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COMPETITION IN TWO-SIDED MARKETS: A MODEL WITH VALUE CREATION

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Biographical Note

Pedro holds a Bachelor's Degree in Management with honours from University of Coimbra. Afterwards, he enrolled in the Master in Economics – English Track in the University of Porto. In the second year of his Master, meanwhile developing the present dissertation, he spent the first semester in Rome at the University LUISS Guido Carli under the Erasmus+ agreement. Throughout the second semester, he spent 3 months in Vigo, working as a Trainee at Groupe PSA before moving to Madrid, where he currently works as a Client Operation Intern at Nextail Labs.

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Abstract

The platform's business model has emerged in the last years, exploiting the functionalities of internet and high-tech. This business model is based on two or multi-sided platforms in which the value to one or more groups of agents arises from the number of agents on the other side. We have seen the high rise of big firms such as Google, Amazon and Facebook. These represent a huge network of different types of agents, connecting them with different offers.

In this dissertation we propose an extension to the model of Armstrong & Wright (2007) that lies on the possibility for both firms to have an intrinsic value different from one another. We aimed at understanding the economic impact that a platform's decision to exogenously increase its stand-alone value has on prices. In particular, to estimate if a deviation on the stand-alone value offered by one platform to one side, affects not only the price offered by the same platform to the other side, but also the prices offered by a competitor. We have tested it in two cases: when there is strong product differentiation on both sides without multihoming and afterwards a second case that allows for multihoming.

The results show that, for case one, increasing the stand-alone value to a group of agents will directly deviate the price that the platform charges to those agents, considering symmetric network effects and symmetric transportation costs. On the other hand, for the multihoming case, applying the same strategy leads to an increase in the price offered to the group of agents in the other side.

JEL codes: D43, L11, L13

Keywords: Two-sided Markets, Value Creation

Resumo

O modelo de negócios de uma plataforma emergiu nos últimos anos, explorando as funcionalidades da internet e da alta tecnologia. Este modelo de negócio é caracterizado por mercados bi ou multi laterais nos quais o valor para um ou mais grupos de agentes depende do número de agentes do outro lado. Temos assistido ao surgimento de grandes empresas deste género como Google, Amazon e Facebook. Estas têm uma enorme rede de diferentes tipos de agentes, conectando-os com diferentes propósitos.

Nesta dissertação propomos uma extensão ao modelo de Armstrong & Wright (2007) onde nos baseamos na possibilidade de ambas as plataformas terem um valor intrínseco diferente entre si. O nosso objetivo é entender o impacto económico que a decisão por parte de uma plataforma de aumentar exogenamente o seu valor intrínseco tem sobre os preços desse mercado. Em particular, para estimar, se um aumento no valor intrínseco oferecido por uma plataforma num lado do mercado, afeta não só, o preço oferecido pela mesma plataforma no outro lado do mercado, mas também os preços oferecidos pela plataforma rival. Para isso, testámos dois casos no modelo: quando há forte diferenciação de produto em ambos os lados, sem multihoming, e um segundo caso no qual se permite multihoming.

Os resultados mostram que, para o primeiro caso, aumentar o valor intrínseco para um grupo de agentes, aumenta diretamente o preço que a plataforma cobra para os mesmos agentes, considerando efeitos de rede simétricos e custos de transporte simétricos. No entanto, para o caso multihoming, aplicando a mesma estratégia leva a um aumento no preço oferecido ao grupo de agentes no outro lado.

Classificação JEL: D43, L11, L13

Palavras-Chave: Mercados Bilaterais, Criação de Valor

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1. Introduction

To a great extent, the interest in two and multi-sided markets in the recent years can be explained by the phenomena of some High-Tech firms such as Facebook, Google or Amazon. When we take a closer look at them and at their industry, we can see that Google has revolutionized the way people access information, Amazon is reshaping the way we buy things online and Facebook has revolutionised the way people connect all around the world. These are just three of the most important protagonists of this new economy. These firms acquired, through a fast growth, a dominant position by providing services to more than one group of customers, collecting benefits from network effects among different groups of participants in their online platforms. Indeed, very often, the business model patronized by these firms is based on two or multi-sided platforms in which the value of the platform to one (or more) group of customers depends on the number of customers on the other side. Because these firms provide a global-scale product/services, their businesses tend to grow tremendously (and fast). Online platform such as the ones mentioned above have benefited on the revenues leverage which only internet allows. As a consequence, they have a global demand taking advantage of holding an online business that is accessible to everyone.

High-Tech markets are also characterised as a rapid changing industry. Due to the use of the most recent technology, the great investment in research and development by these firms has made the industry one of the most competitive ones. Among High-Tech firms, we have seen the rising of the so-called "platform's business model". Digital platforms connect different types of consumers. The three firms mentioned in the beginning are platforms. In a simplistic way, we can describe Amazon as a platform that unites buyers seeking for products and the sellers of those products. Analogously, Facebook closes the gap between people all over the world. Furthermore, it uses its huge network of users as a place to sell advertising spots and collect (Big) Data about the characteristics of its users.

In the national context, we can highlight Farfetch, the first Portuguese start-up to acquire the status of "unicorn", worth more than one billion dollars. Farfetch is an e-commerce platform that places together the most luxury brands and fashionable boutiques worldwide. So, in a common website and also mobile app, this platform unites luxury consumers with these two sides of agents.

The Literature usually describes this type of agent as a two or multi-sided platform, depending on how many different types of agents use the platform; either two or more. In the present work, we are focusing our study on two-sided markets. In particular, we study market outcomes when two competing platforms allow for the interaction between a group of sellers and a group of buyers. The platforms affiliate users of the two sides, making them different from intermediaries who resell a product to the final consumer. Another important feature of our set-up lies on the existence of cross-network effects, which are a prevalent feature of the Digital Age. Network effects arise when the value of a good or service depends, not only on its intrinsic features, but also on its network of adopters. We may have simple network effects (arising in the same-side of the market, meaning that extra agents increase the value of the network) or cross-side network effects, when an additional agent in one side generates value to the other side, such as the Farfetch case, in which adding more luxury consumers increases the expected benefits of the luxury retailers participating in the platform.

At the present moment, there are so many digital platforms and businesses emerging online, that creating a unique value for customers is a crucial strategy to catch their attention, to maintain their loyalty to the platform and to boost the network benefits generated by the platform (which is a necessary condition to prevail in a worldwide market). Because it is so important to have many active users, who access and interact with the platform, there is an urge to offer the best possible experience to the user.

Having this in mind, the main focus of this dissertation lies on the investigation of how platforms' optimal pricing is affected by their (and the rival's) intrinsic value (often referred to as the stand-alone value that platforms create to their users).

The research question relates to the study of platforms' strategies to differentiate itself from the competition (either building a competitive advantage by offering a higher quality product or a lower price than its competitors). What is the key factor making platforms users perceive more utility from one platform than from the rest? Moreover, even though most platforms are free, in some cases, agents still singlehome one platform. Hence, it is important to evaluate how the answers to the previous questions change if we allow agents to be affiliated with several platforms (multihome) or not.

In order to answer these questions, the present works builds on a Game Theory analytical methodology. More specifically, it presents an extension to the model of Armstrong & Wright (2007), with two horizontally differentiated firms (*à la* Hotelling) and two types of agents. The choice of the base model is due to its simplicity and well-structured framework, in terms of modelling not only the consumers' utility, but also in what concerns the network effects (in this case, cross-side network effects).

