}{\partial t} = \frac{1}{1296t^2}\left(65 + 65b^4 + 16\sqrt{(1+b)^2} + 4b^3\left(65 + 4\sqrt{(1+b)^2}\right) - 648t^2 + 6b^2\left(65 + 8\sqrt{(1+b)^2} + 6v_k\right) + 36v_k\left(1 + 8\sqrt{(1+b)^2} + 9v_k\right) + 4b\left(65 + 12\sqrt{(1+b)^2} + 18\left(1 + 4\sqrt{(1+b)^2}\right)v_k\right)\right)$$

Based on these, the increase in the travel cost for all

$$t > \frac{\left((1+b)^2 + 2v_k\right)^2}{2\sqrt{2}}$$

and

$$v_k > \frac{14}{9}$$

reduces the surplus that can be realized by the consumers connected to the platforms.

3.3.2 The model of multi-homing sellers

Now let's turn to the case where sellers decide to enter both platforms. In this case, the effect of the relationship between the two products will also appear on the consumer side, which is embodied in the parameter ϕ in the model, as both platform-specific products can now be purchased.

Based on the solution of the system of equations formed by the first-order conditions resulting from the maximization of consumer utility, at a given price p_i for platform-specific products, there is a demand of

$$q_{i,j}\left(p_{-i}\right) = \frac{2\left(1+b-p_{-i}\right)}{2+\phi} \tag{3.3.22}$$

for all $i = 1,\, 2$ and $j = 1,\, 2$. However, expression (3.3.22) can only be a function of the individual demand of consumers if the condition $p_i = p_{-i}$ is satisfied, that is, the prices of platform-specific products are optimally equal.

The total demand for seller i's product on platform 1 will be $x_{0,1}q_{i,1}$, while on platform 2 it will be $\left(1-x_{0,2}\right)q_{i,2}$. Taking these into account, the sellers maximize the profit function described in (3.2.3) with respect to the prices, from which it follows that the sellers set the following prices in equilibrium:

$$p_1\left(w_{1,1}, w_{1,2}\right) = \frac{1+b+w_{1,2}+w_{1,1}x_{0,1}-w_{1,2}x_{0,2}}{2} \tag{3.3.23}$$

$$p_2\left(w_{2,1}, w_{2,2}\right) = \frac{1+b+w_{2,2}+w_{2,1}x_{0,1}-w_{2,2}x_{0,2}}{2} \tag{3.3.24}$$

Thus, individual demand for platform-specific products, as a function of franchise fees, can be written in the following form for multi-homing:

$$q_{i,j}\left(w_{i,1}, w_{i,2}\right) = \frac{1+b-w_{i,2}\left(1-x_{0,2}\right)-w_{i,1}x_{0,1}}{2+\phi} \tag{3.3.25}$$

Because the contracts are still public, as it was seen in the previous model, the platforms charge the same franchise fees to the sellers who join them. Based on these, $w_{i,j} = w$ still exists for all platforms ($j = 1,\, 2$) and all sellers ($i = 1,\, 2$). Taking this into account, as well as the subscription fees of $p_{0,j}$ set by the platforms in the second period, the utility of the consumer at point x will be

$$U_1\left(w, p_{0,1}\right) = v_k + \frac{\left(1+b-w\right)^2}{2\left(2+\phi\right)} - tx - p_{0,1} \tag{3.3.26}$$

if she enters platform 1 and

$$U_2\left(w, p_{0,2}\right) = v_k + \frac{\left(1+b-w\right)^2}{2\left(2+\phi\right)} - t(1-x) - p_{0,2} \tag{3.3.27}$$

if she enters platform 2.

Now let us turn to the examination of the second period and determine the location of the indifferent consumers. The consumer who is indifferent between connecting to platform 1 and absence, i.e. the utility in (3.3.26) is zero, is located at point

$$x_{0,1}\left(w, p_{0,1}\right) = \frac{\left(1+b-w\right)^2}{2t\left(2+\phi\right)} + \frac{v_k}{t} - \frac{p_{0,1}}{t}. \tag{3.3.28}$$

While the consumer who is indifferent between platform 2 and absenteeism, i.e., the utility defined by (3.3.27) will be zero, is found at

$$x_{0,2}\left(w, p_{0,2}\right) = 1 - \frac{\left(1+b-w\right)^2}{2t\left(2+\phi\right)} + \frac{v_k}{t} - \frac{p_{0,2}}{t}. \tag{3.3.29}$$

Since the market is still allowed not to be fully covered, and because sellers are present on both platforms, consumers will join only one platform, the condition $x_{0,1} + x_{0,2} \leq 1$ holds.

With the fixed access fee specified in the contract offered to the sellers, the platforms continue to earn their total realized profit, i.e., the conditions $f_{i,1} = x_{0,1}\left(p_i - w_{i,1}\right) q_{i,1}$ and $f_{i,2} = \left(1 - x_{0,2}\right)\left(p_i - w_{i,2}\right) q_{i,2}$ continue to be met for all i. Taking these, in addition to the determined subscription fees of $p_{0,j}$ for consumers, the profit functions of the platforms take the following form:

$$\begin{aligned} \pi^1\left(w, p_{0,1}\right) = x_{0,1}\left(w, p_{0,1}\right)&\left[p_{0,1} + p_1\left(w, w\right) q_{1,1}\left(w, w\right) + \right. \\ &\left. p_2\left(w, w\right) q_{2,1}\left(w, w\right)\right] \end{aligned} \tag{3.3.30}$$

$$\begin{aligned} \pi^2\left(w, p_{0,2}\right) = \left(1 - x_{0,2}\left(w, p_{0,2}\right)\right)&\left[p_{0,2} + p_1\left(w, w\right) q_{1,2}\left(w, w\right) + \right. \\ &\left. p_2\left(w, w\right) q_{2,2}\left(w, w\right)\right] \end{aligned} \tag{3.3.31}$$

Thus, at the beginning of the second period, the platforms maximize the profit functions given in (3.3.30) and (3.3.31) in terms of franchise fees as well as subscription fees. As a result of this optimization, the following equilibrium is obtained for public contracts if sellers opted for multi-homing in the first period.

Proposition 4. *In a duopolistic two-sided market where platforms are located at the endpoints, sellers join both platforms, while consumers only join their preferred platform, and contracts are public, the following equilibrium will emerge allowing a market that is not fully covered: the platforms optimally charge a franchise fee of*

$$w = \frac{1 + b - 4\sqrt{(1+b)^2}}{3} \tag{3.3.32}$$

and a subscription fee of

$$p_{0,j} = \frac{(1+b)^2}{2+\phi} + \frac{v_k}{2}. \tag{3.3.33}$$

Consumers will continue to pay a price of

$$p_i = -\frac{2}{3}\left(-1 - b + \sqrt{(1+b)^2}\right) \tag{3.3.34}$$

for the products of the sellers, while their per-capita demand will be

$$q_{i,j} = \frac{2\left(1 + b + 2\sqrt{(1+b)^2}\right)}{3\left(2+\phi\right)} \tag{3.3.35}$$

for this price. The number of consumers entering platform 1 is

$$x_{0,1} = \frac{2 + 16\sqrt{(1+b)^2} + 2b\left(2 + b + 8\sqrt{(1+b)^2}\right) + 9\left(2+\phi\right)v_k}{18t\left(2+\phi\right)}, \tag{3.3.36}$$

while the number of consumers joining platform 2 is

$$x_{0,2} = 1 - x_{0,1}. \tag{3.3.37}$$

The profit realized by the platforms will be

$$\pi^j = \frac{\left(2 + 16\sqrt{(1+b)^2} + 2b\left(2 + b + 8\sqrt{(1+b)^2}\right) + 9\left(2+\phi\right)v_k\right)^2}{324t\left(2+\phi\right)^2}. \tag{3.3.38}$$

Consumers entering the platforms realize a consumer surplus of

$$CS = -\frac{1}{324t\left(2+\phi\right)^2}\left(260 + 260b^4 + 64\sqrt{(1+b)^2} + 16b^3\left(65 + 4\sqrt{(1+b)^2}\right) + \right.$$

$$\left. 162^2\left(2+\phi\right)^2 + 12b^2\left(130 + 16\sqrt{(1+b)^2} - 6t\left(2+\phi\right) + 3v_k\left(2+\phi\right)\right) - \right.$$

$$36t\left(2+\phi\right)\left(2+16\sqrt{\left(1+b\right)^2}+9v_k\left(2+\phi\right)\right)+$$
$$9v_k\left(2+\phi\right)\left(4+32\sqrt{\left(1+b\right)^2}+9v_k\left(2+\phi\right)\right)-8b\left(-130-24\sqrt{\left(1+b\right)^2}+\right.$$
$$\left.18t\left(2+\phi\right)\left(1+4\sqrt{\left(1+b\right)^2}\right)-9v_k\left(2+\phi\right)\left(1+4\sqrt{\left(1+b\right)^2}\right)\right)\right). \tag{3.3.39}$$

For Proposition 4 to be the equilibrium, the $v_k > \frac{14+28b+14b^2}{18+9\phi}$ condition should hold.

It can be seen that the franchise fee set by the platforms is still a function of the network effect, its strengthening increases the amount of support provided to sellers. Consumers continue to pay a positive fee for connection, which increases with the strengthening of the network effect, the increase in the utility generated by the platforms' product, and, in this case, the increasing complementarity of the products. Consumers will continue to have access to platform-specific products free of charge, while their demand for them will be increased not only by the increase in network effect but also by the strengthening of the complementarity of products.

Platforms continue to set franchise fees and fixed access fees for sellers, and connection fees for consumers so that their markets converge, meaning it is still not worthwhile for any consumer to choose to stay away from the market.

The profits that can be realized by platforms increase if the network effect is strengthening, the direct benefits generated by their product are increasing, travel cost is decreasing, and if the complementary nature of the platform-specific products is strengthening. For consumers connected to the platforms, the strengthening of the network effect only increases their realizable surplus if the conditions

$$t > \frac{16\left(1+b\right)^2}{9\left(2+\phi\right)}$$

and

$$\frac{14\left(1+b\right)^2}{9\left(2+\phi\right)} < v_k < \frac{-2\left(1+b\right)^2+2t\left(2+\phi\right)}{2+\phi}$$

hold.

An increase in the utility generated by the platform product and an increase in the complementarity of platform-specific products will also increase the surplus that can be realized by consumers if the above two conditions are met. Finally, an increase in travel costs reduces the surplus that consumers can realize if the conditions

$$t > \frac{16\sqrt{2}}{9}\sqrt{\frac{\left(1+b\right)^2}{\left(2+\phi\right)^2}}$$

and

$$\frac{14\left(1+b\right)^2}{9\left(2+\phi\right)} < v_k < \sqrt{2t^2} - \frac{2\left(1+b\right)^2}{2+\phi}$$

hold.

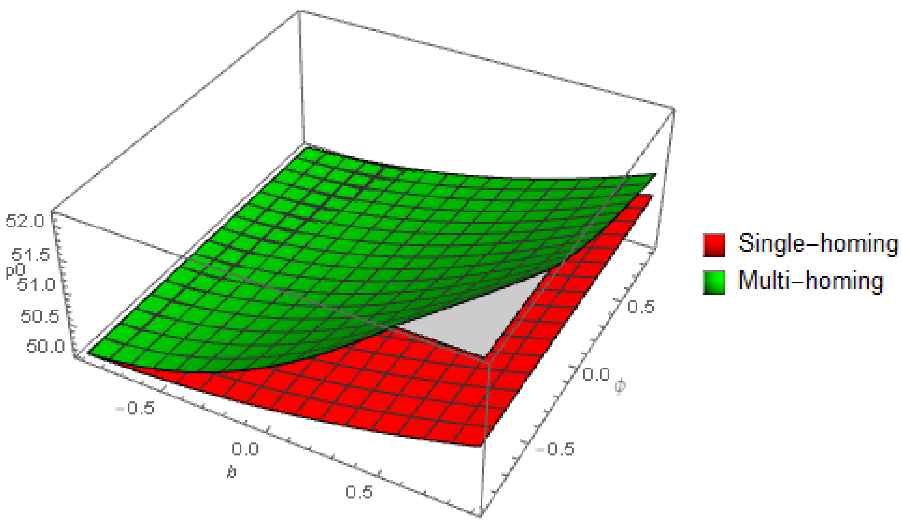
3.3.3 The comparison of the two models

In this subsection, the models of single-homing and multi-homing sellers are compared. For the evaluation of the equilibria, $v_k = 100$ was set, i.e. consumers value the platform's product for 100.

It has been seen in the previous two subsections that, regardless of the sellers' decision, in equilibrium, the platforms charge them the same franchise fee, which covers the provision of support.

In contrast, consumers have to pay to join the platform. Figure 3.3.1 shows how this magnitude evolves for the two models. It can be concluded that if companies entered both platforms in the first period, consumers will be forced to pay a higher connection fee. This can be explained mainly by the increase in network effect: consumers are willing to pay more for joining the platform, so platforms increase the fee charged to the consumer side and thus achieve higher profits. However, with a negative network effect, the amount paid at entry is lower than if there is a strong positive network effect on the consumer side. In terms of the relationship between platform-specific products, platforms charge a high entry fee for complementary products, while as the substitutability, i.e. the competition between sellers, intenzifies, the subscription fee charged decreases.

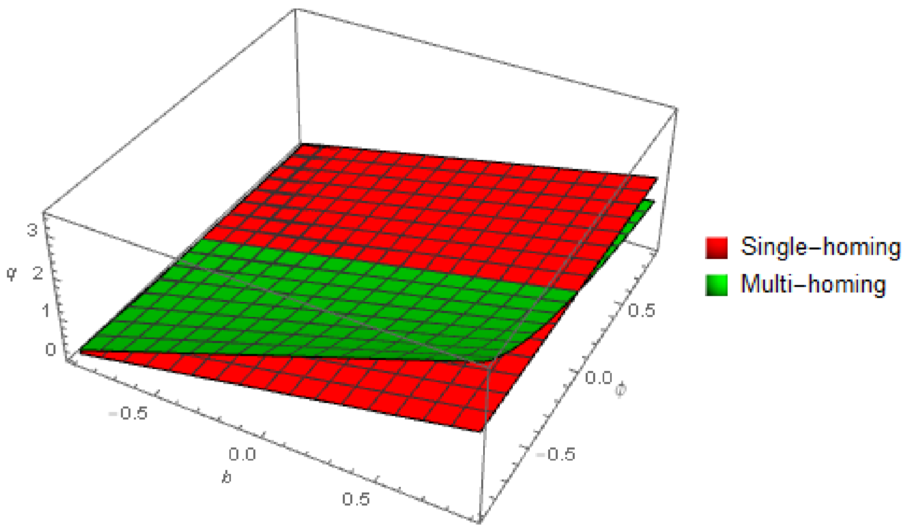
Figure 3.3.1: The connection fee for single-homing and multi-homing



Demand for platform-specific products is significantly affected by the relationship between the products. If the products complement each other, consumer demand will be higher if both products are available to them on that platform. While if they substitute each other, the demand for them will be higher with single-homing.

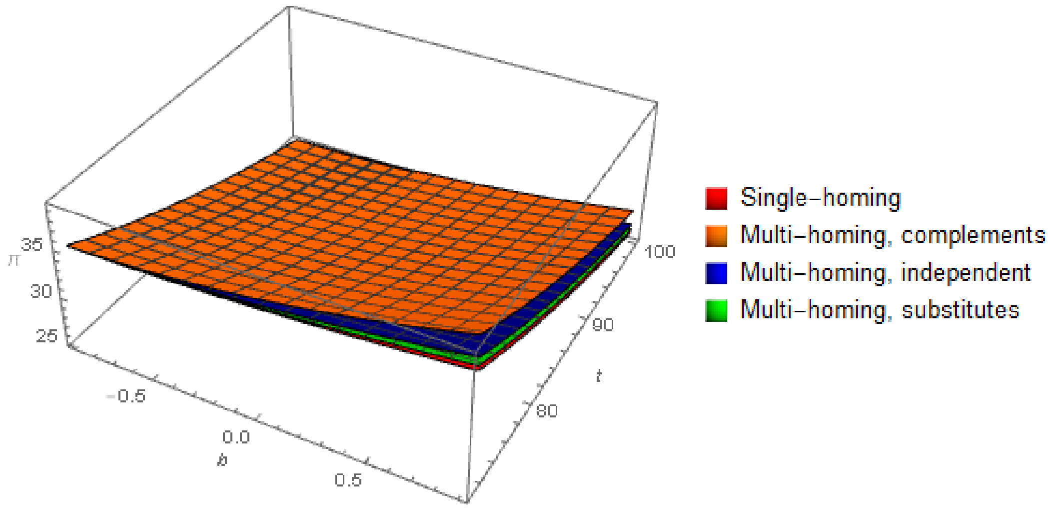
The price of the platform-specific products is zero in both models, i.e. consumers connected to the platforms receive the sellers' products made for the platforms free of charge.