In this setting, agents' utility functions capture the fact that part from the benefits of belonging to the network of a given platform, there are other positive benefits associated with the platform's intrinsic or stand-alone value. We extend their analysis by allowing for asymmetries on the platforms' intrinsic value variable (for each group of users). Hereby, our analysis aims at understanding the economic implication when a platform decides to exogenously increase its stand-alone value. In particular, as we allow for asymmetric stand-alone valuations, it becomes relevant to estimate if a deviation on the stand-alone value offered by one platform to one side, affects not only the price offered by the same platform to the other side, but also the prices offered by a competitor.

This dissertation is divided in two main parts: the literature review and the theoretical model. As far as concerns the overview of the literature, this work enriches two research lines: the first corresponding to the two-sided markets literature (see sub-section 2.1.) and the second corresponding to the literature on value creation (see sub-section 2.2.). In each of these subsections, we cover all the important concepts and insights, we provide a resume of the seminal contributions to the field and compare different conclusions amongst the most relevant studies. This chapter helps us to better understand the field and to put in context our study.

The second part of the thesis contains the model, divided in two different cases: in the first, we focus on strong product differentiation without multihoming, whereas for the second case, we introduce multihoming as a possibility for agents. In the first case (see section 3.1.), agents can only get affiliated with one platform, whereas in the second case (see section 3.2.) they can subscribe both, therefore they can maximize their utility by staying in a single platform or by getting affiliated with both. In the end, we compare the results of both cases (see section 3.3.). The multihoming case will shed some light on the effects of asymmetric stand-alone values within a different market with less strategic interaction since agents can subscribe both platforms. For each model, we will assess which type of agents will be positively or negatively affected by the decision of one firm increasing its stand-alone value. Hence, this study enriches the two-sided markets literature by highlighting the price and competitive effects of asymmetries in platforms' stand-alone value. This allows us to shed some light on the theoretical benefits of investing in value creation strategies in digital markets.[1]

[1] Esta Dissertação foi orientada no âmbito do projecto NORTE-01-0145-FEDER-028540, cofinanciado pelo Programa Operacional Regional do Norte (NORTE 2020), através do Portugal 2020 e do Fundo Europeu de Desenvolvimento Regional (FEDER) e por fundos nacionais através da FCT – Fundação para a Ciência e a Tecnologia.

2. Literature Review

This chapter contains two parts: first, in sub-section 2.1. we explore the two-sided markets literature; second, in sub-section 2.2. we investigate the literature on value creation. The aim is to cover the most important concepts and contribution to the two main topics of this dissertation.

2.1. Two-sided Markets

A classical definition of a two-sided market is that of Armstrong & Wright (2007) *"Two-sided markets involve two distinct groups of agents, each of whom obtains value from interacting with agents from the other group. In these markets, platforms deal with the two groups in a way that allows them to influence the extent to which cross-group externalities are enjoyed."* More recently, Hagiu & Wright (2015) proposes a definition which goes down to the most fundamental features about this type of markets: "*they enable direct interactions between two or more distinct sides*" and "*each side is affiliated with the platform*". Moreover, it is also important to distinguish a two-sided market from pure conventional intermediation. Hagiu (2007) states that *"pure two-sided platforms leave that control entirely to sellers and simply determine buyer and seller affiliation with a common market place."* Differently, intermediaries, also called "*merchants*" by the author, acquire the good from the seller so that they can sell it to the final consumer.

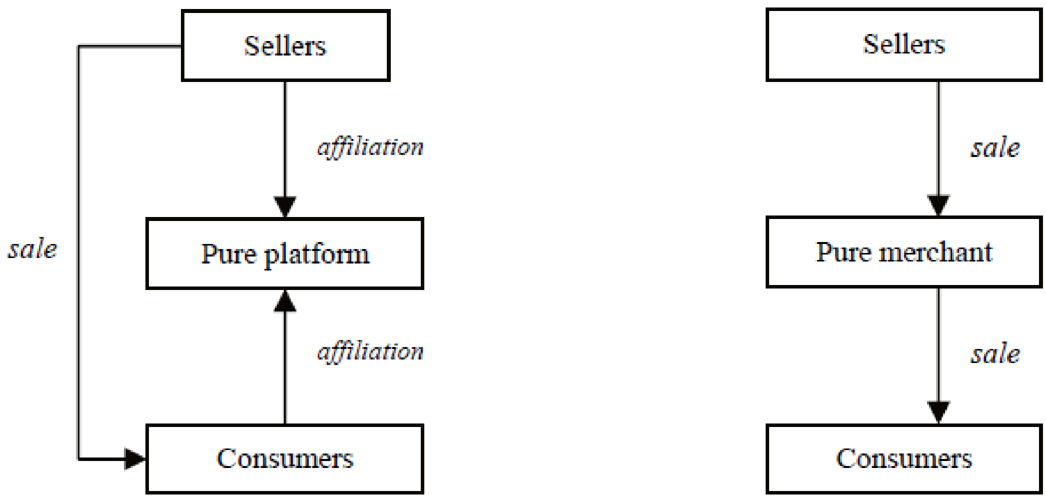

Figure 1. Distinction between a pure platform and a pure merchant by Hagiu (2007)

In Figure 1, we can see the schematic difference between what is a platform and a merchant or intermediary. A platform connects with a relationship of affiliation with both sellers and consumers, whereas a merchant does not connect them, it has an independent relationship with each one.

Some of the seminal models on this literature are those of Rochet & Tirole (2003), Caillaud & Jullien (2003) and Armstrong (2006) which are very relevant references in the literature, contributing to lay down the foundations of the two-sided market theory.

Different authors have tried to test the specificities of two-sided markets, by analysing the role of product differentiation (Armstrong & Wright (2007)) the network externalities (Economides (1996)), the pricing (Weyl (2010) and Hagiu (2009)), the role of exclusive content (Ishihara & Oki (2017)) and also why these platforms have incentives to divert consumers' search (Hagiu & Jullien (2011)).

In respect to modelling two-sided markets, the first seminal contribution comes from Rochet & Tirole (2003) that developed a model of competition between platforms in a two-sided market that shows both the determinants of price allocation and consumers' surplus. The question on price allocation is crucial in two-sided markets. These are very often characterized by an asymmetric price structure in which one side is charged less than the other. More specifically, the authors analyse the way in which platform governance, users' cost of multihoming, platforms' differentiation, platforms' ability to use volume-based pricing, the presence of same-side externalities and platform compatibility affect the price allocation between the two sides of the market. The research concludes that the volume of transactions and profits are determined by the price and its decomposition. The objective of the platform is to maximize transactions and the total price it gets from them. So, given the cross-network externalities, in this type of markets it tends to exist effective cross-subsidization between the end users of different categories. Nonetheless, Rochet & Tirole (2003) identify two possible reasons that may avoid platforms from accomplish cross-subsidization. First, we have the case when both sides of the market may coordinate their negotiation; one of the examples given by the paper is that of *"an Intranet operator offering an Intranet solution to a company"*. Second, the possibility of pass-through and neutrality behaviour that can be caused if agents from both sides have monetary transfers that may cancel the redistributive impact and avoid the occurrence of cross-subsidization.[2]