Figure 3.3.2: Demand for platform-specific products for single-homing and multi-homing



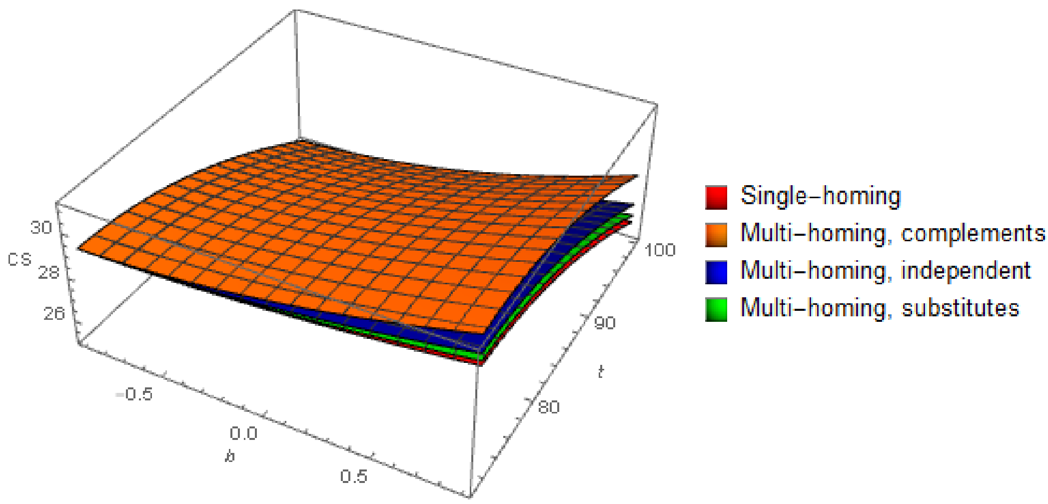
The profit that can be realized by the platforms is the highest in the case of multi-homing sellers when the products are complements and gradually decreases as the substitutability strengthens. The lower the travel cost, the higher the profit that can be realized by the platform. Furthermore, as a result of the increase in the network effect, the platform will be able to generate increasing profits due to the increase in the fee that can be charged for connection.

Figure 3.3.3: Profit of platforms for single-homing and multi-homing



Consumer surplus is the highest when sellers are present on both platforms and complements are available in the market, while with single-homing, they realize the smallest surplus by joining the platform. Both the increase of travel costs and the network effect increase the realizable surplus for consumers.

Figure 3.3.4: Consumer surplus in the case of single-homing and multi-homing



3.4 Private contracts

3.4.1 The model of multi-homing sellers

From now on, the platforms offer private contracts to sellers, meaning that neither the consumers nor the competitor are aware of the content of these contracts. The goal is to define a symmetric perfect Bayesian equilibrium that provides an idea of how actors shape their beliefs when they experience behavior that deviates from the equilibrium on the part of the platform.

Let p_0^* be the subscription fee charged by the platforms to consumers in symmetric perfect Bayesian equilibrium, w^* correspondingly the franchise fee offered to sellers in the optimum, and f^* the contractual fixed access fee. If consumers find that the subscription fee is not the expected optimum, i.e. $p_{0,j} \neq p_0^*$, they conclude that the platforms deviated from the optimal path. This deviation will affect the profitability of the sellers and thus their willingness to join. Therefore, consumers expect that the difference in the subscription fee will result in a change in the fixed access fee and/or in the franchise fee included in the contracts. In this model, just like in Llanes and Ruiz-Aliseda (2015), consumers believe that the deviation in the subscription fee causes a change in the access fee offered to the sellers and leaves the franchise fee unchanged. Because the difference would affect sellers' willingness to enter, but this effect does not appear, it is a rational assumption on the part of the consumers. This belief is called weak passive belief.[6]

Due to the unchanged strategy of consumers, the off-the-equilibrium subscription fees do not carry additional information to the sellers about the content of the contracts, so sellers' beliefs in this regard will also be passive. By contrast, sellers have cautious beliefs about the offered contracts, which means that the seller receiving the contract offer assumes that the platform has made a contract offer to the other seller in order to maximize its profit. These beliefs are determined by the franchise fee and by the fixed access fee offered in the contract, and the seller receiving this offer can perfectly predict what kind of offer the platform has made to the other seller, i.e. how the platform has deviated from its optimal behavior.

It is also assumed that the sellers with cautious beliefs presume that the other seller may have similar beliefs and that the platforms are not intended to exclude sellers from the market offering private contracts.

In this subsection, therefore, it is examined what happens if the contracts offered to the sellers can only be observed by the seller who gets an offer from the platforms, that is, neither consumers nor competitors are aware of their content. This means that, in the second period, seller i knows only the subscription fees ($p_{0,j}$), the number of consumers subscribed to the platforms ($x_{0,1},\ (1 - x_{0,2})$), and the franchise ($w_{i,j}$) and fixed access fees ($f_{i,j}$) included in the contracts offered to her.

Let $B(\hat{w})$ be the belief of seller i about the franchise fee paid by the seller $-i$. Since

[6] According to Llanes and Ruiz-Aliseda (2015), the use of standard passive beliefs would not change the outcome, but the interpretation would be difficult. In this case, consumers assume f^* and w^*, and if they find that sellers continue to accept the offered contracts, they conclude that contracts have been accepted which result in a loss for sellers while facing lower demand on the platform than in equilibrium. (Llanes and Ruiz-Aliseda , 2015, p.13.)

symmetric equilibrium is examined, it is irrelevant which seller receives the unexpected contract offer in the model, the only stipulation regarding the belief is that in the optimum it should be equal with the equilibrium franchise fee, that is $B\left(w^{*}\right)=w^{*}$. This is because sellers form cautious beliefs. It is assumed that seller i's belief does not depend on the paid fixed access fee, nor on the subscription fees charged by the platforms to consumers. The latter has no signal value, it does not carry additional information.

Based on the above, the derivation of the model is the same as the first model up to equation (3.3.24), the determination of the optimal prices of platform-specific goods. Let $p_i\left(w_{i,j}\right)$ be the strategy of seller i in case of receiving an unexpected contract offer that includes the $\left(w_{i,j},\ f_{i,j}\right)$ menu, and if she already knows the subscription fees $p_{0,j}$.

The seller's task remains unchanged, maximizing the profit function (3.2.3) with respect to p_i, on the basis of which he optimally determines the following price:

$$p_i\left(w_{i,1}, w_{i,2}\right)=\frac{1+b+w_{j,2}+(1+b+w_{j,1})x_{0,1}-(1+b+w_{j,2})x_{0,2}}{2(1+x_{0,1}-x_{0,2}} \tag{3.4.1}$$

In the second period, consumers expect a franchise fee w^{*} due to passive beliefs, regardless of the subscription fees $p_{0,j}$ set by the platforms. Therefore, consumers believe that sellers will charge

$$p_i^{*}=\frac{1+b+w^{*}}{2} \tag{3.4.2}$$

for their products in the equilibrium. Based on these, the expected utility of consumers if entering platform 1 will be

$$U_1\left(w^{*}, p_{0,1}\right)=v_k+\frac{\left(1+b-w^{*}\right)^2}{2\left(2+\phi\right)}-tx-p_{0,1}, \tag{3.4.3}$$

while those who subscribe to platform 2 realize

$$U_2\left(w^{*}, p_{0,2}\right)=v_k+\frac{\left(1+b-w^{*}\right)^2}{2\left(2+\phi\right)}-t(1-x)-p_{0,2}. \tag{3.4.4}$$

Based on (3.4.3), the location of the consumer who is indifferent to joining platform 1 and staying away from the market is at point

$$x_{0,1}\left(w^{*}, p_{0,1}\right)=\frac{\left(1+b-w^{*}\right)^2}{2t\left(2+\phi\right)}+\frac{v_k-p_{0,1}}{t}. \tag{3.4.5}$$

From (3.4.4), it follows that the consumer indifferent between platform 2 and the absence can be characterized by the

$$x_{0,2}\left(w^{*},p_{0,2}\right)=1-\frac{\left(1+b-w^{*}\right)^{2}}{2t\left(2+\phi\right)}-\frac{v_{k}-p_{0,2}}{t} \tag{3.4.6}$$

location.

Based on equation (3.3.24), equation (3.3.22), i.e. the demand for the sellers' platform-specific product, can also be written in the following form:

$$q_{i,j}=\frac{2\left(p_{i}\left(w_{i,j}\right)-w_{i,j}\right)}{2+\phi} \tag{3.4.7}$$

It is also known that the platforms charge sellers an access fee that leaves them with no profit, i.e. $f_{i,1}=x_{0,1}\left(p_{i}-w_{i,1}\right)q_{i,1}$ and $f_{i,2}=\left(1-x_{0,2}\right)\left(p_{i}-w_{i,2}\right)q_{i,2}$ conditions hold for each i. These can be expressed, given the equation (3.4.7), in the form of

$$f_{i,1}=x_{0,1}\frac{2\left(p_{i}\left(w_{i,1}\right)-w_{i,1}\right)^{2}}{2+\phi} \tag{3.4.8}$$

and

$$f_{i,2}=\left(1-x_{0,2}\right)\frac{2\left(p_{i}\left(w_{i,2}\right)-w_{i,2}\right)^{2}}{2+\phi}. \tag{3.4.9}$$

The platforms can perfectly predict the volume sold by the two sellers in the third period. Their goal is to maximize their profits, taking into account the subscription fee of $p_{0,j}$ charged to consumers and the contracts offered to sellers which include the $(w_{i,j},\ f_{i,j})$ menus. Based on (3.4.5) and (3.4.6), the profit functions of platforms can be given in the form of

$$\pi^{1}\left(w_{1,1},f_{1,1},w_{2,1},f_{2,1},p_{0,1}\right)=x_{0,1}\left(w^{*},p_{0,1}\right)\left(p_{0,1}+w_{1,1}q_{1,1}\left(p_{1}(w_{1,1}),p_{2}(w_{2,1})\right)+\right.$$

$$\left.w_{2,1}q_{2,1}\left(p_{1}(w_{1,1}),p_{2}(w_{2,1})\right)\right)+f_{1,1}+f_{2,1} \tag{3.4.10}$$

and

$$\pi^{2}\left(w_{1,2},f_{1,2},w_{2,2},f_{2,2},p_{0,2}\right)=\left(1-x_{0,2}\left(w^{*},p_{0,2}\right)\right)\left(p_{0,2}+w_{1,2}q_{1,2}\left(p_{1}(w_{1,2}),p_{2}(w_{2,2})\right)+\right.$$

$$\left.w_{2,2}q_{2,2}\left(p_{1}(w_{1,2}),p_{2}(w_{2,2})\right)\right)+f_{1,2}+f_{2,2}. \tag{3.4.11}$$

Since both sellers are characterized by cautious beliefs, seller i assumes the other seller has received such an offer from the platforms that $B\left(w_{i,j}\right)$, i.e., her belief maximizes the profits of the platforms. Suppose seller 2 receives an unexpected contract offer from the platforms. As she can be characterized by cautious belief, she concludes that the other seller received a contract offer with a $B(w_{2,j})$ franchise fee. If the belief of seller 2, as well as equations (3.3.22), (3.4.8), and (3.4.9) are substituted into the profit functions given in (3.4.10) and (3.4.11), the objective functions will take the following forms:

$$\pi^1(w_{1,1}, f_{1,1}, w_{2,1}, f_{2,1}, p_{0,1}) = x_{0,1}(w^*, p_{0,1})\Big(p_{0,1} + w_{1,1}q_{1,1}(p_1(w_{1,1}), p_2(w_{2,1})) + w_{2,1}q_{2,1}(p_1(w_{1,1}), p_2(w_{2,1})) + \frac{2(p_1(w_{1,1}) - w_{1,1})}{2+\phi}\Big) + f_{2,1} \tag{3.4.12}$$

and

$$\pi^2(w_{1,2}, f_{1,2}, w_{2,2}, f_{2,2}, p_{0,2}) = (1 - x_{0,2}(w^*, p_{0,2}))\Big(p_{0,2} + w_{1,2}q_{1,2}(p_1(w_{1,2}), p_2(w_{2,2})) + w_{2,2}q_{2,2}(p_1(w_{1,2}), p_2(w_{2,2})) + \frac{2(p_1(w_{1,2}) - w_{1,2})}{2+\phi}\Big) + f_{2,2}. \tag{3.4.13}$$

Since the belief of seller 2 regarding the franchise fee of the other seller maximizes the profit of the platforms, the first-order conditions of the platforms can be determined from the partial derivative of the above profit functions with respect to $w_{2,j}$:

$$\frac{\partial \pi^j}{\partial w_{2,j}} = \frac{1 + b - 2w_{2,j} - B(w_{2,j}) + (1 + b - w_{2,j})B'(w_{2,j})}{2+\phi} + \frac{4(-B(w_{2,j}) + p_2(w_{2,j}))(-B'(w_{2,j}) + p_2'(w_{2,j}))}{2+\phi} \tag{3.4.14}$$

Suppose that for any $w_{2,j}$ there exists a solution to the first-order conditions. Due to the symmetry, it is also assumed that for the two platforms it is not worthwhile to charge different franchise fees to the same seller and that due to cautious beliefs

$$p(w) = \Phi + \Sigma w \tag{3.4.15}$$

and

$$B(w) = \Gamma + \Theta w. \tag{3.4.16}$$

According to Rey and Vergé (2004), when determining symmetric perfect Bayesian equilibria is the goal, in the case when both prices and beliefs can be expressed as polynomials, one cannot make a mistake if the investigations are limited to affine functions. In the light of this, the system of equations given by the first-order conditions of sellers in (3.3.24) and the first-order conditions in (3.4.14) resulting from the optimization of the platforms taking into account the beliefs can already be solved.

The first-order conditions of the platforms, that is, equation (3.4.14) can be written as

$$1 + 4\Phi\Sigma + \Theta - 4\Phi\Theta + b\left(1+\Theta\right) + \Gamma\left(4\Theta - 1 - 4\Sigma\right) +$$
$$2\left(2\Sigma^2 - 1 - \Theta - 4\Sigma\Theta + 2\Theta^2\right) w_{2,j} = 0 \tag{3.4.17}$$

based on (3.4.15) and (3.4.16), while the first-order condition of sellers, i.e. equation (3.3.24), can be given in form of

$$1 + b - 2\Phi + \left(1 - 2\Sigma\right) w_{2,j} = 0. \tag{3.4.18}$$

Since the first-order conditions (3.4.17) and (3.4.18) should be satisfied for all $w_{2,j}$, it is obtained that, in equilibrium, the following four conditions must be met:

$$1 + 4\Phi\Sigma + \Theta - 4\Phi\Theta + b\left(1+\Theta\right) + \Gamma\left(4\Theta - 1 - 4\Sigma\right) = 0, \tag{3.4.19}$$

$$2\left(2\Sigma^2 - 1 - \Theta - 4\Sigma\Theta + 2\Theta^2\right) = 0, \tag{3.4.20}$$

$$1 + b - 2\Phi = 0, \tag{3.4.21}$$

and

$$1 - 2\Sigma = 0. \tag{3.4.22}$$

Based on (3.4.22) the value of Σ can be clearly determined, $\Sigma = \frac{1}{2}$, while based on (3.4.21), $\Phi = \frac{1+b}{2}$. Taking into account the value of Σ, it follows from condition (3.4.20) that

$$\Theta = \frac{1}{4}\left(3 + \sqrt{13}\right),$$

while based on condition (3.4.19), the value of Γ can already be given:

$$\Gamma = \frac{-5 + \sqrt{13} - 5b + \sqrt{13}b}{4\sqrt{13}}.$$

An interesting result is that the value of the above four parameters is not affected by the relationship between platform-specific products in the market, in contrast to the results of Llanes and Ruiz-Aliseda (2015), who, in the case of a monopolistic platform, obtained beliefs depending on the relationship between platform-specific products as a result.

For beliefs, as described above, $B\left(w^*\right) = w^*$ should hold, which is the basis for the following proposition.

Proposition 5. *In a Hotelling-type duopolistic two-sided market where platforms are located at the two endpoints, sellers are present on both platforms and consumers are present exclusively on their preferred platform, while contracts are private, the equilibrium will be the following allowing for not fully covered market: the equilibrium franchise fees* *are*

$$w^* = \frac{\Gamma}{1-\Theta} \tag{3.4.23}$$

and the equilibrium subscription fees are

$$p_0^* = \frac{1}{4(2+\phi)(\Theta-1)^2}\Big(\Gamma^2(1-8(\Sigma-1)\Sigma)+2\Gamma(1+b+4\Phi(2\Sigma-1))(\Theta-1)+$$

$$\Big((1+b)^2+2(2+\phi)v_k-8\Phi^2\Big)(\Theta-1)^2\Big). \tag{3.4.24}$$

Sellers ask for a price of

$$p^* = \Phi - \frac{\Gamma\Sigma}{\Theta-1} \tag{3.4.25}$$

for their products, for which they can sell

$$q_{i,j}^* = \frac{2(\Phi(\Theta-1)-\Gamma(\Sigma-1))}{(2+\phi)(\Theta-1)} \tag{3.4.26}$$

products. The number of consumers that join platform 1 will be

$$x_{0,1}^* = \frac{1}{4t(2+\phi)(\Theta-1)^2}\Big(\Gamma^2(1+8(\Sigma-1)\Sigma)+2\Gamma(1+b+4\Phi(1-\Sigma))(\Theta-1)+$$

$$\Big((1+b)^2+2(2+\phi)v_k+8\Phi^2\Big)(\Theta-1)^2\Big), \tag{3.4.27}$$

while the number of consumers that enter platform 2 will be

$$x_{0,2}^* = 1 - x_{0,1}^*. \tag{3.4.28}$$

In this case, platforms realize a profit of

$$\pi^* = \frac{1}{16t(2+\phi)^2(\Theta-1)^4}\Big(\Gamma^2(1+8(\Sigma-1)\Sigma)+2\Gamma(1+b+4\Phi(1-2\Sigma))(\Theta-1)+$$

$$\Big((1+b)^2+2(2+\phi)v_k+8\Phi^2\Big)(\Theta-1)^2\Big)^2, \tag{3.4.29}$$

while the consumers realize a surplus of

$$CS^* = \frac{1}{32t(2+\phi)^2(\Theta-1)^4}\Big(\Gamma^2(1+8(\Sigma-1)\Sigma)+2\Gamma(1+b+4\Phi(1-2\Sigma))(\Theta-1)+$$

$$\Big((1+b)^2+2(2+\phi)v_k+8\Phi^2\Big)(\Theta-1)^2\Big)\cdot$$

$$\Big(-2\Gamma^2(19+8\Sigma(-7+5\Sigma))-4\Gamma(\Phi(28-40\Sigma)+(1+b)(-13+16\Sigma))(\Theta-1)-$$

$$2\left(3\left(1+b\right)^2-2\left(2+\phi\right)v_k+8\Phi\left(-4\left(1+b\right)+5\Phi\right)\right)\left(\Theta-1\right)^2\right). \qquad (3.4.30)$$

Based on the above Proposition, the franchise fee offered by the platforms as well as the price charged by the sellers depends only on the parameter b, which embodies the network effect. However, the demand for platform-specific products and the subscription fee charged by platforms are already affected by the parameter ϕ, which embodies the relationship between the products, while the profit realized by the platforms and the realizable surplus of consumers are also affected by the value of the t parameter representing travel costs. Equation (3.4.28) shows that on the consumer side, the market remains fully covered. That is, platforms design contracts in such a way that their impact does not lead to a reduction in consumer demand.

Let us also look graphically at the evolution of the equilibrium. To represent equilibrium, v_k was set to 100.

Figure 3.4.1: Evolution of the franchise fee as a function of the network effect

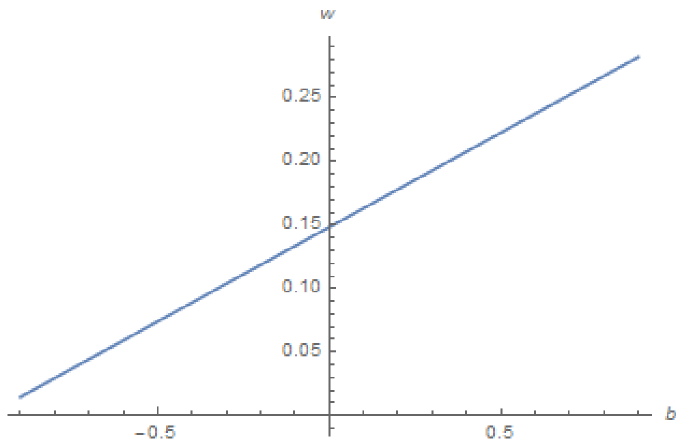
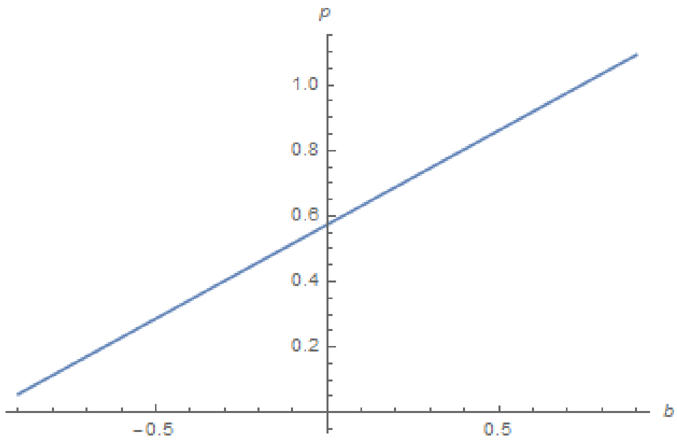


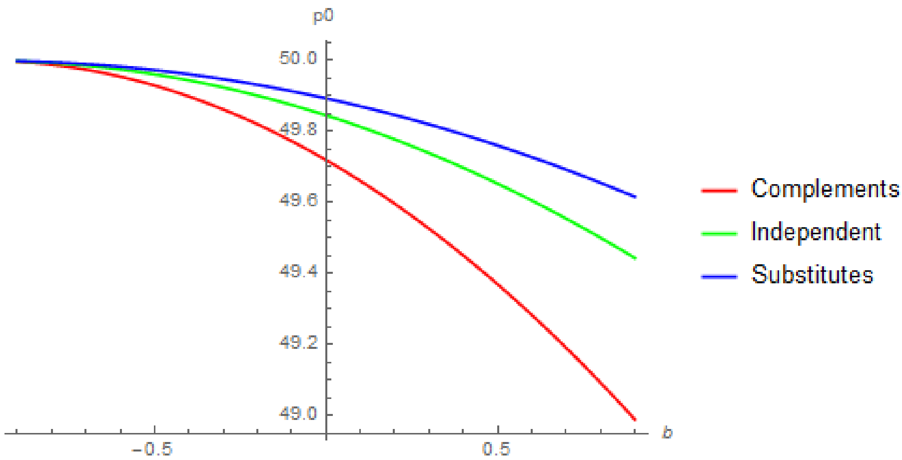
Figure 3.4.1 shows the evolution of the franchise fee using private contracts. It can be seen that the franchise fee charged by the platforms increases as the network effect increases. If there is a negative network effect in the market, the platforms are forced to charge a lower franchise fee, while in case of a positive network effect they are able to set a higher franchise fee. However, the fee charged is positive in all cases. That is, under private contracts, sellers pay the platforms for each of their transactions, regardless of whether the network effect in the market is positive or negative.

Figure 3.4.2: Evolution of the price of platform-specific products as a function of the network effect



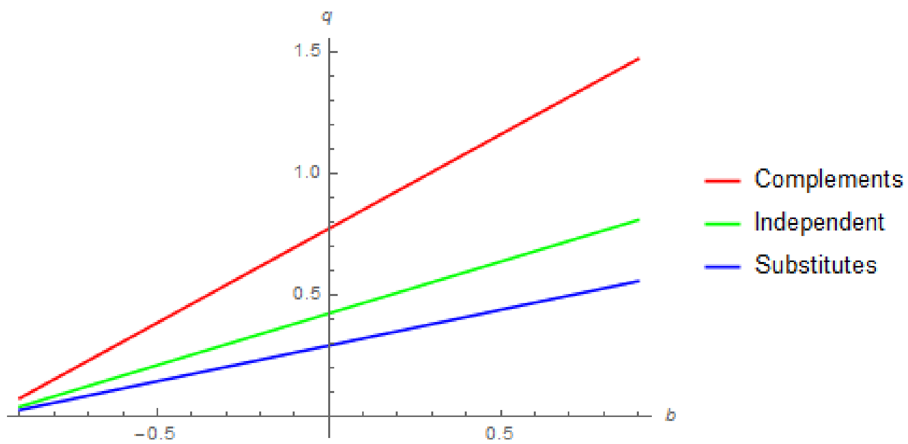
The price of platform-specific products, like the franchise fee, also increases as the network effect increases. It can also be seen that, in addition to the use of private contracts, the price charged to consumers is positive. They have to pay a lower price for platform-specific products with a negative network effect and a higher price with a positive network effect.

Figure 3.4.3: Evolution of the subscription fee as a function of the network effect and the relationship between the products



Based on Figure 3.4.3, the platform continues to set a positive subscription fee for consumers. That is, in the case of private contracts, contrary to the findings in the literature, the platform does not offer discounts to consumers if a competitor is also present in the market. The subscription fee is higher with a negative network effect and is lower with a positive network effect. It can also be seen that consumers pay the least for joining the platform for complementary products and the most for substitute products.

Figure 3.4.4: Evolution of demand for platform-specific products as a function of the network effect and the relationship between products



According to Figure 3.4.4, the strengthening of the network effect increases the demand for platform-specific products. If the prevailing network effect is negative, then the demand for products manufactured for the platforms is lower, while with a positive network effect it is higher. As the network effect for consumers was realized in the wake of the products purchased, this result is not surprising. It can be seen that consumers are looking for complementary products the most, as they then gain additional benefits from consuming the product and pay the least for joining the platform, while demand for substitute products is the lowest.

Figure 3.4.5: Evolution of the profit of platforms as a function of the network effect, the relationship between products, and the travel cost

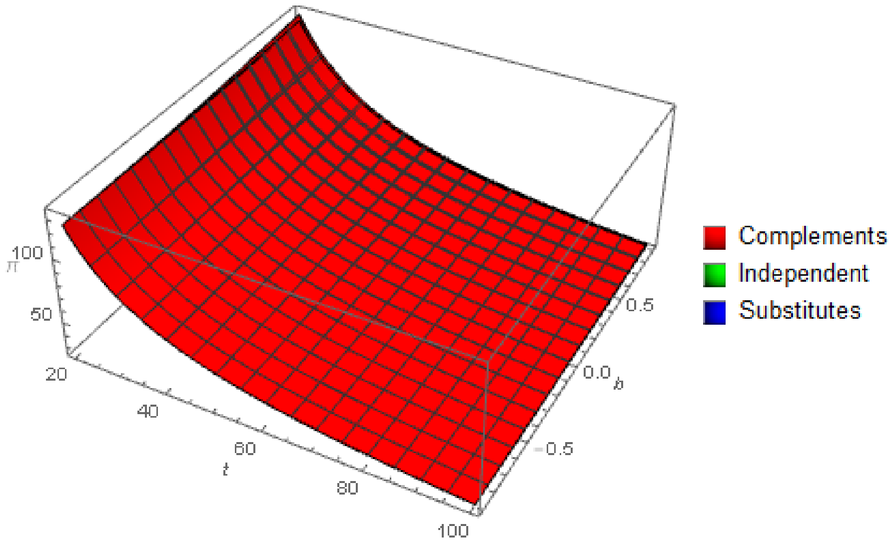
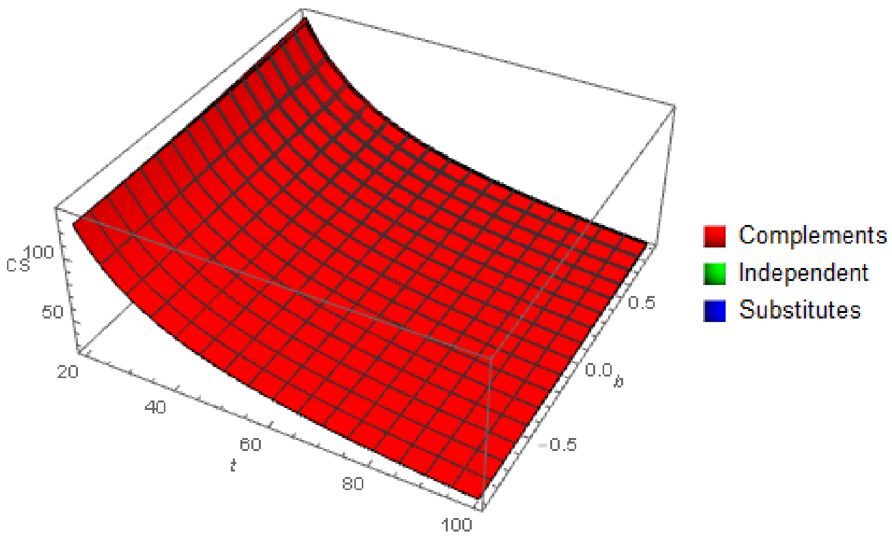


Figure 3.4.5 shows the evolution of platforms' profit. It can be stated that with the strengthening of the network effect, the realizable profit increases, and the decrease of travel costs has a similar effect. If the travel cost is high in the market and there is a negative network effect, the platform has little or no ability to realize profits. If complementary products are present in the market, the highest profit can be achieved.

Figure 3.4.6: Surplus of connected consumers as a function of the network effect, the travel cost, and the relationship between products



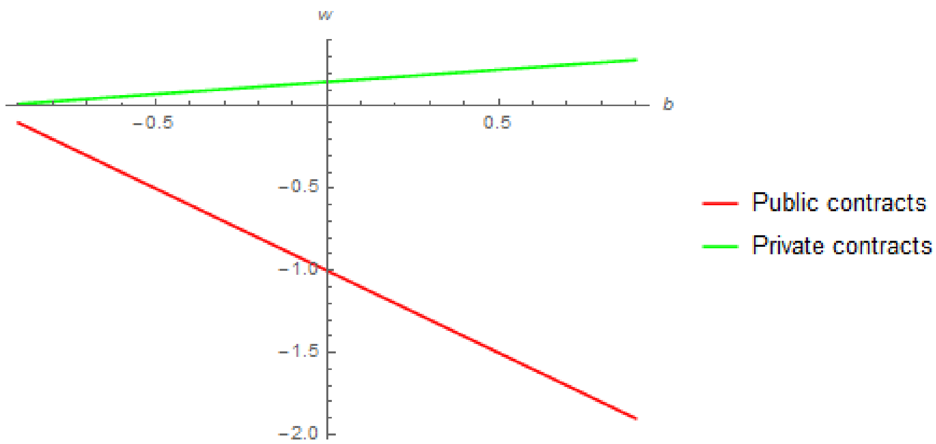
The realized surplus of consumers is the lowest in the case of a strong, negative network effect and high travel costs, while it is the highest in the case of negligible travel costs and positive network effect. That is, the consumer surplus increases as the network effect increases and travel cost decreases. Consumers realize the highest surplus in the case of complementary products because then the co-consumption of the products generates additional benefits for them, and they pay the least for connecting to the platform.

3.5 Comparison of the model of public and private contracts

In the following section, the results obtained for public and private contracts reported in Proposition 4 and 5 are compared.

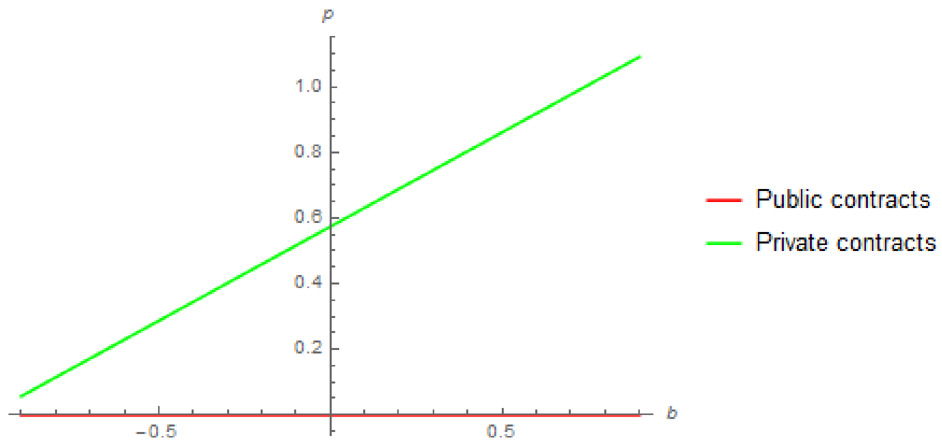
Figure 3.5.1 shows the evolution of the franchise fee with the use of public as well as private contracts. It can be seen that the platforms changed their strategy in favor of private contracts and imposed a positive franchise fee on the previously supported seller segment. This result is consistent with the results of Armstrong and Wright (2007) and Llanes and Ruiz-Aliseda (2015).

Figure 3.5.1: Evolution of the franchise fee as a function of the network effect



As a result of the franchise fee included in the contract, in addition to the use of private contracts, consumers already pay a positive price to sellers for their products. This also confirms in a duopolistic model framework the proposition by Llanes and Ruiz-Aliseda (2015) that platforms include franchise fees in private contracts that ultimately result in collusive pricing on the part of sellers.

Figure 3.5.2: Evolution of the price of platform-specific products as a function of the network effect



In the case of the subscription fee imposed on consumers based on Figure 3.5.3, the platforms did not change their strategy, in contrast to the results of Llanes and Ruiz-Aliseda (2015). Although the subscription fee for private contracts is lower than for public contracts, consumers do not receive support in a duopolistic environment. Furthermore, it can be stated that while in addition to public contracts, the fee charged for subscription increases as the network effect strengthens, in the case of private contracts it decreases. The largest discrepancy in the subscription fee is seen for complementary products, while the smallest is for substitute products.

Figure 3.5.3: Evolution of the subscription fee as a function of the network effect and the relationship between the products

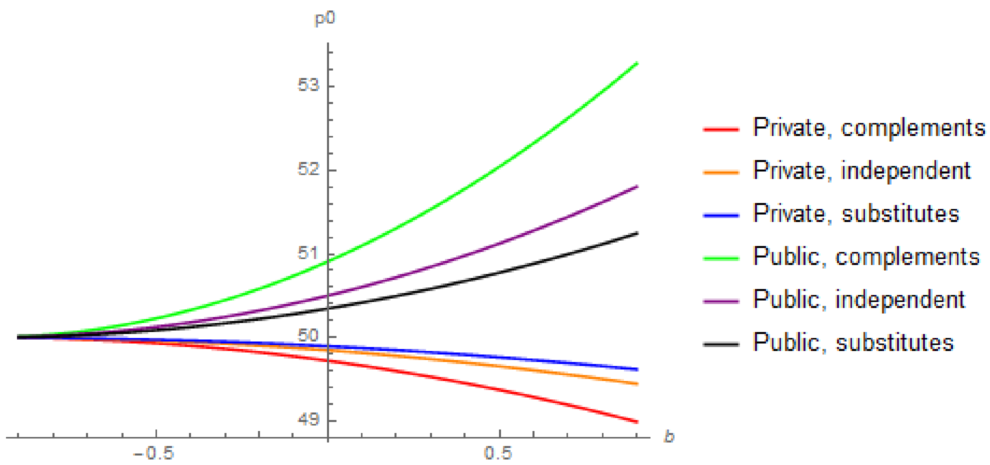


Figure 3.5.4 shows that in the case of public contracts, regardless of the relationship between the products, the demand for platform-specific products is higher than in the case of private contracts. Regardless of the type of contract, the highest demand is observed for complementary products, while the lowest is observed for substitute products.