Having in mind the intermediation services via internet, Caillaud & Jullien (2003) present a model of (imperfect) competition with indirect network externalities between two matchmakers, designed into a Bertrand game. The results show that consumers experience the highest level of welfare under exclusive services. On the other hand, exclusivity means low profits for intermediators. The quality of technology might play a role on exclusivity. If it is really high quality, exclusivity can be a good strategy, otherwise the equilibrium tells matchmakers to allow users for multiple registration with rivals. So, users end up using more than one intermediary strengthening intermediation profits and moderating price competition. The authors also describe how the chicken-and-egg problem may be generated by indirect externalities for intermediaries. This comes from the fact that, in order to have a large number of buyers, intermediaries should have a large number of sellers, which will only be available to join if the first condition is noticed and vice-versa. The authors suggest that intermediaries "*have incentives to propose non-exclusive services, as this moderates competition and allows them to exert market power."* In this context, it is important to mention the "divide and conquer" strategy which is used by intermediaries when they have to face competition with homogeneous intermediaries. Belleflamme & Peitz (2010) show that if all agents register themselves in one intermediary, the other intermediary can opt for a "divide and conquer" strategy. The first part is "divide", meaning that it has to subsidize one group (usually buyers) in order to convince them to join. Then it has to "conquer" the sellers. The game of Belleflamme & Peitz (2010) ends with only one intermediary acting in the market, among homogeneous intermediaries competing in membership and transaction fees, dominating the market but making no profit.

Armstrong (2006) builds a general model of two-sided markets. This model analyses the case for a monopoly platform, for competing platforms with singlehoming and for "competing bottlenecks" in which one group has the desire to multihome by joining all platforms. From the equilibria found, we can see that prices are effected by three main reasons: the relevance of cross-group externalities is crucial since the two group might affect

[2] So, neutrality reduce the mechanisms of platforms to generate cross-subsidization. For example, we can look at the value-added tax. The price will be adjusted in a way that makes consumer pay the seller's tax. Furthermore, there are three reasons to justify neutrality: the transaction costs between sides, the volume-insensitive costs and Platform-determined constraints on pass-through.

each other in different ways with different impacts, for example if men value more interacting with women, then the nightclub has incentives to lower fees for women, leading to more men and women in the night club; the fixed fees or per-transaction charges lessen network effects; whether users single or multihome platforms.

We have learned with the previous models that it is only possible to talk about two-sided markets in the presence of network effects. Therefore, the agents' utility depends on the characteristics of the network. A seminal work on network externalities, a fundamental aspect of two-sided markets, is that of Katz & Shapiro (1985). Their model shows how important consumers' expectations are for markets with network externalities. These expectations of consumers arise towards the size of competing networks, before competition takes place in the market. They do not explain how expectations are formed, instead they assume that consumers' expectations are self-fulfilled in a situation of Nash equilibrium. Consumers are also expected to have similar expectations. Using a static model of oligopoly, the authors test two scenarios in which consumers make their expectancy before, in the first scenario, and after, in the second, the firm decides its output. In the end, firms can only control the network size in the second scenario, because consumers will perceive the network size as having the same size as the output yield by the firm. Contrarily, in the first scenario, consumers' expectations are already made before seeing the firms' output, therefore firms cannot control the network size. Some years later, Economides (1996) presented an important contribution to the study on network externalities which explores the sources and resources of positive network externalities, in terms of consumption and production. According to the author, "*many important non-network industries share many essential economic features with network industries*". Network externalities are a consequence of the complementarity between the components. Therefore, industries in which vertical relations are crucial can learn with the lessons of markets with network effects. For example, in financial markets, an increase on the participation of traders increase the expected utility of all participants.

As we can notice, the simple network externalities studied in the previous two papers, take place when utility depends, not only on the intrinsic value that the agent will get, but also on how many other agents are part of it, sharing the same experience. On the other hand, for different situations it is more relevant to talk about cross-network externalities. More properly, when agents belong to distinct categories. They value the intrinsic value of the good/service for its intrinsic characteristics, but their utility depends also on the amount of agents from the other category sharing this activity (see Amir *et al.* (2014)). The authors illustrate this using thematic clubs. In the first case, both men and women (the agents from each category) get utility from simple-network externalities though the thematic club' specific activities. The cross-network externalities emerge for men or women when they merely value social interaction with the opposite sex.

Hagiu & Wright (2015) model focus on the strategic choice of the business model, either multi-sided platforms or vertical integration, which is a model of pure intermediation. Having this in mind, the design of this model tries to emphasize a crucial trade-off between the benefits of coordination under vertical integration when there are *spillovers* across the decisions of individual professionals/employees and the benefits of individual demand on multi-sided platforms. The authors take Amazon as an example of a firm that was a retailer in its beginnings, moving gradually to mix of marketplace, with the characteristics of a two-sided market, with reselling. Under these circumstances, the authors conclude that firms can make better decisions due to private information.[3] Hagiu & Wright (2015) also contribute by stating that affiliation is not enough to create a multi-sided platform, as we can see from Figure 2. By affiliation the authors refer to the conscious decision of users from each side to invest specifically on this platform so that they have permission to interact with each other. We should also consider that these platforms enable direct interactions between two or more distinct sides. So, differently to vertically integrated firms, platforms allow agents to have controlled interactions between the parts, additionally to the direct interactions between the firm and its customers.

[3] An example of private information is when a professional knows better how much advertising in its services expands its client pool.

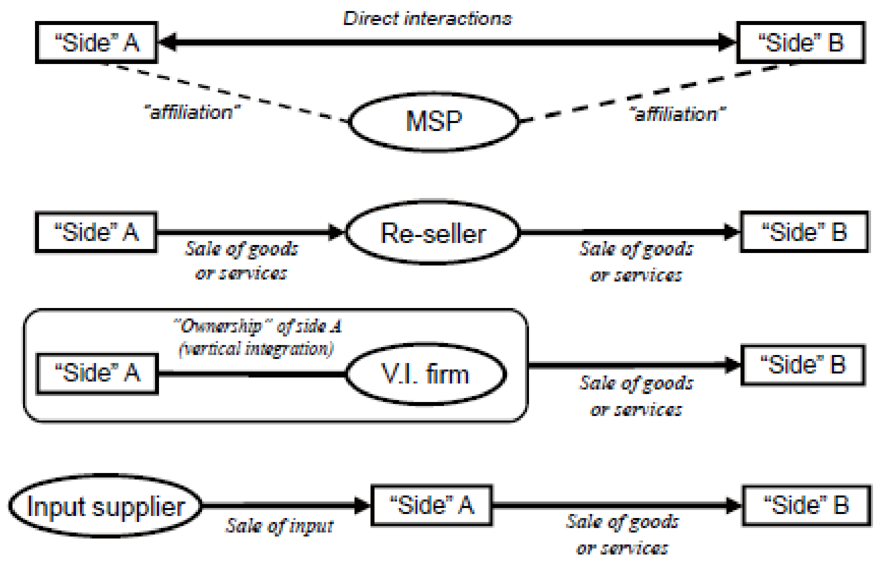

Figure 2.The multi-sided platform business model compared to alternative business models, by Hagiu & Wright (2015)

The authors claim that the choice of adapting a business design based on a multi-sided platform should be preferred over a reselling one, when the variance of the suppliers' local information is superior to the variance of the intermediary's local information. On the other hand, we have to consider that for some markets it may be preferred to operate with a reseller instead of a multi-sided platform. They point out that the heterogeneity of buyers explain why we can detect different modes of operation within the same industry.

Eisenmann *et al.* (2006) analyse the specificities of two-sided markets on the subject of firms' strategy definition. They point out three important aspects that firms need to take into consideration: "pricing the platform", "winner-Takes-All Dynamics" and "The threat of envelopment". The first is a crucial point since two-sided markets rely on gathering together two different types of groups. One side is usually very sensitive to price and quality. Therefore, this is the group that the company should subsidize so that they will put together a greater amount of users allowing the platform to charge a higher premium on the other side, which will have access to business opportunities with the other group. So, the platform is looking for cross-side network effects. The more users it has on one side, the more the platform can charge the other side. In order to assure that firms get pricing schemes right, the authors suggest companies to look for: user sensitivity to price, user sensitivity to quality, output costs, same-side network effects and users' brand value.[4] The second aspect refers to higher costs, at least, on one side as a result of multihoming. For example, most of PCs use Windows as their Operating System which facilitates the common use of files and communication. It would be very expensive to buy multiple Operating Systems. To the side that platforms charge a higher price, network effects are positive and strong, hence platforms should have a cost or differentiation advantages if they want to be successful. Not every time, moving first will make a certain platform the winner of its market.[5]

In this context, it is important to mention the *lock-in* problem. Belleflamme & Peitz (2010) describe how that effect arises either from environmental factors[6] or firms' conduct[7]. It refers to the situation in which consumers constantly buy from the same firm, as a result from the market power that this firm gained over them. This lock-in effect is also present with network effects, referring to the switching costs that consumers face if they want to change to another platform. At this point, the *lock-in* may result either from the consumer's previous choices or from others consumers' choices. With network effects, the firm can use its power to raise prices, by the amount of switching costs, as large as the size of the network allows to.

The third important aspects that firms need to take into consideration according to Eisenmann *et al.* (2006) is the constant threat of facing the entry of an adjacent platform. This rival may opt for a multiplatform bundle, which can result in a product including more functionalities at a lower price. Moreover, these rivals may be able to leverage their customers from one market to another.[8]

[4] One can take the Facebook as an example. If users were asked to pay even a small amount of money to use the platform, the actual millions of user's network would decrease and the economic viability could be compromised. On the other side, advertisers and other companies are asked to pay huge amounts so that their advertising may reach so many potential consumers.

[5] MySpace was the leading social network but then Facebook overtook its position and now MySpace has a very small network compared to its rival.

[6] Learning costs, an example given by Belleflamme & Peitz (2010).

[7] Discounts for past consumers, an example given by Belleflamme & Peitz (2010).

[8] In 1995, Navigator was the leading internet browser used by PC holders, but later on, the company started to face the competition from the companies that developed Operating Systems (OS). These started to develop their own browser included with the OS. As an illustration, Windows integrated the "Internet Explorer" as part of the OS. This situation led to an antitrust investigation against Microsoft concerning possible abuse of dominance practices. As described by Eisenmann *et al.* (2006).

Regarding product differentiation, there are important studies to mention. This concept depends from consumers' heterogeneity in their preferences. Belleflamme & Peitz (2010) notice how for most markets, identical products do not exist. Consumers may perceive a product as different from its branding, even if the physical characteristics are quite similar. Product differentiation can be either horizontal or vertical. The authors suggest a definition to distinguish these two types "*if for equal prices consumers do not agree on which product is the preferred one, products are horizontally differentiated; if on the contrary, for equal prices, all consumers prefer one over the other product, products are vertically differentiated.*"

Armstrong & Wright (2007) analysis consents distinct levels of product differentiation on both sides of the market. The *competitive bottlenecks* arise endogenously when sellers perceive platforms as homogenously, buyers instead perceive it as heterogeneous. The role of exclusive contracts is seen as a key aspect in these markets, since they can be used as a strategic weapon to attract and keep buyers. In the equilibrium of their model, platforms actually incur on losses on buyers, but recover from sellers trying to reach buyers. For example, in the video game industry, consoles have exclusive games in order to attract customers, especially those who do not want to multihome. In this context, Ishihara & Oki (2017) using a model, based on that of Choi (2010), examine a two-sided platform where a monopolistic multi-product firm and consumers interact with each other. The content provider strategically decides the optimal amount of exclusive contents supplied to each platform. This exclusive content can bring more multihoming consumers, becoming a source of bargaining power against platforms. Contrarily to the literature, the authors found that actually the content provider cares more about maximizing the bargaining rent than the opportunities of transaction with consumers.

Defining the market power in two-sided markets is not a straight forward task. It can get problematic and lead to antitrust authorities concerns. Argentesi & Filistrucchi (2007) research examines Italian daily newspapers industry, using it as the case study to empirically assess the specifics of pricing policies in two-sided markets. They find that in most cases, one side subsidizes the other, therefore we should not estimate market power focusing on just one side. In order to measure it, the authors suggest that estimating price elasticities of demand is not enough. Their model tries to fill in the gap by introducing two demand equations, one for each side and also one condition for profit maximization. The results show indications of joint profit maximization on the newspaper cover price while the advertising market is closer to competition. Later on, Filistrucchi *et al.* (2014) puts in evidence the importance of defining the market. The justification comes from the importance of understanding the group of substitutable products so that we can identify which firms are under competition.

The most usual procedure to define market limits is the SSNIP test. According to Motta (2004) if a firm is able to raise its prices unilaterally without hurting its profits, it is a sign of market power. In the SSNIP test the question is whether consumers would switch to substitutes available or elsewhere as a response to a small (between 5 and 10%) but permanent relative increase in the price. If substitution proves to make the price increase unprofitable, this means that this firm does not hold the power to raise prices. Here, the question is about determining if enough customers would switch making this price increase unprofitable. So, for Motta (2004) this is about demand substitution.

Filistrucchi *et al.* (2014) further explore the definition of two-sided markets and take Google as an example of a multi-sided platform, in which there are non-transaction markets and a transaction market at the same time. In Figure 3, we can see how the authors perceive Google as a multi-sided platform. Accordingly, Google has no money transactions with its users, providing them services for free. They also point out that, even though the online advertising market implies transaction, the websites hosting the advertising are considered non-transaction market, since there is only interaction between them. From a general point of view, in order to define the market, the authors suggest that we should take all sides of the platform into account. There is only one case in which is safe not to consider the other side: a two-sided non-transaction market with only one externality. The study gives the example of a market in which advertising does not affect on readers. In this case, publishers will not have an effect on readers, therefore it will behave as a single-sided market.