Figure 3.5.4: Evolution of the demand for platform-specific products as a function of the network effect and the relationship between platform-specific products

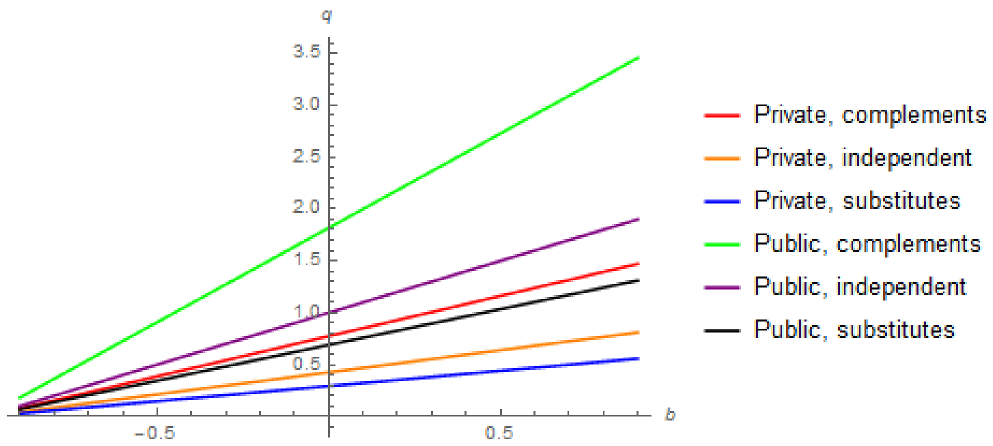
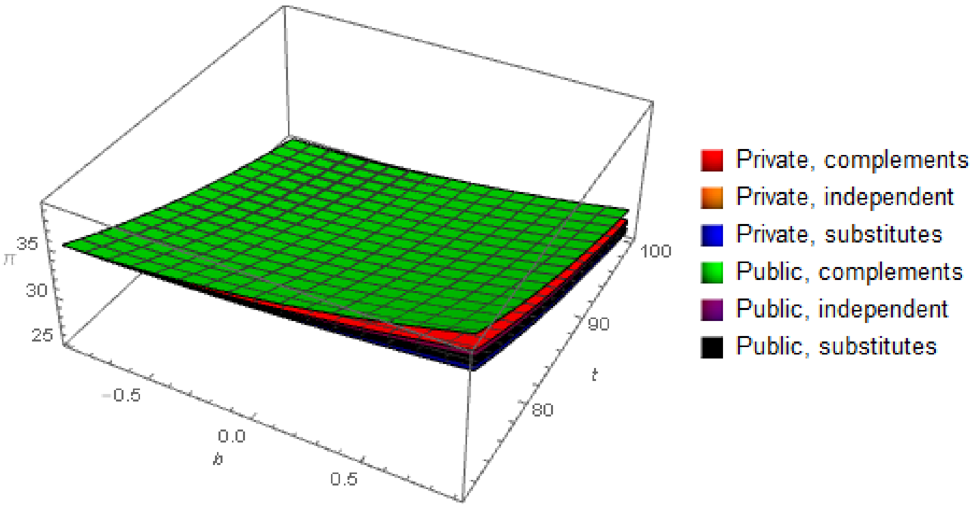


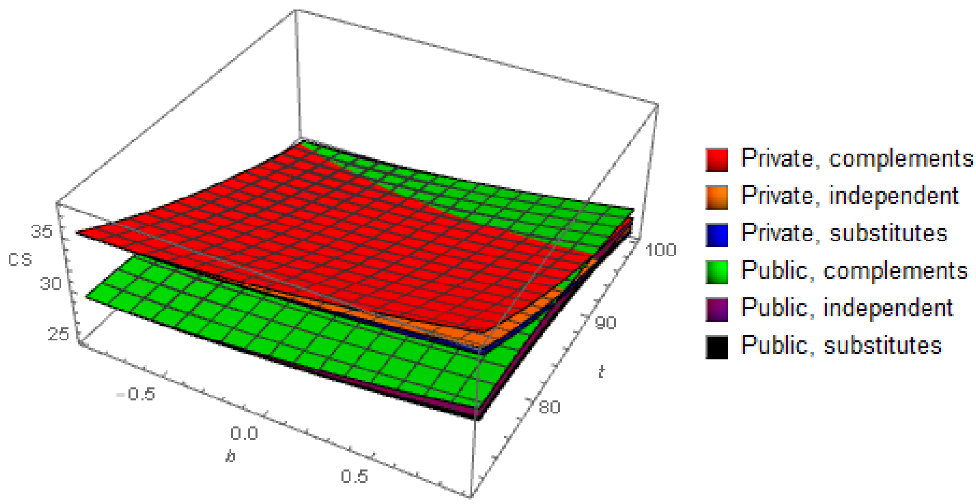
Figure 3.5.5 shows the evolution of platforms' profits. It can be concluded that the use of public contracts results in a more favorable outcome for platforms than the use of private contracts, regardless of the relationship between platform-specific products. Platforms are able to realize the highest profit if the platform-specific products present in the market complement each other, while if there is a substitution relationship between them, lower profit can be achieved for them.

Figure 3.5.5: Evolution of the platforms' realized profit as a function of the network effect, the relationship between platform-specific products, and the travel cost



In the case of the realized surplus of consumers, it can be stated that with a negative network effect, consumers typically do better if the platforms use private contracts, as shown in Figure 3.5.6. However, with the strengthening of the network effect and the increase in travel costs, after a while, public contracts will become the preferred one. In the case of complementary products, this occurs at a significant travel cost. It can also be seen that if there is a positive network effect, the use of public contracts will become the preferred outcome with lower travel costs. The realizable surplus is highest when complementary products are available in the market, while it is lowest when platform-specific products are substitutable.

Figure 3.5.6: Evolution of consumer surplus as a function of the network effect, the travel cost, and the relationship between platform-specific products



Overall, it is preferable for platforms to use public contracts for the model specification reported in this chapter. In contrast, on the consumer side, there is a case where they prefer private contracts because then their realized surplus exceeds their surplus available under public contracts.

3.6 Summary

In this chapter, the impact of public and private contracts were presented within the framework of a duopolistic two-sided market. It has been seen that when using public contracts, the profits of the platforms, as well as the surplus of consumers, are also the highest when the sellers enter both platforms, regardless of the relationship between the platform-specific products.

If the platforms were able to offer private contracts, on the one hand, their strategy changed and positive franchise fees were set for previously supported sellers. This result is consistent with the results of Armstrong and Wright (2007) and Llanes and Ruiz-Aliseda (2015). On the consumer side, on the other hand, in contrast to the results of the above two papers, the platforms did not offer discounts but continued to set a positive subscription fee. However, this was lower for private contracts than for public contracts, and the increase in network effect reduced the subscription fee charged to consumers, while it increased it for public contracts. As a result of the above, consumers had already to pay for platform-specific products previously available for free for private contracts. The change in sellers' pricing when the platforms offer private contracts was also reflected in the monopolistic model of Llanes and Ruiz-Aliseda (2015). Contrary to the results of this paper, however, the conclusion was made that sellers' beliefs in the case of duopolistic platforms do not depend on the relationship between platform-specific products.

Evaluating the models of public and private contracts from the point of view of platforms and consumers, it was found that platforms always do better with the use of public contracts, as their realized profits were higher. The question then arises as to why the platforms still use private contracts. A potential response to this could be to use them to give consumers a discount and thus attract them. But following the example of Microsoft and Apple, they may aim to create a unique platform for which they want to produce compatible products with exclusive programmers (sellers). This, on the one hand, differentiates the service they provide and, on the other hand, gives them monopolistic power in terms of those who join them. The practice of product differentiation with exclusive contracts was proven in the case of traditional markets by Bakó (2012) and

Bakó (2016). Consumers, on the other hand, preferred the case when platforms used public contracts only at high travel costs. Conversely, if travel cost was moderate, the use of private contracts became preferred on their part.

On the one hand, the above results highlighted that, in the case of two-sided markets, platforms are typically encouraged to offer public contracts and attract as many sellers as possible. On the other hand, from a consumer perspective, several factors play a role in determining the desired outcome. The strongest factor was clearly the travel cost on the consumer side: if the travel cost was low, they strongly preferred the case where the platform offered private contracts to multi-homing sellers. In contrast, in the case of high travel costs, the use of public contracts was preferred. This was due to the lower subscription fee for private contracts, but also due to the fact that low travel cost can also be interpreted as a differentiated product, which represents a higher benefit in the eyes of consumers.

Chapter 4

Mixed duopoly in two-sided markets

4.1 Mixed duopolies in the literature

The state can choose from several strategies when regulating markets. It can choose to levy a tax, introduce price regulation[1], or create/purchase a company in a particular market. In this chapter, the impact of the latter intervention is examined in the context of two-sided markets, whereas different results have been obtained for these platforms, both in terms of the need for regulation and its way.

If a state-owned company operates alongside a privately owned competitor in a given market, we are talking about a mixed duopoly. Mixed duopolies have been at the center of economic research since the late 1960s, and their literature has expanded greatly since then. The first pioneering paper can be attributed to Merrill and Schneider (1966), who first examined the short-term effects of the possibility of some companies being in public hands and others in private hands within a given market. In the model they presented, the state-owned company maximized the industry's output under the restrictive assumptions that its emergence would not generate losses for private firms and would not result in a low price that would generate overdemand in the industry. The game took place in a Stackelberg environment where companies decided on prices, the public company was the Stackelberg leader, while the private companies were the Stackelberg followers. Three pricing strategies are analyzed by the authors in the paper: the first is when the public company meets the demand at a price it sets, and the private companies satisfy the remaining demand at a monopolistic price. According to the second strategy, private companies charge a lower price for their products than the price set by the state-owned company and meet the demand at that price, or, if they are unable to do so, sell all their products at that price. Finally, privately-owned companies could choose to set the same

[1]For example, it imposes a price floor to enhance competition. About the effect of price floor in the case of traditional markets, see e.g. Bakó (2010)

price as the state-owned company and share the market equally. For the state-owned company, two pricing strategies were examined: it could use neutral or discriminatory pricing. In addition, the impact of a state-owned company deciding on company size was also examined. The authors concluded that in an oligopolistic environment, the emergence of a state-owned company can result in a more favorable outcome – lower prices and higher output. It was also pointed out that while the state-owned company cannot sell exclusively to consumers with high reservation prices, the output of the industry will remain below full capacity and the average price will be above the marginal cost.

In the case of state-owned companies, there is no consensus on the objective function, but the maximization of the social surplus (consumer and producer surplus) has become typical. Nett (1993) summarized the results obtained in the literature for homogeneous products. He examined a total of five topics in his paper on mixed oligopolies: the optimal pricing strategy of a state-owned company, the state-owned company as a tool for regulation, the effect of cost functions in the literature on the resulting equilibria, investment (incentive) contracts, and the relationship between strategic commitment and market entry. A review of the literature has led the author to conclude that the assumptions used in the papers substantially influence the results obtained in them, which are typically contradictory.

For example, the optimal pricing used by a state-owned company depends on the existence of a constraint: if the state-owned company does not face a constraint, marginal cost pricing is the best strategy, while if it faces a zero profit condition, the price will follow the modified Ramsey pricing formula. In general, however, marginal cost pricing is not dominated by other pricing strategies.

The most controversial results have been achieved in the area of nationalization and privatization. Furthermore, due to the condition of perfect information, Nett stressed that the conclusions presented here should be treated with caution. In the papers examined, the state could decide to set up a new company in a given market or to buy one of the private companies. If the companies in the market can be characterized by unique technology, then the social welfare is maximal if only a state-owned company is present in the market. If the technology is characterized by declining returns to scale, more than one company may appear on the market at optimum. Another influencing factor in terms of results is the nature of competition between firms: under the assumption of Cournot and Stackelberg, privatization affects the profits of the originally privately owned firm and the privatized firm and social surpluses differently (Grau, 1990, as cited in Nett , 1993). According to Nett's review, under certain conditions, nationalization results in the formation of a state monopoly in the long run (Cremer, Marchand, and Thisse, 1987, as cited in Nett , 1993), while under other assumptions, it entails a decline in social welfare

(De Fraja and DeIbono De Fraja - Delbono , 1989).

With the difference between the costs associated with the production, the authors typically tried to capture efficiency. However, the results obtained on this issue have been refuted by subsequent empirical analyzes. For example, De Fraja (1993)[2] justified the difference in costs between the public and the private company with the different outcomes of the wage negotiations. Based on his results, the state-owned company pays its employees higher wages than its privately held competitor, which would result in the formation of a state monopoly in the long run. The above result is obvious from Nett's argument and can be illustrated with a contradiction. If the private firm can be characterized by a higher fixed unit cost, then the public firm can be considered a monopolist in the market. As a result, the private company gets rid of its employees and withdraws from the market. However, this would also put workers and unions at a disadvantage, so that can be no equilibrium outcome. On the other hand, a state-owned company has to pay a positive wage to its employees due to the bargaining position of the union, which creates an opportunity for private companies to enter. Subsequent empirical analyzes also refuted De Fraja's (1993) findings, as they showed that public wages are typically lower than wages in the private sector. Another approach to explaining the difference in cost is innovation. In an earlier paper, Nett examined the effect of innovation (Nett, 1991, as cited in Nett , 1993), which results in an increase in the fixed cost of the company performing the innovation, while a decrease in the variable cost. Based on the obtained results, a state monopoly and a mixed duopoly can also be the equilibrium. In the case of the latter, there is a scenario where the output of the private company will be higher, while its average cost will be lower than that of the state-owned company. However, this does not mean that the private company is more efficient. In addition, the author also realized that if two state-owned firms compete in the market, the price is lower and the welfare is higher than in a mixed duopolistic market. Finally, it was also found that if companies maximize output rather than profit, destructive competition becomes more likely to result, i.e., at least one company becomes unprofitable.

The use of incentive contracts typically arises as a solution to the principal-agent problem. In the case of a mixed duopoly, the literature concludes according to Nett that in the case of a principal-agent problem, there is an allocation in a mixed duopoly market that qualifies as a Pareto improvement compared to the situation where the two owners decided to issue their company. That is, the two owners offer managers contracts that do not fully address the differences in interests. This results in a higher surplus for a mixed duopoly based on Laffon (1986), as cited in Nett (1993) than for a private duopoly, where a prisoner dilemma typically develops.

[2]Nett (1993) refers to an earlier version in his paper that was published in 1990.

Finally, the relationship between strategic commitment and market deterrence was also analyzed in the case of mixed duopolies. Based on the papers examined, Nett found that there was a strong assumption as to whether or not the state-owned firm faced a constraint. If there is no constraint on the state-owned company, the presence of the state-owned company in the market deters private entrants, unless the latter can produce at a lower cost (Fershtman , 1990). If, on the other hand, the state-owned company faces a budget constraint, the private company can enter at symmetrical costs (Nett, 1990, as cited in Nett , 1993). As a solution, a long-term strategic commitment on the part of the state-owned company may arise, but this will not deter the entrant based on the results either.

Based on Nett (1993), it can be concluded that the initial assumptions significantly influence the results obtained. In addition to a review of the literature, Nett (1993) also highlighted an interesting phenomenon in relation to mixed duopolies, which he called the Cournot-Paradox in the wake of the Bertrand-Paradox. The Bertrand-Paradox arises when duopolistic firms compete on price, do not face capacity constraints, and have constant and symmetric average costs. In this case, the price will be optimally equal to the average cost, i.e. companies will not make a profit. The Bertrand-Paradox also exists in the case of mixed duopolies. If a Cournot competition develops in a mixed duopolistic market, equilibrium output will give competitive output, i.e., the best answer for a given technology will be equilibrium allocation. However, then only the state-owned company will be present in the market and it will not be worthwhile for private companies to enter. Nett outlined two solutions to this problem: either there should be declining returns to scale in production, or the privately-owned company should produce at a lower cost. In these cases, the Cournot-Paradox does not exist, it may be worthwhile for a private company to enter the given market.

In the case of papers examining product differentiation, it can also be stated that, depending on the assumptions, different results are obtained in terms of its extent and its effect on optimal pricing. Matsumura and Matsushima (2003) examined the optimal role of the state-owned company, the impact of price regulation, and the impact of the privatization of the state-owned company in the context of the Stackelberg duopoly. They were interested in whether, according to the literature, the state-owned company chooses the role of the follower in the optimum in all cases, and how the introduction or abolition of price regulation affects the location chosen by the companies and the market structure. They examined a two-period model. In the first period the leader company chooses a location, and then the follower observes this decision and determines its location. In the second period, companies set their prices. The authors concluded that without price regulation, the highest level of welfare is achieved when the public company is the leader and the private is the follower. Then the products are more differentiated than when companies change roles. If companies were to seek to maximize profits, they would be located at the two endpoints, however, the welfare achieved in this way is lower than in the state leader – private follower case. If price regulation is introduced in the market, the desired outcome in terms of welfare is where the private company is the Stackelberg leader and the state company is the Stackelberg follower. Then the differentiation of the products is the same as in the relevant case without price regulation. Conversely, if the state-owned company acted as a leader with price regulation, homogeneous products would be available on the market. Comparing the two desirable outcomes, Matsumura and Matsushima came to the conclusion that higher social welfare could be achieved without price regulation. The authors also examined the effect of simultaneous location decision, for which there are several equilibria. If the expected pay-offs for this game are the same as the pay-offs in the Stackelberg case when companies play their desired role in the game, a single equilibrium occurs, however, in this case, the welfare is lower than when companies sequentially decide on their location.

Ogawa (2006) examined the impact of product differentiation on companies' capacity decisions. Previously, the literature has assumed that products are perfect substitutes for each other, in which case, the state-owned company chooses under-capacity at optimum, while the private company chooses excess capacity optimally. On the one hand, the author supported the results of the literature in the case of perfect substitutes, but in the case of perfect complements, both companies decided to choose excess capacity.

In their paper, Kitahara and Matsumura (2013) presented a model for the effect of product differentiation of mixed duopolies on equilibrium prices. It was examined whether the phenomenon that occurs with inelastic demand also exists in the case of elastic demand, namely that an increase in product differentiation leads to a decrease in price competition. In addition, the impact of the privatization of the state-owned company was examined and the model of Matsumura and Matsushima (2003) without price regulation was also reproduced in the above environment. The authors came to the conclusion that in the case of elastic demand, the decreasing differentiation of products can lead to a loosening of competition. In addition, at optimum, the private company is too close to the state-owned company, i.e., product differentiation in equilibrium will be too small compared to the socially optimal case. The above results are robust with low privatization, so product differentiation still lags behind the socially optimal, however, with large-scale privatization, the opposite can be said. Thus, if the state becomes a minority owner in the company it founded or sells it to the private sector, the two companies will be located as far apart as possible, i.e., the degree of product differentiation will be higher than the socially optimal level. Under the Stackelberg model, the results of Kitahara and Matsumura show that product differentiation will be lower under the assumption of elastic demand than in the case of inelastic demand if the state-owned company is the leader in the model. In contrast, in the case of welfare, despite decreasing differentiation, an increase is observed, contrary to the respective results of Matsumura and Matsushima (2003). That is, with elastic demand, the leading role of the state-owned company is significant. Finally, based on the results of the privatization model, companies are located as far apart as possible even in the case of elastic demand, which results in a decrease in welfare.

In the case of two-sided markets, the appearance of the state in each market is also an important issue. The literature on this issue typically focuses on the media as well as open-source platforms – the latter are not in state hands, but their behavior is very similar to that of a state-owned company. With the spread of the Internet, open-source platforms have become the focus of research. The most typical examples are operating systems (Linux and Windows or Android and Apple iOS) and software (Open Office and Microsoft Office, Firefox and Google Chrome). The analyzes focus on the diversity and differentiation of the products available on the market, however, the approaches used to capture them are varied.

González-Maestre and Martínez-Sánchez (2015) analyzed the impact of the platforms' decision on quality and advertising and the emergence of a public actor in the broadcasting industry. In addition, the impact on the quality and welfare of policies aimed at eliminating advertising funding for public platforms has been examined.[3] The authors presented three models: the case of private, mixed, and "zero" duopoly.[4] The impact of private and mixed duopolies on welfare depends, based on the results, on the net direct impact of advertising on welfare and the interaction between the degree of substitutability between platforms. From a welfare comparison of the three models, it was found that at low travel costs, if the rate of revenue per viewer and advertisement and the loss of revenue from viewers due to ads (k) is sufficiently low, the zero duopoly, while if it is sufficiently high, the private duopoly is desirable. For high travel costs, zero duopoly is the optimal system for low k, mixed duopoly for medium-low and high k, and private duopoly for medium-high k is the optimal system. For intermediate values of travel cost, a zero duopoly is desirable if k is low, a private duopoly if k is medium, and a mixed duopoly if k is high.

Pires (2016) also analyzed the market for media service providers and examined the claim that the emergence of a state-owned media service provider increases media pluralism in the market. However, his results highlighted that this statement is not

[3] In France, for example, advertising on public TV was phased out and then taxed on private broadcasters and telecommunications platforms to provide the resources needed to sustain public TV. The same was done in Spain, but in some aspects, the advertising tax introduced in Hungary can be included here, although the purpose was not to eliminate advertising on the state platform.

[4] The latter corresponds to the case where there are no ads on the state platform, hence the name "zero".

necessarily true, as the adjustment of news to readers' political preferences, the intensity of these political preferences, and the size of the advertising market significantly influence the impact of a state-owned company's appearance on social surplus. That is, the appearance of the state with its own company in a given market is not necessarily a suitable regulatory tool. This is due to the fact that in the media markets, in addition to price competition, there is also competition between companies in terms of the information offered. As media pluralism increases, price competition increases in the market, which a state-owned company cannot always offset by its activities.

Open-source and proprietary platforms were the subjects of the research of Casadesus-Masanell and Llanes (2015). In the paper, the authors analyzed the incentives to invest in the quality of platforms. They sought to answer the question of how the openness of the platform affects investment in quality, what type of relationship can be observed in terms of access and investment strategy, and how competition in a mixed duopolistic environment affects access fees and investment in quality. Casadesus-Masanell and Llanes have come to the conclusion that with the same number of developers and users, they are investing more in the quality of the private platform. In contrast, open-source platforms may benefit from limited developer access if, as a result of investing in platform quality, developer revenue decreases as the number of applications increases. Then a lower number of developers can result in a higher level of investment. These results are similar to multiple users connect to the open-source platform, or when multiple developers connect to the open-source platform, and investing in platform quality increases developer revenue as the number of applications increases. If the proprietary platform becomes available to one site free of charge, it will be less encouraged to invest in quality, as it will then not be able to internalize the network effect with the access fee. In a mixed duopolistic environment, the structure of access fees is determined by two factors based on the authors' findings: how changes in the number of developers affect investment in an open-source platform, and how investing in an open-source platform affects the private platform's revenues. An interesting conclusion is that a proprietary platform can also benefit from investing in an open-source platform, as the quality of the platform improves developer revenues, resulting in more applications in the market. This in turn increases the revenue of the platform.

In connection with the above papers, the rest of the chapter will focus on mixed duopolistic two-sided markets. In subchapter 4.2, the "zero" duopolist case of González-Maestre and Martínez-Sánchez (2015) is analyzed in a different approach. This is because the idea behind the model is that the state broadcaster chooses the level of advertising to be zero, i.e. it excludes the advertiser side from the given platform. And if the advertisers do not have access to the product or service of the state-owned company, the state-owned company will cease to be a platform but it will continue to compete with a private platform in that market. The effect of this on pricing and product differentiation is the subject of this study.

4.2 The model of competition between a public company and a private platform

Consider a classic Hotelling market. Let us suppose there is a state-owned company (s) and a privately-owned platform (p) operating in the market. The two companies are located along the section, namely that the public company can be characterized by the l_s location, while the private platform can be characterized by the l_p location. Regarding the locations, it is assumed that the private platform either chooses the same location as the state-owned company or is located to the right of the state-owned company, i.e., $l_s \leq l_p$. A potential situation is illustrated in Figure 4.2.1.

Figure 4.2.1: The location of companies

There are two types of consumer groups that can enter the market, viewers (v), and advertisers (a). Only viewers can buy from the public company, while members of both segments can enter the private platform, where they can then interact with each other. It is assumed that the members of the two consumer groups are evenly distributed over the unit section representing the market. For simplicity, it is assumed that both the public company and the private platform produce their product at zero cost.

That is, it is assumed that viewers either buy a product from only one company or, if it is in their interest, purchase both products. Because advertisers only have access to a privately-owned platform, they can choose between entry and absence.

Viewers realize a benefit of the size of v_v when they buy a company's product. v_v is assumed to be at least large enough for all viewers to purchase a product from at least one company. In the case of the state-owned company, it is assumed that viewers receive the product for free ($p_{v,s} = 0$) while joining the private platform has a non-negative price ($p_{i,p}$, where $i = v$, a) for viewers and advertisers.

In addition to the connection fee, a further reduction in utility for viewers is caused by the fact that the company's product differs from the one they prefer, which preference is embodied in the location of the viewers. The extent of this reduction in utility is given by the transportation cost given as a linear function of the distance between the location of the viewer and the company. More specifically, a viewer at a distance x who buys a product from company j suffers a reduction in utility $t_{i,j}x$. The transportation cost for viewers is assumed to be $t_{v,j} \geq 0$ for every $j = s$, p, while the transportation cost for the advertiser side is constant 1.

According to the literature on two-sided markets, it is assumed that consumers who connect to the privately-owned platform realize additional benefits when interacting with members of the other side, i.e. there is a network effect between the two segments. The magnitude of this, if the number of $-i$-type consumers connected to platform p is denoted by $n_{-i,p}$, is $b_i n_{-i,p}$.

Based on the above, the utility function of the viewer at point x_v purchasing the product of the state-owned company can be given by

$$u_{v,s} = v_v - t_{v,s} \left| x_v - l_s \right| \tag{4.2.1}$$

while the utility function of the viewer connecting to the private platform is as follows:

$$u_{v,p} = v_v - p_{v,2} - t_{v,p} \left| l_p - x_v \right| + b_v n_{a,p}. \tag{4.2.2}$$

Viewers who buy the products of both companies realize the utility of

$$u_{v,s,p} = v_v - t_{v,s} \left| x_v - l_s \right| + v_v - p_{v,p} - t_{v,p} \left| l_p - x_v \right| + b_v n_{a,p}. \tag{4.2.3}$$

The utility function of advertisers who enter the private platform:

$$u_{a,p} = b_a n_{v,p} - p_{a,p} - \left| l_p - x_a \right|. \tag{4.2.4}$$

The profit function of a private company is as follows:

$$\pi_p = \sum_i p_{i,p} D_{i,p} \left(\mathbf{p} \right), \tag{4.2.5}$$

where $D_{i,p}(\mathbf{p})$ is the demand of type i consumer for the platform as a function of $\mathbf{p} = (\mathrm{p_{v,p}}, \mathrm{p_{a,p}})$, i.e. the vector of prices determined by the private platform.

In the operation of the state-owned company, it maximizes the surpluses for viewers and advertisers, based on which its objective function can be given in the following form:

$$W = \int_0^{x_{v,p}} u_{v,s} dx_{v,0} + \int_{x_{v,s}}^1 u_{v,p} dx_{v,0} + \int_{x_a}^1 u_{a,p} dx_{a,0}, \tag{4.2.6}$$

where

- $x_{v,s}$ is the location of the viewer who is indifferent to purchasing the product of the public company or both companies,
- $x_{v,p}$ is the location of the viewer who is indifferent to purchasing the product of the private platform or both companies,
- x_a is the location of the advertiser who is indifferent to joining and staying away from the private platform.

In the following, a two-period game is examined. The game is as follows: In the first period, the state-owned company and the private platform simultaneously decide on their location, i.e. the differentiation of their product. In the second period, the private platform sets the subscription fees for the two segments. Finally, the players on both sides decide on the entrance, observing the degree of product differentiation chosen by the companies and the prices charged by the private platform.

The solution to the game is given by its subgame-perfect Nash equilibrium, which can be obtained by backward induction due to the sequential nature of the game.

Consider the second period. Let us suppose the state-owned company chose l_s, while the private platform chose l_p location in the previous period. The private platform set $p_{v,p}$ for viewers and $p_{a,p}$ non-negative price for advertisers. To specify demand on the viewer side, the location of viewers who are indifferent to whether they buy the product of only one company or the product of both companies is needed to determine. In the case of advertisers, the location of the advertiser who is indifferent to joining the private platform and staying away from the market is needed to determine.

Consider first the case of viewers, i.e. the v segment. A viewer in location x who is satisfied that $x \leq x_{v,s}$ buys exclusively the product of a public company, while a viewer who has $x_{v,p} \leq x$ location, buys only the product of the private platform. Type v consumers with location $x_{v,s} \leq x \leq x_{v,p}$ purchase the products of both companies. For the location of indifferent viewers, the values of utility functions given by the terms (4.2.1) and (4.2.3), as well as the values of utility functions given by the terms (4.2.2) and (4.2.3), are the same. Note that in equilibrium, the number of viewers connected to the private platform ($n_{v,p}$) will be $1 - x_{v,s}$, while the number of advertisers ($n_{a,p}$) will be $1 - x_a$.

Based on the above, the indifferent viewer with respect to buying from a state-owned company and multi-homing behavior is at

$$x_{v,s} = \frac{b_v + b_v b_a - b_v l_p - p_{v,p} - b_v p_{a,p} - l_p t_{v,p} + v_v}{b_v b_a - t_{v,p}}. \tag{4.2.7}$$

The indifferent viewer regarding connection to the private platform and multi-homing can be characterized by the

$$x_{v,p} = \frac{l_s t_{v,s} + v_v}{t_{v,s}} \tag{4.2.8}$$

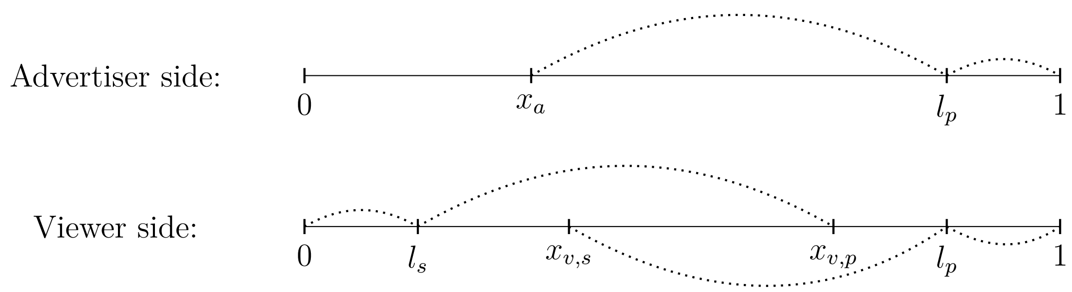
location.

For advertisers, to determine demand, the advertiser is looked for in a location that is indifferent to entering the private platform, i.e., whose utility in (4.2.4) will be 0. From this, it follows that the indifferent advertiser will be located at

$$x_a = l_p + p_{a,p} + b_a x_{v,s} - b_a. \tag{4.2.9}$$

Figure 4.2.2 illustrates the situation of indifferent viewers and advertisers, as well as the demand for companies' products.

Figure 4.2.2: The location of indifferent consumers and the demand for companies' products



Demand for the private platform on the viewer side will therefore be $(1 - x_{v,s})$. Substituting the location of the indifferent viewer results in

$$D_{v,p}(\mathbf{p}) = \frac{p_{v,p} + b_v (l_p - 1 + p_{a,p}) + (l_p - 1) t_{v,p} - v_v}{b_v b_a - t_{v,p}}. \tag{4.2.10}$$

The demand on the advertiser side will be $(1 - x_a)$, based on which the demand function can be written in the form

$$D_{a,p}(\mathbf{p}) = \frac{(l_p - 1 + p_{a,p})\, t_{v,p} + b_a\left(p_{v,p} + (l_p - 1)\, t_{v,p} - v_v\right)}{b_v b_a - t_{v,p}}. \tag{4.2.11}$$

Using the demand functions (4.2.10) and (4.2.11), the profit function of the platform given in (4.2.5) can be given as follows:

$$\pi_p = p_{v,p} D_{v,p}(\mathbf{p}) + p_{a,p} D_{a,p}(\mathbf{p}) \tag{4.2.12}$$

The privately-owned platform sets prices for the two segments for which it is true that

$$\frac{\partial \pi_p}{\partial p_{i,p}} = 0,\ \forall i = v,\, a. \tag{4.2.13}$$

From the solution of the system of equations formed by the first-order conditions, it follows that the prices determined by the private platform will be in equilibrium

$$p_{v,p} = \frac{(1 - l_p)\left(b_v (b_a - 1) + b_a + b_a^2 - 2t_{v,p}\right) t_{v,p} + \left(b_a (b_v + b_a) - 2t_{v,p}\right) v_v}{(b_v + b_a)^2 - 4t_{v,p}} \tag{4.2.14}$$

and

$$p_{a,p} = \frac{(1 - l_p)\left(b_v^2 - (2 + b_a)\, t_{v,p} + b_v (b_a + t_{v,p})\right) + (b_v - b_a)\, v_v}{(b_v + b_a)^2 - 4t_{v,p}}. \tag{4.2.15}$$

In addition to the connection fees set for the two sides, the profit of the private platform is as follows:

$$\pi_p = \frac{-(l_p - 1)^2\, t_{v,p} (1 + b_v + b_a + t_{v,p}) + (l_p - 1)(b_v + b_a + 2tv, p)\, v_v - v_v^2}{(b_v + b_a)^2 - 4t_{v,p}}. \tag{4.2.16}$$

Knowing the locations of the indifferent viewers and advertiser in equation (4.2.7) to equation (4.2.9) and the equilibrium prices specified in equation (4.2.14) and equation (4.2.15), the objective function of the state-owned enterprise can also be determined on the basis of expression (4.2.6), which takes the form:

$$W = \frac{1}{2}\Bigg(-l_s^2 t_{v,s} + \frac{t_{v,p}\left((l_p - 1)\left(b_v + b_v^2 + b_a + 2b_v b_a + b_a^2 - 2t_{v,p}\right) - 2v_v\right)^2}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2} + 2l_s v_v +$$

$$\frac{v_v^2}{t_{v,s}} + \frac{(l_p - 1)\, t_{v,p}\left(-(l_p - 1)\left(3b_v^2 + b_a (2 + 3b_a) + b_v (2 + 6b_a) - 8t_{v,p}\right) + 4v_v\right)}{(b_v + b_a)^2 - 4t_{v,p}} +$$

$$\frac{\left((l_p - 1)\left((b_v + b_a)^2 + (b_v - 2 + b_a)\, t_{v,p}\right) - (b_v + b_a)\, v_v\right)^2}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2} +$$

$$\frac{(l_p-1)\left((l_p-1)\left(-3\,(b_v+b_a)^2-2\,(b_v+b_a-4)\,t_{v,p}\right)+2\,(b_v+b_a)\,v_v\right)}{(b_v+b_a)^2-4t_{v,p}}\Bigg). \tag{4.2.17}$$

Let us now turn to the examination of the first period and consider the location decision of the public company and the private platform, i.e. the degree of product differentiation chosen by them. The state-owned firm determines its location so that the viewer and advertiser surplus given in (4.2.17) is maximal. And the private platform seeks to maximize its profit function as defined in (4.2.16). It follows from the two optimizations that the state-owned company will make the

$$l_s^* = \frac{v_v}{t_{v,s}} \tag{4.2.18}$$

location decision in equilibrium, while the location chosen by the private platform in equilibrium would be

$$l_p = 1 + \frac{(b_v+b_a+2t_{v,p})\,v_v}{2t_{v,p}\,(1+b_v+b_a+t_{v,p})}. \tag{4.2.19}$$

However, since the location must be $l_p \leq 1$, the privately-owned platform will be located on the right edge of the section, i.e.

$$l_p^* = 1$$

will be in equilibrium. It can be seen that the location chosen by the private platform is not affected by the location decision of the state-owned company.