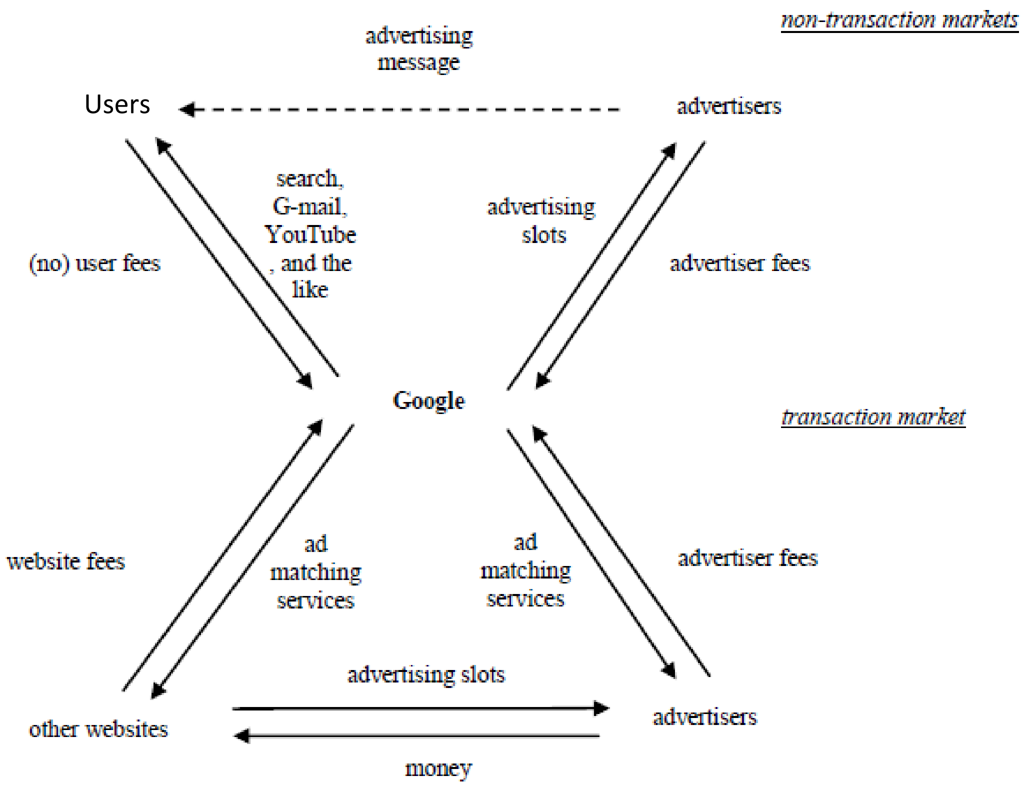

Figure 3. The two-sided transaction and non-transaction markets in which the multi-sided platform Google participates, adapted from Filistrucchi *et al.* (2014)

The pricing strategy is a key topic on two-sided markets. As already argued before, it plays an important role on the firms' business model and it may present rather unconventional features (as illustrated by the seminal results of Rochet & Tirole (2003)). Weyl (2010) gave an important contribution to the literature of multi-sided platforms upon the topic of pricing. The research helps to simplify the analysis of networks and clarifies how platforms set their prices. Hagiu (2009) explores indirect network effects, which makes us remind the study of Katz & Shapiro (1985), and states that these effects are determined endogenously given the consumers' taste for variety and producer competition. Hence, the paper contributes to explain why the consumers' demand for variety is a crucial factor to determine the optimal platform pricing structure. This demand for variety makes products less substitutable, which means that the platform may have higher market power over its consumers. The author also points out a conflict between membership fees[9] and royalties[10]. This happens because the objective of delivering the right investment incentives to producers

[9] Fixed fees to be a member.

[10] Per-transaction fees.

clashes with the objective of reducing the hold-up problem. This problem appears when producers make their platform adoption choices before consumers. Platforms wish to have good products, but in order to have them, platforms should not ask producers to pay very high usage fees, so that producers' incentives to create quality products do not decrease. On the other hand, platforms need to take compensation of the usage fees from the sales of producer's products.

In some industries, the pricing strategy is different and very often, platforms have to deal with price parity clauses. For example, in the hotel industry, many platforms agreed with hotels not to practice better price offers or other conditions to consumers on other third-party platforms. In this respect, Johansen & Vergé (2016) analyse the welfare effects of price parity clauses. Their model has two platforms competing against each other. These platforms offer secretly per-unit commissions to suppliers who compete for the best prices and do not know the commissions offered to its rivals. In this context, the authors study the role of price parity clauses. The present paper describes two types: wide price parity clauses, under which suppliers are not allowed to sell at lower prices elsewhere, for example when a platform applies a price parity clause to the distribution channel[11]; and narrow price parity clauses, under which suppliers can set prices freely on the platform with the restriction of not surpassing the direct sales price[12], in this case the platform does not allow the supplier to set a price higher than that of its own direct price. The results are innovative since the authors find that price parity clauses not always lead to higher commissions or final prices. Moreover, they can simultaneously benefit platforms, suppliers and consumers. Additionally, the level of competitiveness between suppliers and their ability to explore direct sale can actually increase both profits and consumer surplus. Competition brings suppliers to a situation in which they cannot increase the commission fees, moreover they may be forced to decrease them. Regarding the results of their model, the wide price parity clauses should not always be replaced by narrow price parity clauses.

Rysman (2009) clarifies the concept of what is a two-sided market and its strategies and public policy implications. Regarding strategy, the most important decisions a firm face is pricing and the degree of openness. The pricing results from the demand and costs on the side of consumers and on how the consumers' participations impact the profits taken from

[11] For example, an online travel agency under this agreement has the best price offer of a certain room hotel.

[12] In this context, the Hotel cannot offer a better price on its own website than the online travel agency involved in this agreement.

the other side. A low price in one of the sides, the more price sensitive side, can attract agents from that side and increase the price on the other side. Openness refers to how many sides does the platform accommodates and how the platform does relate to competition (incompatibility, compatibility or integration). In terms of Public Policy, two-sided markets likely generate a single dominant platform due to network effects, leading to antitrust and regulation concerns about pricing, monopolization or any exclusionary conduct. Johnson (2013) based on classical models of spatial competition, Hotelling (1929) and Salop (1979), aimed to investigate, when there is consumer lock-in, the performance of the agency model of pricing, a situation in which the retail price is set by suppliers who share revenues with retailers. The investigation was motivated by the e-book market. More precisely, after 2010 when Apple adopted the agency model and was accused of conspiracy to increase the prices for e-books. Before, the only big player in the market was Amazon selling e-books, many of which at prices below the physical copies, and Kindle, its e-book reader. The author concludes that the increase in prices are a consequence of the transition to the agency model, but contrary to expectations consumers end up better off when one accounts for the long-term price effects. Prices are expected to decrease afterwards in comparison with the wholesale model. Early high retail prices are set by suppliers since they sell through both retailers, in contrast to the wholesale model in which they compete to lock consumers in. More specifically, Abhishek *et al.* (2015) try to answer when it is more efficient for a firm, instead of conventional reselling, to use agency selling, an agreement in which the e-tailers, in exchange for charging a fee, gives its approval to the manufacturers to directly contact their customers. The results suggest that agency selling is more efficient and allows for lower prices. Moreover, agency selling is preferred by e-tailers when the traditional channel demand faces a negative effect resulting from the sales on the electronic channel. On the other hand, when the effect is positive, e-tailers prefer reselling. When competition between e-tailers becomes more intense, the more they prefer agency selling. They may also experience an increase in sales resulting from the selling of associated products of the focal product, the one that serves as the "engine" of the business (for example, if a e-tailer sells e-books and compatible e-readers, the e-books are the focal product). The innovative features of this paper lie on the characterization of equilibrium selling formats, when the presence of interactions with the traditional channel is taken into consideration. The paper is also innovative in its investigation of the impact of positive or negative *spillovers* from the e-channel into the traditional channel.