Knowing the above location decisions, the equilibrium output of the game can already be determined, which is summarized in Proposition 6.

Proposition 6. *In a duopolistic market where a public company and a private platform compete, viewers can exhibit single-homing and multi-homing behavior, while on the advertisers' side the market is not fully covered, the following equilibrium emerges: the private platform is located on the right edge of the section, while the public company chooses the*

$$l_s^* = \frac{v_v}{t_{v,s}} \tag{4.2.20}$$

location. Viewers will pay a price of

$$p_{v,p}^* = \frac{(b_a\,(b_v+b_a)-2t_{v,p})\,v_v}{(b_v+b_a)^2-4t_{v,p}} \tag{4.2.21}$$

for the product of the private platform, while the price charged to advertisers will be

$$p_{a,p}^* = \frac{(b_v-b_a)\,v_v}{(b_v+b_a)^2-4t_{v,p}}. \tag{4.2.22}$$

At these prices, the private platform makes a profit of

$$\pi_p^* = -\frac{v_v^2}{(b_v + b_a)^2 - 4t_{v,p}}. \tag{4.2.23}$$

The surplus for viewers and advertisers will be

$$W^* = \frac{1}{2}\left(\frac{2}{t_{v,s}} + \frac{(b_v + b_a)^2 + 4t_{v,p}}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2}\right) v_v^2. \tag{4.2.24}$$

In equilibrium, viewers in location

$$x \in \left[1 + \frac{2v_v}{(b_v + b_a)^2 - 4t_{v,p}}, \frac{2v_v}{t_{v,s}}\right] \tag{4.2.25}$$

will buy the products of both companies, while on the advertiser side, the indifferent player will be located at point

$$x_a^* = 1 + \frac{(b_v + b_a)\, v_v}{(b_v + b_a)^2 - 4t_{v,p}}. \tag{4.2.26}$$

Equation (4.2.23) shows that the profit realized by the private platform will be positive only if the condition $(b_v + b_a)^2 - 4t_{v,p} < 0$ is satisfied. In this case, it follows from (4.2.22) that $b_v < b_a$, otherwise the price charged to advertisers would be negative. Since advertisers can only meet viewers here, the platform has a monopolistic power over the viewers connected to it, so it is a rational assumption that it sets a positive price for the advertisers that join it.

The price charged to viewers is also non-negative. As the network effect generated by viewers on the advertisers' side increases, i.e. $b_a \to 1$, the connection fee imposed on them decreases. Only in the case of $0 < t_{v,p} < b_a^2$ and $b_v = \frac{2t_{v,p}v_v - b_a^2 v_v}{b_a v_v}$, the private platform allows viewers to enter for free, as does the public company. That is, although the decision of the state-owned company to differentiate the product does not affect the level of product differentiation chosen by the private platform, the competition on the viewer side is reflected in the prices.

The social surplus in (4.2.24) will be positive for all rational parameter values.

To illustrate the above, consider two numerical examples. Suppose viewers do not like ads ($b_v = -\frac{1}{2}$), while advertisers benefit from viewers their ad reaches ($b_a = 1$). For viewers, buying a company's product generates 1 unit of benefit ($v_v = 1$).

Then the public company is located at

$$l_s = \frac{1}{t_{v,s}}.$$

For viewers, the privately-owned platform sets a price of

$$p_{v,p} = \frac{0.5\left(t_{v,p} - 0.25\right)}{t_{v,p} - 0.0625},$$

while it sets a positive price for advertisers, which will be

$$p_{a,p} = \frac{0.375}{t_{v,p} - 0.0625}.$$

Viewers opting for multi-homing are located in the

$$x \in \left[\frac{t_{v,p} - 0.5625}{t_{v,p} - 0.0625}, \frac{2}{t_{v,s}}\right]$$

interval, while the advertiser who is indifferent to entry is in the

$$x_a = \frac{t_{v,p} - 0.1875}{t_{v,p} - 0.0625}$$

point. The profit realized by the platform will be

$$\pi_p = \frac{0.25}{t_{v,p} - 0.0625},$$

while the surplus realized by consumers will be

$$W = \frac{1}{2}\left(\frac{2}{t_{v,s}} + \frac{0.25\left(0.0625 + t_{v,p}\right)}{\left(t_{v,p} - 0.0625\right)^2}\right).$$

Now consider the case where viewers entering a private platform can benefit from being able to transact with as many advertisers as possible ($b_v = \frac{1}{2}$). And the network effect on the advertiser side should be strong ($b_a = \frac{3}{4}$). The value of the direct utility is unchanged compared to the previous example.

The state-owned company then makes the

$$l_s = \frac{1}{t_{v,s}}$$

location decision. In this case, viewers will pay a price of

$$p_{v,p} = \frac{0.5\left(t_{v,p} - 0.4688\right)}{t_{v,p} - 0.3906}$$

for the connection, while the price charged to advertisers will be

$$p_{a,p} = \frac{0.0625}{t_{v,p} - 0.3906}.$$

Viewers opting for multi-homing are in the

$$x \in \left[\frac{t_{v,p} - 0.8906}{t_{v,p} - 0.3906}, \frac{2}{t_{v,s}}\right]$$

interval and indifferent advertiser is in the

$$x_a = \frac{t_{v,p} - 0.7031}{t_{v,p} - 0.3906}$$

point. The profit of the platform in this case will be

$$\pi_p = \frac{0.25}{t_{v,p} - 0.3906},$$

while the surplus realized by viewers and advertisers will be

$$W = \frac{1}{2}\left(\frac{2}{t_{v,s}} + \frac{0.25\,(0.3906 + t_{v,p})}{(t_{v,p} - 0.3906)^2}\right).$$

4.2.1 Comparative statics

Following the examples, let us look at how changes in each parameter affect the equilibrium.

The connection fees charged to viewers and advertisers, the location of the first viewer deciding on multi-homing, the location of the advertiser deciding on the connection, and the profit of the privately-owned platform are influenced by the parameters representing network effects, by the transport cost in the case of connecting to the private platform and by the parameter v_v, which represents the benefit of owning the product of the private platform. In addition to the parameters listed above, the objective function of the state-owned company also depends on the transportation costs of viewers who purchase its product. The location of the state-owned company and the location of the last viewer who opts for multi-homing is determined by the transportation cost incurred when purchasing the product of the state-owned company, as well as the benefits of owning the product.

Let us first look at what happens when the network effect on the advertiser side, i.e. b_a, starts to increase. The partial derivative of the connection fee charged to viewers by the private platform, indicated in (4.2.21), will be

$$\frac{\partial p_{v,p}}{\partial b_a} = \frac{\left(b_v \left(b_v + b_a\right)^2 - 4b_a t_{v,p}\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0.$$

The above expression is negative due to the conditions $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$ and $b_v < b_a$, i.e. as the price increases, the price tailored to viewers decreases. As it is more beneficial for advertisers to interact with viewers, it is a rational decision for the platform to entice viewers. As a result, demand on the side of advertisers increases, allowing the private platform to achieve higher profits by setting a higher price for the advertisers. This is also supported by the partial derivative of the connection fee of the advertisers with respect to the network effect on their side, which results in

$$\frac{\partial p_{a,p}}{\partial b_a} = \frac{\left(4t_{v,p} - \left(3b_v - b_a\right)\left(b_v + b_a\right)\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} > 0.$$

The above expression is positive due to the $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$ and $b_v < b_a$ conditions, i.e., the greater the benefit to advertisers from interactions with members of the other segment, the higher the price the platform charges them. The private platform can do this as the willingness of the advertiser segment to pay increases as the network effect strengthens.

As the connection fee tailored to viewers decreases, the number of viewers opting for multi-homing will also increase. Examining the boundaries of the interval given in (4.2.25), it can be seen that the location of the last multi-homing viewer is not affected by the growth of b_a, but that of the first one is. For the partial derivative with respect to b_a, it follows that

$$\frac{\partial x_{v,s}}{\partial b_a} = -\frac{4\left(b_v + b_a\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0,$$

i.e. the location of the indifferent viewer, gets closer and closer to the left edge of the section. The same is true on the advertiser side. Deriving the location of the advertiser, which is indifferent between the connection and the absence, with respect to the parameter embodying the network effect at the advertisers, it follows that

$$\frac{\partial x_a}{\partial b_a} = -\frac{\left(\left(b_v + b_a\right)^2 + 4t_{v,p}\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0.$$

Although the platform will increase the price tailored to advertisers, as the number of viewers increases, so will the willingness of advertisers to join as they gain greater utility.

Although the connection fee of viewers will decrease, the profit realized by the platform will increase as the connection fee of the advertisers, as well as the number of viewers and advertisers connected to the platform increases, as a result of the strengthening network effect on the advertiser side. The partial derivative of the profit function given in (4.2.23) with respect to b_a will be as follows:

$$\frac{\partial \pi_p}{\partial b_a} = \frac{2\left(b_a + b_v\right) v_v^2}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} > 0$$

In the case of the surplus realized by viewers and advertisers, the following partial derivative is obtained with respect to the network effect on the advertisers' side:

$$\frac{\partial W}{\partial b_a} = -\frac{\left(b_v + b_a\right)\left(\left(b_v + b_a\right)^2 + 12t_{v,p}\right) v_v^2}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^3} > 0.$$

It was previously assumed that $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$, based on which it can be stated that with the increase of the network effect realized by the advertisers, the surplus realized by the viewers and the advertisers will also increase.

The next case which is needed to look at is what happens when the network effect starts to intensify on the other side, i.e. the viewer side. Deriving the connection fee imposed on viewers with respect to the parameter representing their network benefit (b_v), the expression

$$\frac{\partial p_{v,p}}{\partial b_v} = -\frac{\left(b_a\left(b_v + b_a\right)^2 - 4b_v t_{v,p}\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2}$$

is obtained. Its value is determined by the magnitude of $t_{v,p}$: if

$$t_{v,p} > \frac{b_a\left(b_v + b_a\right)^2}{4b_v},$$

the increase in b_v raises the price tailored to viewers.

If the network benefits realized by viewers change, the change in the price charged to advertisers is shown by the following term:

$$\frac{\partial p_{a,p}}{\partial b_v} = -\frac{\left(\left(b_v - 3b_a\right)\left(b_v + b_a\right) + 4t_{v,p}\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0.$$

It was assumed beforehand, that the $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$ condition holds. Based on this, if the network benefit realized by the viewers increases, the price charged to the advertisers decreases. This is in line with what has been established for changes in viewers' connection fees.

If viewers' utility is increased by the transactions with advertisers, more and more viewers will choose to join the platform, meaning the number of viewers opting for multi-homing will increase. Examining (4.2.25) again, it can be seen that this will affect the location of the first viewer to choose multi-homing as follows:

$$\frac{\partial x_{v,s}}{\partial b_v} = -\frac{4\left(b_v + b_a\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0.$$

Thus, as the network benefit realized on the viewer side increases, the location of the first viewer who opts for multi-homing is getting closer and closer to the left edge of the section. Based on this, the number of viewers connecting to the private platform will increase, which will also increase the willingness of advertisers to connect. If it is examined how the location of the indifferent advertiser is affected by the increase of b_v, the partial derivative will be

$$\frac{\partial x_a}{\partial b_v} = -\frac{\left(\left(b_v + b_a\right)^2 + 4t_{v,p}\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0,$$

i.e. the location of the indifferent advertiser, also gets closer and closer to the left edge of the section.

The profit realized by the private platform as well as the surplus realized by the consumers, similarly to the previous case, will increase here as the network benefit of the viewers increases.[5]

Let us now examine how the increase in transportation cost on the viewer side affects the equilibrium described above. If the transportation cost incurred during the connection to the state-owned company increase, the location of the private platform and the connection fees, the location of the first viewer choosing multi-homing, the location of the indifferent advertiser, and the realized profit of the platform will not change. On the other hand, the location of the state-owned company will be affected. Deriving the location decision of the state-owned company given in (4.2.20) with respect to $t_{v,s}$, it follows that

$$\frac{\partial l_s}{\partial t_{v,s}} = -\frac{v_v}{t_{v,s}^2} < 0.$$

The above expression represents a negative value, i.e. the increase of $t_{v,s}$ shifts the location chosen by the state-owned company to the left. In other words, the state-owned company differentiates its product more, when the transport cost occurring when viewers joining

[5] The profit function of the platform and the objective function of the state-owned enterprise are symmetric for the parameters embodying the network effect, hence their partial derivative is the same.

to it increases.

The number of viewers opting for multi-homing will decrease with increasing transportation cost. Looking more closely at (4.2.25), it can be seen that the location of the viewer who is indifferent between multi-homing and connection to the private platform is influenced by the size of $t_{v,s}$. Derived from the term, it follows that

$$\frac{\partial x_{v,p}}{\partial t_{v,s}} = -\frac{2v_v}{t_{v,s}^2} < 0,$$

i.e. more and more viewers decide to buy only the product of the platform. This is the reason why the profit of the platform is not affected by the size of $t_{v,s}$, as in its case the number of subscribed viewers does not change, there is only a rearrangement with respect to the multi-homing and exclusively connected viewers.

In the case of surpluses realized by viewers and advertisers, the following expression is derived after derivation:

$$\frac{\partial W}{\partial t_{v,s}} = -\frac{v_v^2}{t_{v,s}^2} < 0.$$

Thus, the increase in transportation cost incurred in joining the state-owned company reduces the amount of surplus that can be realized by viewers and advertisers.

If the transportation costs incurred by viewers due to connecting to the private platform increase, the location decision of the state-owned company and the private platform would not change. The partial derivative of the price tailored to viewers with respect to their transportation cost will be

$$\frac{\partial p_{v,p}}{\partial t_{v,p}} = \frac{2\left(b_a^2 - b_v^2\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2}.$$

It can be stated that the effect of the change in transportation cost in terms of the connection fee charged to viewers varies depending on the network effect on viewers. If the network effect on the viewers side is negative and the condition $b_v < -b_a$ holds, then the increase in viewers' transportation costs will reduce the connection fee charged to them. If $-b_a \leq b_v < b_a$, the change in transportation cost increases their connection fee.

The partial derivative of the connection fee set for advertisers with respect to $t_{v,p}$ takes the form of

$$\frac{\partial p_{a,p}}{\partial t_{v,p}} = \frac{4\left(b_v - b_a\right) v_v}{\left(\left(b_v + b_a\right)^2 - 4t_{v,p}\right)^2} < 0.$$

As it was assumed, $b_v < b_a$ should hold which means that an increase in viewers' transportation cost will reduce the price charged to the advertiser side.

On the viewer side, the number of those opting for multi-homing is affected by the increase in transportation cost incurred when connecting to the private platform, according to term (4.2.25). The partial derivative of the location of the first indifferent viewer with respect to $t_{v,p}$ is

$$\frac{\partial x_{v,s}}{\partial t_{v,p}} = \frac{8v_v}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2} > 0.$$

As the $t_{v,p}$ increases, the location of the first indifferent viewer shifts to the right. Based on these, the higher the transportation cost for viewers, the more they decide to buy exclusively the product of the state-owned company. Examining the indifferent advertiser, a similar finding can be made. The derivative of the indifferent advertiser's location with respect to $t_{v,p}$ will be

$$\frac{\partial x_a}{\partial t_{v,p}} = \frac{4\,(b_v + b_a)\,v_v}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2} > 0,$$

i.e. the willingness to enter will also decrease on the advertiser side. The reason behind this is that the decline in the number of viewers reduces the demand of advertisers for the platform, which cannot be completely compensate with the decrease in the connection fee.

As a result of the above, the profit that can be realized by the platform will also decrease. Examining the partial derivative, it follows that

$$\frac{\partial \pi_p}{\partial t_{v,p}} = -\frac{4v_v^2}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2} < 0.$$

At the same time, the change in the surplus realized by consumers is shown by the following expression:

$$\frac{\partial W}{\partial t_{v,p}} = \frac{2\left(3\,(b_v + b_a)^2 + 4t_{v,p}\right)v_v^2}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^3} < 0$$

The numerator is positive, while the denominator is negative due to $(b_v + b_a)^2 - 4t_{v,p} < 0$, so the value of the fraction is negative overall. Based on these, as the transportation cost incurred when connecting to the private platform increases, the surplus that can be realized by consumers will decrease.

The last case to be examined is when the benefit to viewers from owning a product of the public company and/or the private platform, i.e. v_v, increases. Then, deriving the location decision of the state-owned company with respect to the parameter representing the direct benefit, it is found that

$$\frac{\partial l_s}{\partial v_v} = \frac{1}{t_{v,s}} > 0.$$

The value of the derivative is positive, i.e. as the benefit from owning the product of the public company and/or the private platform increases, the location of the state-owned company shifts to the right. So in this case, the state-owned company makes its product less differentiated.