Jiang *et al.* (2011) is the first study to examine the strategic interactions between the platforms and independent seller in the "mid-tail" of online platform-based retailing. Given the example of Amazon, the study analyses the interaction between a platform owner and an independent seller. The platform charges a fee, a percentage of the sellers' revenue. The "mid-tail" products are defined as the type of products that cannot be classified either as high-volume or low-volume products. Curiously, not always is optimal for the platform to identify the independent seller's demand. Instead, it prefers to observe how sales perform and only after select the best and sell them directly. Thus, the seller has incentive to hide the information that a specific product will have high-demand, by reducing its services so that its early sales will not reveal the true demand. On the other hand, the platform anticipates this incentive and tries to adapt its strategy. The platform can try to get more information by buying reviews from consumers. However, this strategy may not have the desired effect since reviews are made after the sale rather than before.

Multi and two-sided markets may allow customers for the affiliation with more than one company. For example, an individual can have a credit card for different banks; an online buyer can buy different things from different online platforms. This possibility is especially important when addressing completion on these markets. It also brings concerns to the firms, since they have to put more effort to attract the consumer attention.

Taking the Video Game Console Industry as example, Landsman & Stremersch (2011) show that increased platform-level multihoming of applications affects platform sales negatively. Moreover, the sales of platforms depend more on platform-level multihoming of applications than on the number of applications. Regarding consumers, they have less uncertainty, and as a consequence, they prefer older platforms that hold higher market shares. These platforms tend to have more multihomed applications. Contrarily, if the larger market share platform is recent, it will have less applications multihomed.

Gabszewicz & Wauthy (2004) used a model with heterogeneous agents allowed to multihome. Under singlehoming, the results show two possible equilibria. An equilibrium in which the dominant firm does not charge one side while charging the monopoly price to the other side of the market. Yet, there is another equilibrium, similar to the collusive outcome, meanwhile the network size is asymmetric. It justifies the relevance of multihoming for platforms because price competition becomes relaxed. This last equilibrium is similar to that of Caillaud & Jullien (2003), with the difference that these last authors assume homogeneous and active agents on each side.

Tying is a common way to attract consumer's attention in multi-sided markets, where multihoming is present. Choi (2010) model studies the effects of tying under a two-sided market that allows multihoming. The conclusion shows that multihoming is enhanced by tying, which also raises the issue of the availability of platform-specific exclusive contents to consumers. According to the study, multihoming will neutralize the tipping and lock-in effects that happen in industries that experience network effects.

Considering the classical model of Hotelling (1929), the stings of a two-sided market can also influence the products location. Gabszewicz *et al.* (2001) inspired by the *Pensée Unique* Theory builds a model with two editorial firms, readers and advertisers. In a sequential game, editors choose their political image during the first stage. Later, in the second stage of the game, they have to choose the prices to the newspapers. On the third-stage comes the novelty of their model: platforms make non-cooperative decision about the advertising tariffs they will offer to advertisers. So, in this case, the multihoming exists on the side of advertiser. Hence, this last stage will influence the previous two stages, making it different from a simple Hotelling's location model. As a consequence, editors will likely choose a centrist image to the newspaper characterized by bland political opinions, rather than a leftist or rightist image according to the externalities of the opinions' interval. The authors compare this result with the "median voter theorem".

Another important topic are why platforms may have incentives to divert consumers' search, which Hagiu & Jullien (2011) research seeks to answer. This refers to intermediaries' incentives not to optimize the process through which consumers could follow in order to access the stores affiliated to the intermediary. The authors give examples of intermediaries such as Bing Cashback[13], Kaboodle.com[14] and ThisNext.com[15]. It is the first study that considers the design of information services as an instrument to increase revenues. They found two original results to support the strategy of diverting search. First, even though consumers do not realize all externalities of their search, they may anticipate that the intermediary is trying to divert search. So, intermediaries have to trade-off between higher consumers' demand for the information service and the number of searches per visitor. Second, diverting search may be a strategic move to impact affiliated stores in such a way

[13] A program developed by Microsoft aimed at allowing advertisers to give back a percentage of sales to users by offering search advertisements.

[14] Shopping website that allows users to list favourite products and download the details of these products.

[15] Social media in which users can recommend products to one another.

that the consumers' surplus increase, by influencing their demand which can force affiliated stores to lower their prices.

2.2. Value creation

No firm can survive without creation its own value. A firm creates something to sell. This is the basic idea behind businesses. But, what does it really mean to create value? According to Porter & Millar (1985) *"the value a company creates is measured by the amount that buyers are willing to pay for a product or service"*. In addition, from the strategic point of view, the same authors also point out that a firm can only be *"profitable if the value it creates exceeds the cost of performing the value activities."* Therefore, the firm is creating value for the consumer and also for the society, because the value of the product or service created exceeds the resources used to make it. In this section of the Literature Review, I am going to address the approach of recent literature towards what value is and how it is created.

Value is seen as more than a production process by Prahalad & Ramaswamy (2004); it incorporates the customers and the experience they have with the firm. Afterwards, I address the role of personalized strategies, especially regarding the delivering of quality (Desai (2001)) and the importance of customization (Dewan *et al.* (2003)) as a way to create value. As a consequence, it is also important to clarify the process of value creation and, in particular, the role that customers can have in the process of co-creation Grönroos & Voima (2013) and Ramaswamy (2008). Then, I address an important study that uses a model with vertical product differentiation, and tries to describe the strategic implications of personalized pricing on the quality offer to consumers (Choudhary *et al.* (2005)). In the end, it is important to mention a recent debate on how the regulatory role of platforms can create value (Boudreau & Hagiu (2009)).

Value creation became one of the main worries for managers. According to Prahalad & Ramaswamy (2004), now the focus is to create a personalized consumer experience rather than a product and firm centric view. Therefore, firms have incentive to dialogue with consumers, because given the new landscape for value creation, the consumer is no longer outside of the company. They are interested in co-creating alongside with the firm and have a personal opinion on how firms should create value for them.

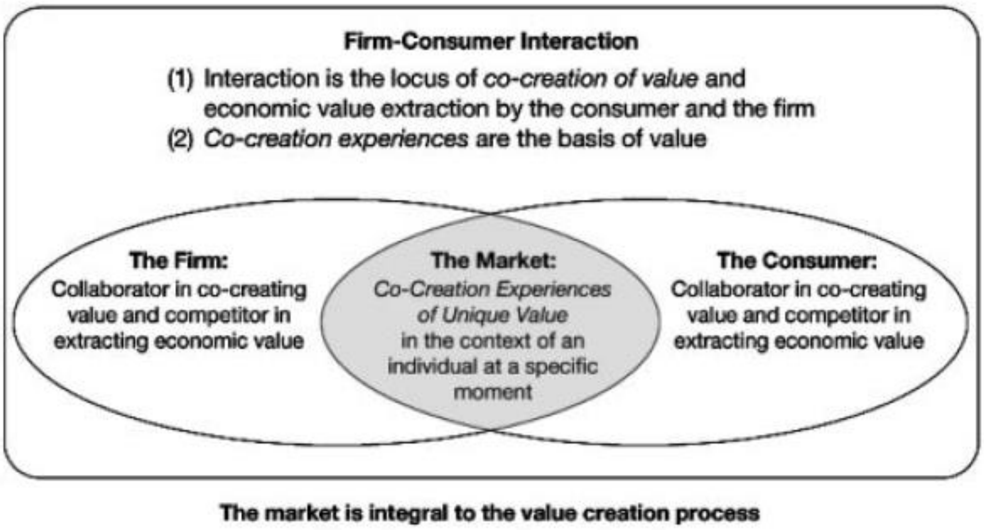

Figure 4. Interactions between firms and consumers by Prahalad & Ramaswamy (2004)

As a consequence, they will choose the firm they can have a good relationship, based on their own view about how value should be created. Prahalad & Ramaswamy (2004) point out the challenge that arises to firms in terms of being super-efficient. Moreover, if firms do not differentiate themselves, consumers will go for the cheap option. So, the authors see co-creation based on high-quality interactions, which enable the consumer to have a unique personalized experience with the company, as the greatest source of competitive advantage. In the end, they conclude that *"products can be commoditized but co-creation experiences cannot be*." On Figure 4, we can see how the authors see the co-creation experiences has a process that involves both the firm and the consumer. The objective is to find what they can create in a specific moment by putting together their will to extract economic value from each other. This interception is their market for co-created experiences.

Personalized strategies are key topic. Many firms, try to adopt personalized strategies so that they can serve better their costumers and as a consequence increase their business value. So, firms try to deliver quality according to costumers' needs. At the present moment, Desai (2001) explores a model, based on that of Hotelling (1929), which represents a market that has two segments. The focus of both sides on quality is asymmetric, as one side values quality more than the other. In a linear city, the different preferences of consumers are represented in the context of a Hotelling framework with transportation costs. Since the market coverage depends on the trade-off between quality and preferences, firms will likely provide the correspondent preferred quality to each side. When the market is fully covered, a monopolist provides efficient quality just to the high-quality preference side. In the case of a duopoly, the firms will differentiate more their products to the high-quality preference side, but if it decreases the price in the low preference side, it can worsen the problem of cannibalization. In this case, for a full market covered duopoly, the strength of taste preferences by consumers will influence the per-unit margins in each segment. So, if the two segments share the same preference, margins will be the same, on the other side, when the high-quality preference is stronger in one side, per-unit margins will be higher for the best products.

In the same manner, during the last decade, firms have paid an increasing attention to customization, since they realize each customer has specific needs. In light of this, Dewan *et al.* (2003) developed a model, based on the Salop (1979) circle, focused on product customization and flexible pricing allowed by prominent features of information and flexible manufacturing technologies. The objective of this paper is to put in evidence the benefits of those technologies in reducing the related costs and also their impact on pricing strategies, consumer welfare and social welfare. Furthermore, the authors try to measure the optimal mix of customized and standard products, the effect of customization on price competition under a duopoly and also who has an advantage in a sequential duopoly (between the first mover and the second adopter). The originality of this work (*vis-à-vis* other authors studying mass customization issues) lies on the specifics of the cost-structure for customization. More precisely, the authors consider a fixed initial investment with decreasing returns without compromising efficiency. The author mentions the classic conflict between flexibility and cost efficiency. This requires a trade-off between the capacity of the manufacture to produce variety and the available capital investment. Therefore, many firms allow customers to customize in a limited ray of variety[16]. The study finds that under a duopoly, customization reduces the differences between the standard products of both firms. Customization makes sellers worst-off while consumers may benefit from these new business practices. The authors conclude that the timing of customization is a critical feature, since the early adopter has advantage in securing and sustaining its innovation if it invests more in customization and, at the same time, develops the ability to raise prices and increase its market share. On the other hand, the first adopter also has an advantage in keeping out potential competitors. None the less, the authors recognize that the model may not be suitable for industries such as customized newspaper and travel packages.

[16] See Dell Computers as an example.

The value creation process is seen by many authors as a process that includes the consumer. Walter *et al.* (2001) made an empirical study over more than two hundred firms about value creation in buyer-seller relationships. The authors identify direct and indirect functions of customer relationships as contributors to the value that the supplier perceives. They mention the direct functions as "*profit*", "*volume*" and "*safeguard*". On the other hand, the indirect functions are "*innovation*", "*market*", "*scout*" and "*access*". In order to secure the long-term survival of the relationship, all involved in the relationship must understand the value-creating functions, given that all partners want to benefit from the relationship. They conclude that there is a positive correlation between the accomplishments of a customer direct and indirect functions and the value of the relationship perceived by the supplier. For Lepak *et al.* (2007) value creation differs depending on its creator, whether it is an individual, an organization or society. Each one has different targets or users of value and value capture process. More recently, using data from a panel of fifty-nine American and European e-businesses recently public traded firms, Amit & Zott (2001) examined the way these firms created value. They conclude that in e-businesses, value can be created through transactions. The value creation will depend on four independent variables: efficiency, complementarities, lock-in and novelty. This study suggests that the design of the firm's business model is a crucial source of value creation not only for the firms and customers, but also for the suppliers.

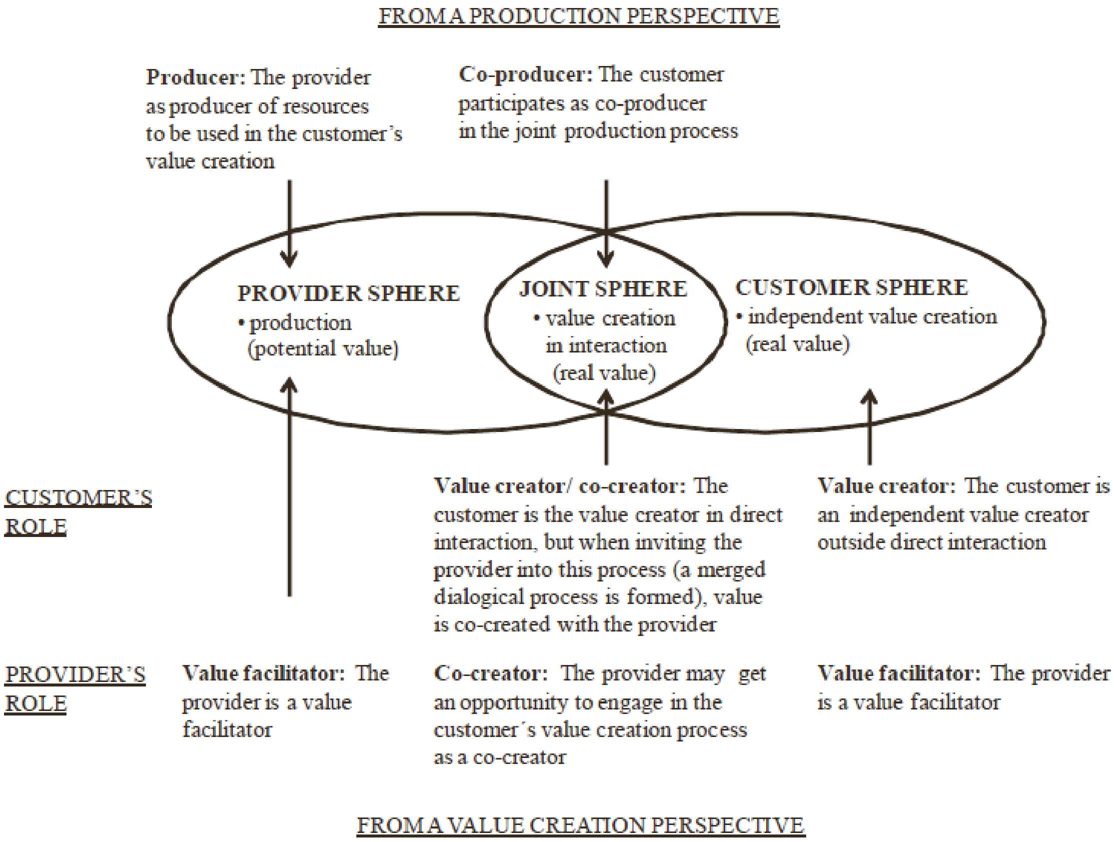

Figure 5. The two spheres in which firms and customers create value by Grönroos & Voima (2013)