Deriving the connection fee charged to viewers by the private platform with respect to the benefits realized by them, it follows that

$$\frac{\partial p_{v,p}}{\partial v_v} = \frac{b_a\left(b_v + b_a\right) - 2t_{v,p}}{\left(b_v + b_a\right)^2 - 4t_{v,p}}.$$

Since it was previously assumed that $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$, the denominator is negative. The value of the above expression is positive if the condition $t_{v,p} > \frac{b_a(b_v+b_a)}{2}$ holds. That is, if the transport cost occurring when viewers join the private platform is negligible, the fee charged to viewers decreases as the benefits of owning the product increase. While if the transportation cost is high, the platform will increase the price charged to them. As viewers value the platform's product more and more, they are more and more willing to pay for it so it is a rational decision for the platform to increase the price charged to them.

The partial derivative of the price tailored to advertisers with respect to v_v will be

$$\frac{\partial p_{a,p}}{\partial v_v} = \frac{b_v - b_a}{\left(b_v + b_a\right)^2 - 4t_{v,p}} > 0.$$

Based on the conditions $b_v < b_a$ and $\left(b_v + b_a\right)^2 - 4t_{v,p} < 0$, the above expression will be positive, i.e. the more viewers value the platform's product, the higher the price the platform sets for advertisers. This is because as more and more viewers join the platform, advertisers will be more willing to enter and pay a higher price.

Following the above line of reasoning, the location of the viewers is examined who choose multi-homing and the indifferent member of the advertiser side. Deriving (4.2.25) with respect to v_v results in

$$\frac{\partial x_{v,s}}{\partial v_v} = \frac{2}{\left(b_v + b_a\right)^2 - 4t_{v,p}} < 0$$

and

$$\frac{\partial x_{v,p}}{\partial v_v} = \frac{2}{t_{v,s}} > 0,$$

while deriving (4.2.26) will be

$$\frac{\partial x_a}{\partial v_v} = \frac{b_v + b_a}{(b_v + b_a)^2 - 4t_{v,p}} < 0.$$

That is, the number of viewers opting for multi-homing will indeed increase, as the location of the first viewer who buys the products of both companies will be closer to the left edge of the section, while the last one will be closer to the right edge. And the location of the advertiser that is indifferent to joining and staying away is getting closer and closer to the left edge of the section, meaning more and more advertisers will be present on the platform.

The partial derivative of the platform's realized profit with respect to v_v is as follows:

$$\frac{\partial \pi_p}{\partial v_v} = -\frac{2v_v}{(b_v + b_a)^2 - 4t_{v,p}} > 0.$$

As viewers value the platform's product more and more, more people are choosing to join, causing more advertisers to enter the platform. In addition, the platform will have the opportunity to charge a higher price to advertisers – and in some cases to viewers – so that its realizable profit will increase.

The realizable surplus of viewers and advertisers is affected by the increase in v_v as follows:

$$\frac{\partial W}{\partial v_v} = \left(\frac{2}{t_{v,s}} + \frac{(b_v + b_a)^2 + 4t_{v,p}}{\left((b_v + b_a)^2 - 4t_{v,p}\right)^2}\right) v_v > 0.$$

That is, if viewers value the product of the state-owned company and/or the platform more and more, the surplus realized by them and by the advertisers will increase.

Table 4.1: Comparative statistics – Summary table

	$\mathbf{l_s}$	$\mathbf{p_{v,p}}$	$\mathbf{p_{a,p}}$	$\mathbf{x_{v,s}}$	$\mathbf{x_{v,p}}$	$\mathbf{x_a}$	π	**W**
$\mathbf{b_a}$	0	-	+	-	0	-	+	+
$\mathbf{b_v}$	0	+ (low $t_{v,p}$) - (high $t_{v,p}$)	-	-	0	-	+	+
$\mathbf{t_{v,s}}$	-	0	0	0	-	0	0	-
$\mathbf{t_{v,p}}$	0	- ($-1<b_v<-b_a$) + ($-b_a<b_v<b_a$)	-	+	0	+	-	-
$\mathbf{v_v}$	+	+ (high $t_{v,p}$) - (low $t_{v,p}$)	+	-	+	-	+	+

4.2.2 Summary

In this chapter, a model was presented where a private platform competed for viewers with a public company. The justification for the model is given by the efforts in the European Union to ensure that public service broadcasters do not cover their operations from the proceeds of advertising. This intervention was analyzed by González-Maestre and Martínez-Sánchez (2015) in a "zero" duopolistic model framework, where the state set the level of advertising at zero. However, this has excluded the advertiser side from that platform. And if the advertisers do not have access to the product or service of the state-owned company, the state-owned company will cease to be a platform but it will continue to compete with a private platform in that market.

Therefore, the question of how competition between the two service providers affects their pricing and their decision to differentiate their products was examined. That is, what effect does it have if the public platform ceases to exist and continues to compete as a public company with a privately-owned platform. The product differentiation was captured in the usual way in the literature, by determining the location.

The conclusion was reached that the location decision of either service provider is not influenced by the location chosen by the other: that is, their decision to differentiate the product is not influenced by the competitor's decision. Because advertisers can only interact with viewers on the platform, in their case, the company sets a positive price because it has a monopolistic power over the viewers that join it. On the other hand, it imposes a low price on viewers in order to attract as many of them as possible and thus increase its ability to generate profit on the other side's players. The stronger the network effect viewers generate on the advertiser side, the lower the price they have to pay to join. These results are in line with the literature on two-sided markets. Furthermore, it was illustrated that although product differentiation is not affected by competition between the two companies on the viewer side, it does reduce the price charged to viewers.

Overall, therefore, with the abolition of the state platform, the strategy of regulation of entry loses its strength in two-sided markets. So, if the state wants to take action against a private platform to represent the interests of consumers, it either uses other tools of regulation (taxation, price regulation, competition law) or creates a public platform in the given market that forces the private company to compete.

Summary

In the dissertation, the research focused on issues related to two-sided markets, which have not yet been examined in the literature or in a form different from that presented here.

In the chapter on product differentiation (Chapter 2), the question was examined of how the price of a platform's product or service is affected by the fact that it provides consumers with the opportunity to consume it to a limited or fully personalized extent. The hypothesis was that the more a product can be customized, the lower will be the transportation cost on the consumer side and the higher will be the price the platform will charge for it. The results supported this hypothesis, as in equilibrium, the platforms charged a positive price for full customization, while when product differentiation was limited, they provided it for free. This conclusion is supported by several practical examples. The free and paid versions of anti-virus software were mentioned in the dissertation as an example. The above result is also interesting because, in the case of traditional markets, the literature has shown just the opposite: there, companies are encouraged to reduce the differentiation of their products. Thus, it has been shown that in the case of two-sided markets, it is not necessarily a concern that a platform has a large market share in one segment. If it has to compete for subscribers on the other side, this competition will automatically spread to the other consumer group, and if not in terms of prices, but in other dimensions, the effect can be traced.

In the model for analyzing public and private contracts, discussed in Chapter 3, the incentives of platforms were examined to use public and private contract and the impact of contracts on pricing. In addition to public contracts, platforms and consumers preferred sellers to be present on both platforms. It has been shown that in addition to the use of private contracts, in the case of duopolistic platforms, platforms change their pricing strategy on the sellers' side and set a positive franchise fee for the previously subsidized segment. This is in accordance with the literature. However, on the consumers' side, the platforms do not offer subsidies, they continue to set a positive subscription fee. Comparing the two relevant models, it was highlighted that platforms are typically encouraged to use public contracts. Although there are many examples of private contracts in practice, it was argued that this is much more for the purpose of product differentiation and increasing market power. Public contracts are designed by platforms in such a way as to attract as many sellers as possible, as this is the only way they can reap the benefits of the network effect in the market. On the consumer side, on the other hand, the type of network effect, the size of the transportation cost, and the relationship between the products manufactured on the platforms determined which type of contract can generate the largest surplus for them.

Finally, in the last chapter, the impact on pricing and product differentiation of the endeavor in the European Union was examined which aims to ban advertising funding from public service broadcasters. It was argued that this will reclassify the state platform as a state-owned company as the advertiser side will be banned from entering. The results revealed that none of the service providers' product differentiation decisions are influenced by the competitor's decision. Because advertisers can only interact with viewers on the platform, and the platform has the opportunity to charge them a high price, due to its monopoly over the viewer side. On the viewer side, on the other hand, it is forced to set a low price to exploit the network effect on the market, and as a result of a competitor providing free services. Overall, however, it has been shown that if one side is banned from a state platform, the state must resort to other tools of regulation to protect the interests of consumers.

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Appendix

Subsection 3.3.3: Comparison of public contract models

Figure 4.2.3: Evolution of platforms' profit as a function of the network effect and the travel cost for complementary products

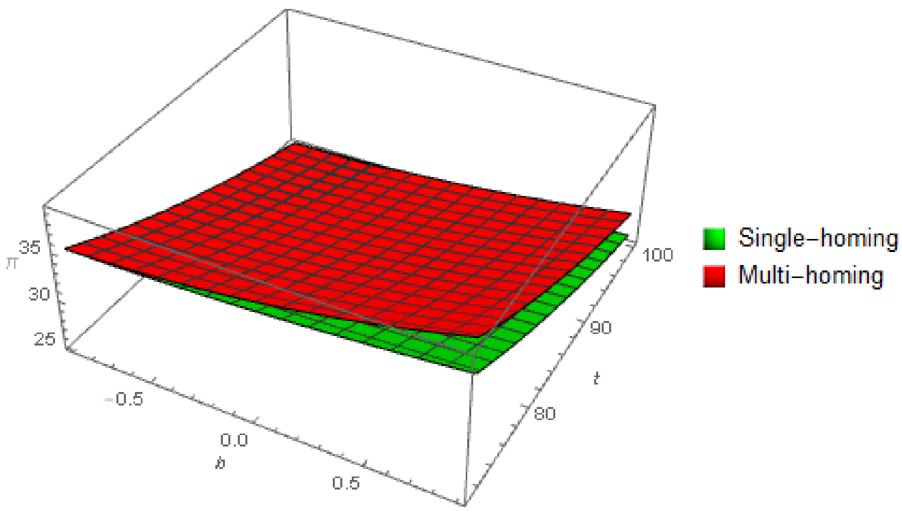


Figure 4.2.4: Evolution of platforms' profit as a function of the network effect and the travel cost for independent products

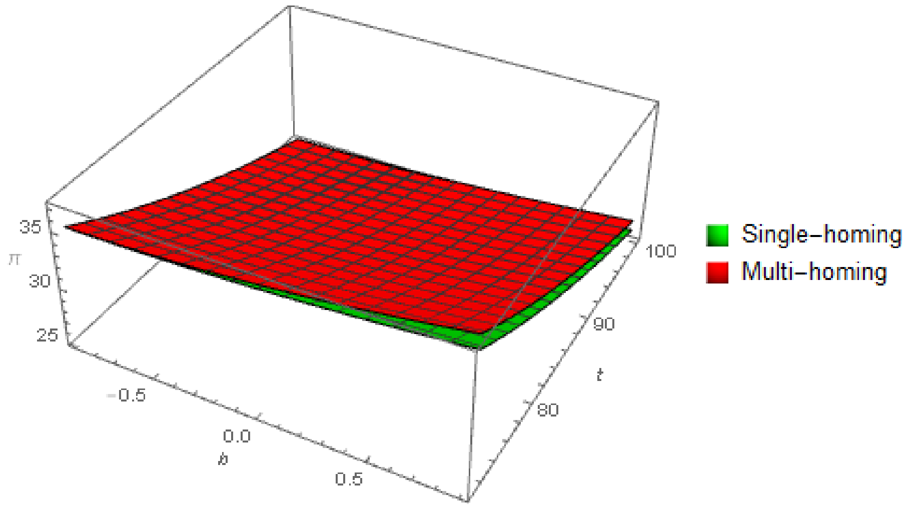


Figure 4.2.5: Evolution of platforms' profit as a function of the network effect and the travel cost for substitute products

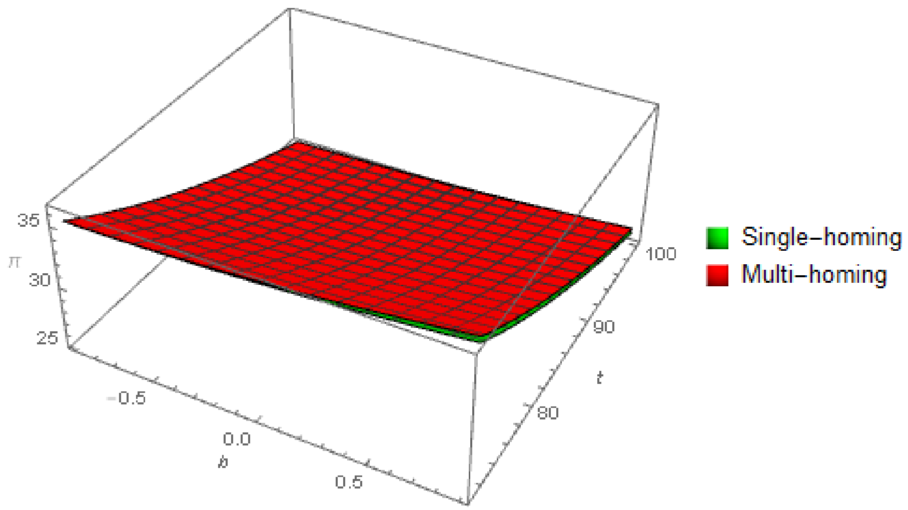


Figure 4.2.6: Evolution of consumer surplus as a function of the network effect and the travel cost for complementary products

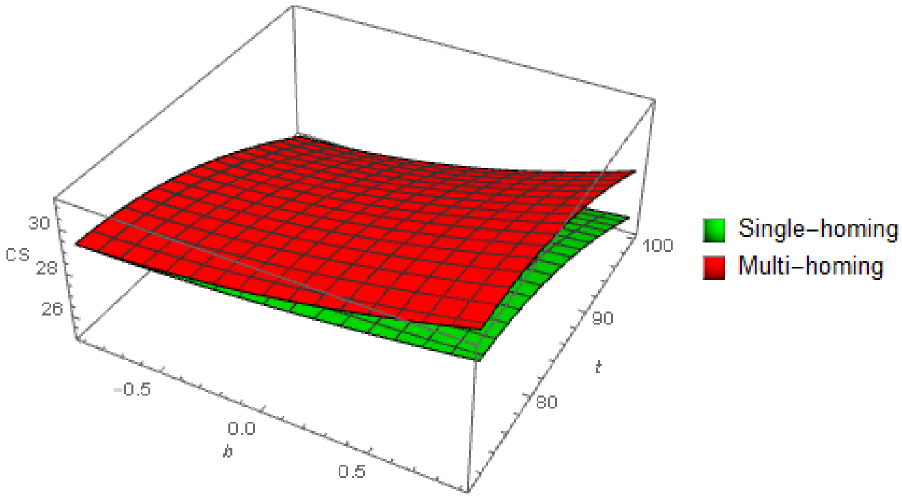


Figure 4.2.7: Evolution of consumer surplus as a function of the network effect and the travel cost for independent products

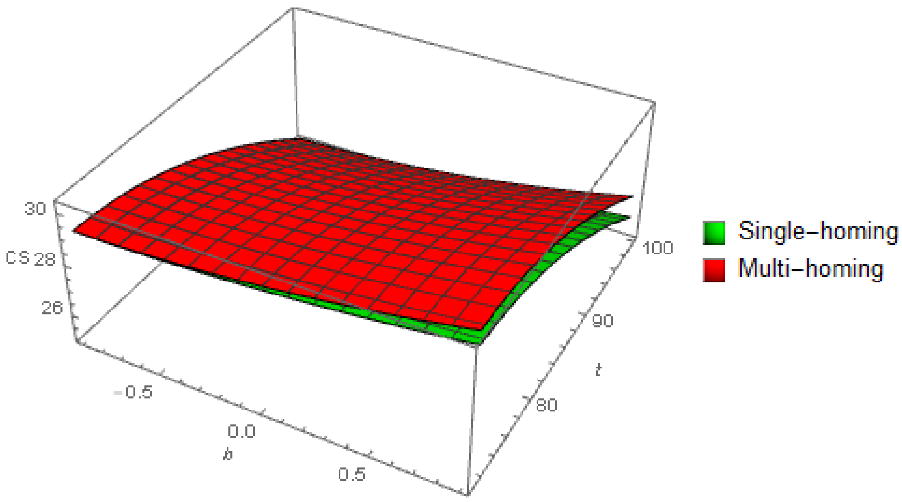
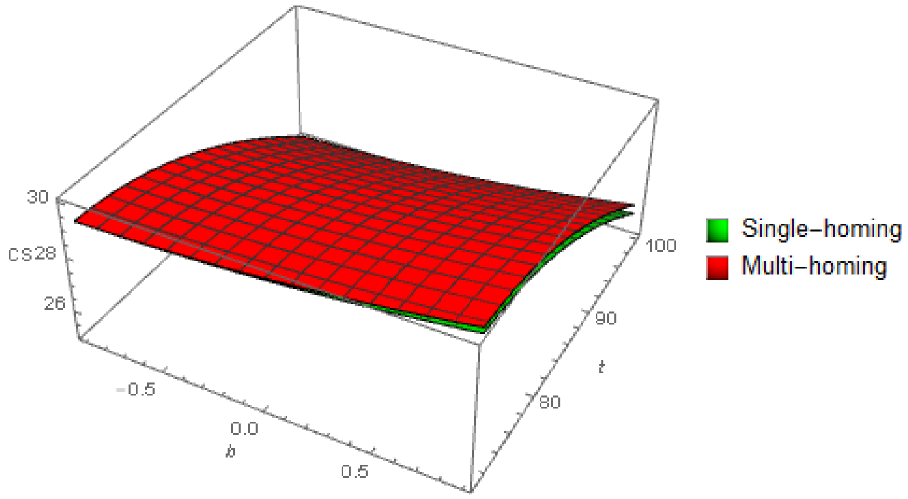


Figure 4.2.8: Evolution of consumer surplus as a function of the network effect and the travel cost for substitute products



Section 3.5: Comparison of public and private contract models

Figure 4.2.9: Evolution of the demand for platform-specific products as a function of the network effect for complementary products

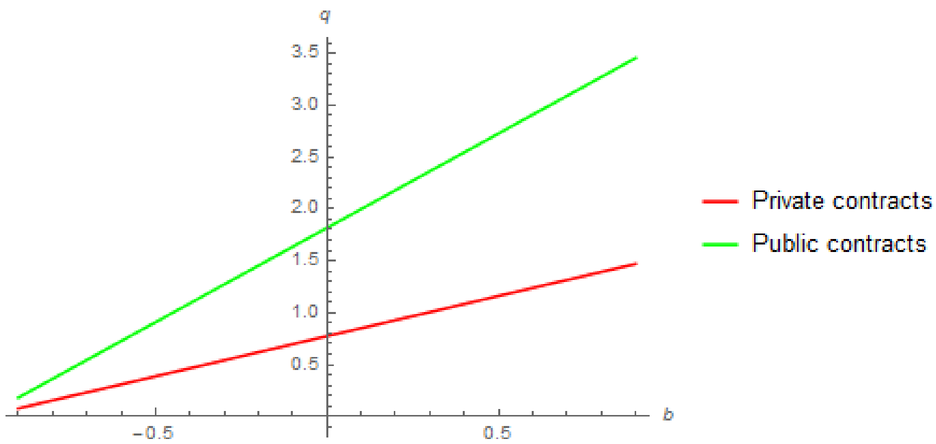


Figure 4.2.10: Evolution of the demand for platform-specific products as a function of the network effect for independent products

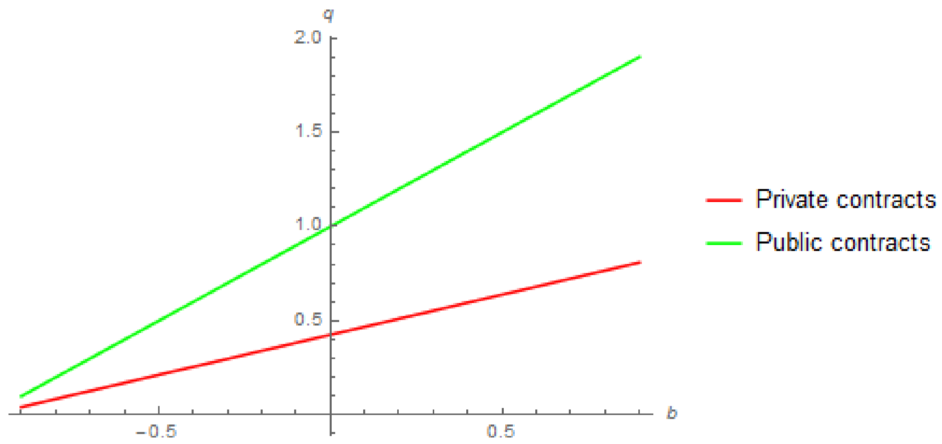


Figure 4.2.11: Evolution of the demand for platform-specific products as a function of the network effect for substitute products

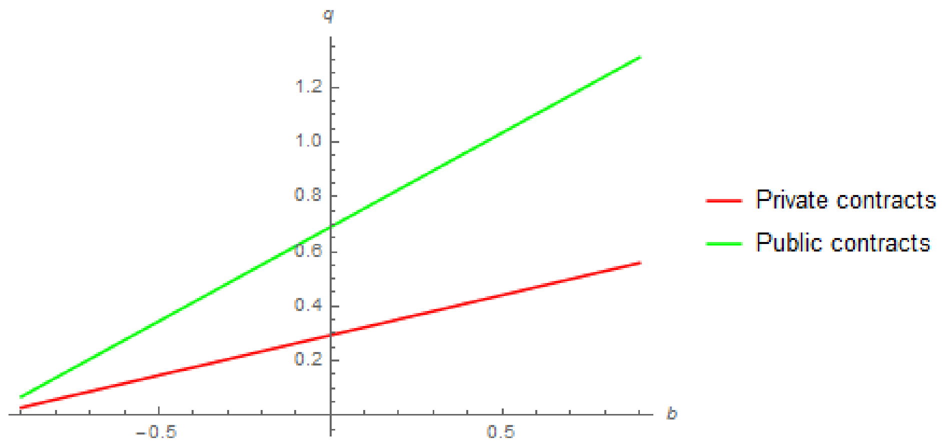


Figure 4.2.12: Evolution of the subscription fee as a function of the network effect for complementary products

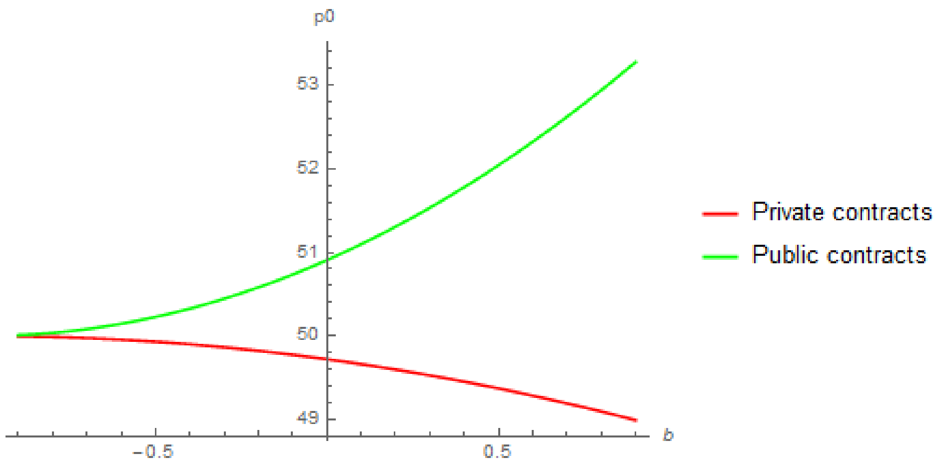


Figure 4.2.13: Evolution of the subscription fee as a function of the network effect for independent products

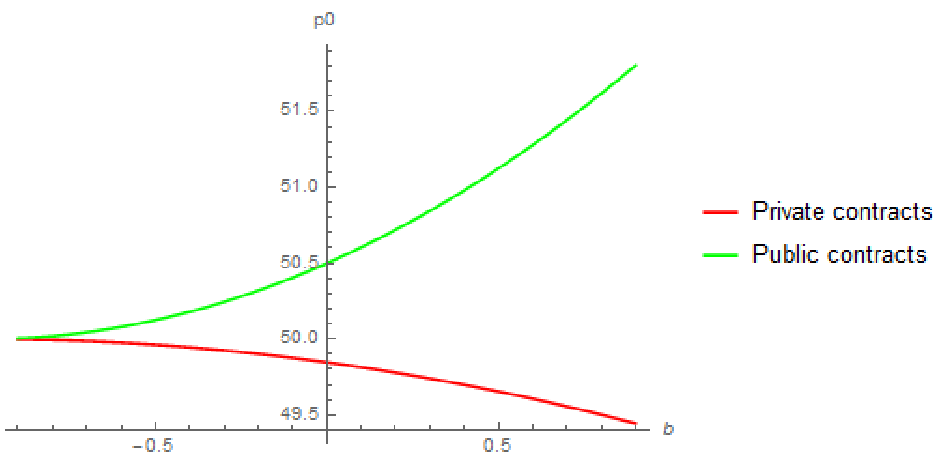


Figure 4.2.14: Evolution of the subscription fee as a function of the network effect for substitute products

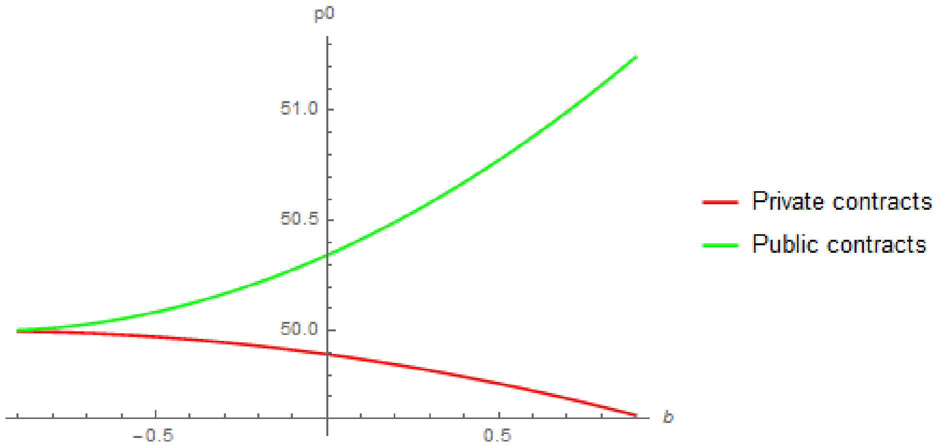


Figure 4.2.15: Evolution of platforms' profit as a function of the network effect and the travel cost for complementary products

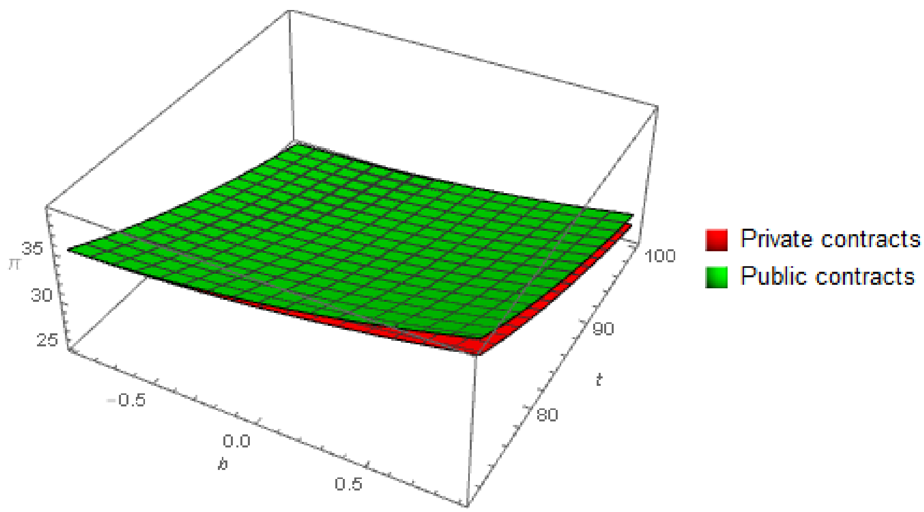


Figure 4.2.16: Evolution of platforms' profit as a function of the network effect and the travel cost for independent products

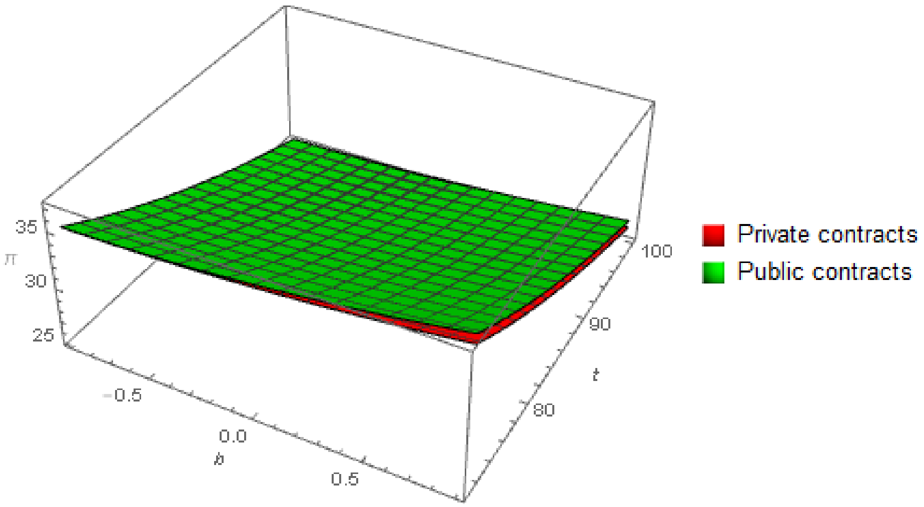


Figure 4.2.17: Evolution of platforms' profit as a function of the network effect and the travel cost for substitute products

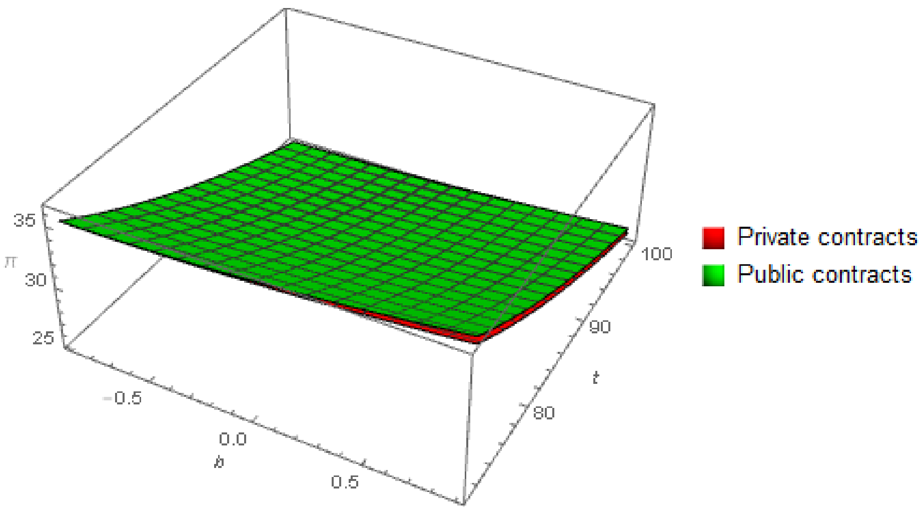


Figure 4.2.18: Evolution of consumer surplus as a function of the network effect and the travel cost for complementary products

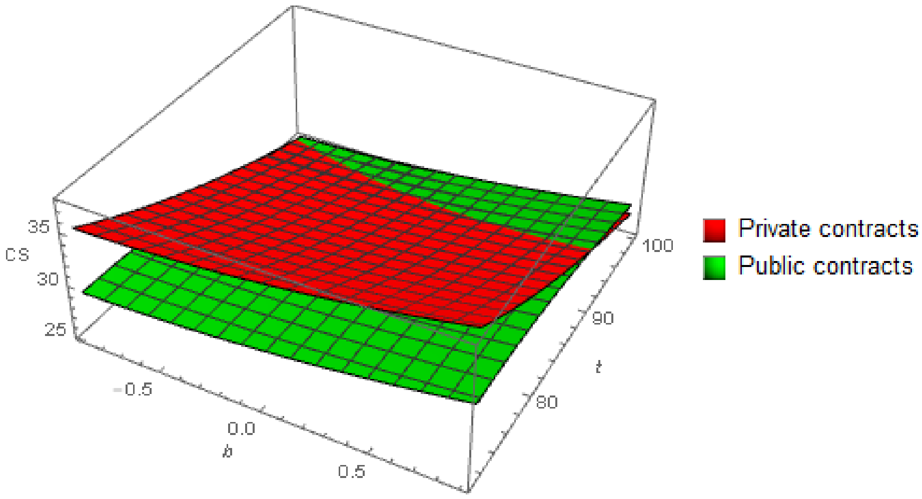


Figure 4.2.19: Evolution of consumer surplus as a function of the network effect and the travel cost for independent products

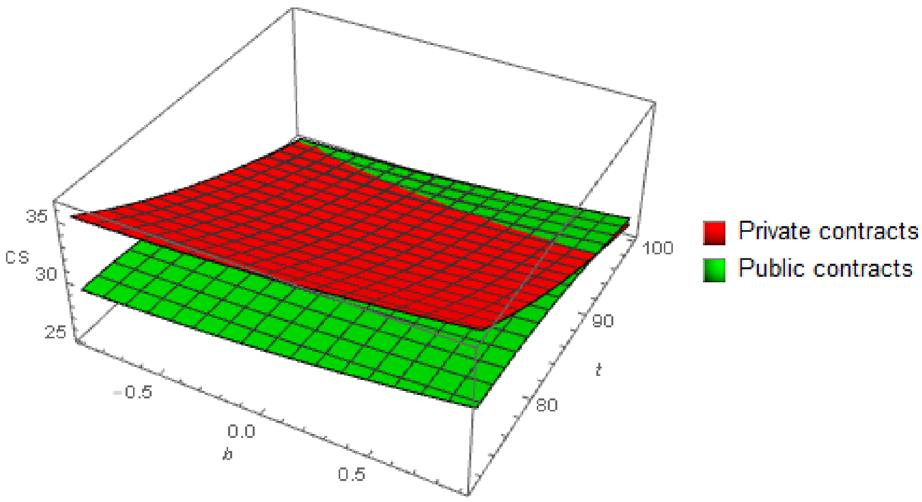


Figure 4.2.20: Evolution of consumer surplus as a function of the network effect and the travel cost for substitute products