The study of Grönroos & Voima (2013) helps to clarify the difference between value creation and value co-creation. The authors define value creation as *"the customer's creation of value-in-use."* As we can see from Figure 5, they suggest that the firm's and customer's processes and activities are alienated in two spheres: a *"provided sphere"* closed for the customer and a "*customer sphere"* closed for the firm. Given this, the analysis points out that value creation occurs inside the "*customer sphere*", meanwhile in the "*provider sphere*" the firm should create resources and processes that provide potential and expected value-in use for the customer. If the firm has access to the "*customer sphere*", it allows for the possibility of joint value creation (co-creation). So, in the "*joint sphere*" the value creation is in charge by the customer while keeping a constant dialogue with the firm (co-creator), which can influence customer's choices.

The value creation is attached to the value chain, so we have to analyse as well the way business models help to create more value. Ramaswamy (2008) takes the Nike case, specifically its campaign during the 2006 Football World Cup. It analysis how the firm was able to engage their customers inside the process of co-creation of value. The study suggests that nowadays firms have to build strategic capital during a constant interaction process with its customers, in order to grow. Customer experience lies at the heart of these interactions. The authors notice that firms should be constantly informed about customer desires. It also describes the "DART Model" used by Nike that holds for dialogue, access, risk-return and transparency. The author claims that the competitive advantages from conventional value chains are dying. The idea is to incentive co-creative interactions making meaningful experiences for individuals, *"from a unilateral value creation process by the firm to co-creation with individuals"*.

An important analytical study on product personalization is that of Choudhary (2005) which uses a model of vertical product differentiation displays that firms apply personalized prices to different consumers having in mind their willingness to pay (the firm has complete knowledge about it). The focus is not how do firms acquire this knowledge, but rather on its strategic implications. Regarding discounts, larger customers can get bigger discounts. Once a low-quality firm uses personalized pricing, both firms lower their quality till equilibrium. Contrary, if the high-quality firm implements personalized pricing, both firms have incentive to expand quality offering an additional product. The main issue of personalized pricing in vertically differentiated industries is to handle the increase in market coverage and intensified competition. Because the two effects have opposite impacts, the net effect will depend on the nature of the cost function. For lower degree of convexity of the cost function, both firms have higher profits with personalized pricing. Regarding consumers, the model predicts that the adoption of personalized pricing by high-quality firms is beneficial. Furthermore, if every firm applies personalized prices, consumers will benefit the most. Therefore, under competition, higher knowledge about the willingness to pay of consumers would likely increase the welfare of consumers.

More recently, the new economy brought firms that work as online platforms such as Facebook and Amazon to the top of most valued firms in the world. Given this, Boudreau & Hagiu (2009) address the regulatory role of platforms and its role on value creation. The authors describe, for example, how a platform like Facebook can create value for its network by creating an ecosystem that incentives the development of widgets and applications by develop partners. When other firms produce applications or widgets for Facebook they want to benefit from its big network and in return they create value for the platform. This study points out that Multi-sided platforms use a range of legal, informational and technological instruments to generate the outcomes they desire. Given this, the authors suggest a strategy for platforms: first, they should care about generating the maximum possible value for the entire ecosystem; second, create mechanisms to understand the industry so that they can maximize the value extracted incentives, allowing the firm to best design the optimal way to regulate its platform.

3. The Model

The basic model builds on Armstrong & Wright (2007), extending it in order to allow heterogeneity across consumers' stand-alone valuations. The model is based on the standard Hotelling with exogenous locations and cross-network effects. Consequently, the two platforms, platform 1 and platform 2, are placed at either end of the unit interval, whereas agents are uniformly distributed between the platforms. As in standard two-sided market models, the platforms act as an interface between two types of agents: the sellers, type A, and the buyers, type B. These two types of agents want to interact with the agents on the other side. There is a unit mass of consumers that is uniformly distributed in the unit line, according to Hotelling assumptions.

The utility of an agent in group A located at $x \in [0,1]$ when he joins platform 1, 2 or both, is respectively:

$$V_A^1 = v_1 - p_1 - tx + b(n_1 + N)$$

$$V_A^2 = v_2 - p_2 - t(1 - x) + b(n_2 + N)$$

$$V_A^{12} = v_{12} - p_1 - p_2 - t + b(n_1 + n_2 + N)$$

Where:

v_1,v_2 and v_{12} – represent the stand-alone value for a group A agent if he subscribes one of the platforms or both, respectively. This value is an intrinsic benefit. v_1 is the intrinsic value of platform 1 to group A agents. The v_2 is the intrinsic value of platform 2 to group A agents. Finally, v_{12} is the intrinsic value to group A agents after subscribing both platforms.

p_1 and p_2 – denote the subscription prices that each platform sets to agents from group A. More precisely, p_1 is the price platform 1 sets to agents of group A and p_2 is the price set by platform 2 to agents A;

t - represent the unit transportation cost of travelling. The total transportation cost can be obtained by multiplying t by the distance agents incur in order to join the platform, either x or $(1-x)$;

b - the benefit of an agent from group A by participating in a market that allows him to interact with an additional agent on the other side of the market, therefore measuring the intensity of network effects;

n_1 and n_2 - the number of exclusive group A agents from platform 1 or 2, respectively;

N - the number of agents in side A who multihome, meaning that they pay to be on the two platforms;

We assume that the two platforms have different intrinsic (or stand-alone) values, v_1 for platform 1 and v_2 for platform 2. Multihoming also yields a unique intrinsic value represented as v_{12}. The utility of a group B agent located at $x \in [0,1]$ when he joins platform 1, 2 or both, respectively is:

$$V_B^1 = \mu_1 - \rho_1 - \tau x + \beta(\eta_1 + \Gamma)$$

$$V_B^2 = \mu_2 - \rho_2 - \tau(1-x) + \beta(\eta_2 + \Gamma)$$

$$V_B^{12} = \mu_{12} - \rho_1 - \rho_2 - \tau + \beta(\eta_1 + \eta_2 + \Gamma)$$

μ_1, μ_2 and μ_{12} – represent the stand-alone value for a group B agent if he subscribes one of the platforms or both, respectively. This value is an intrinsic benefit. μ_1 is the intrinsic value of platform 1 to group B agents. The μ_2 is the intrinsic value of platform 2 to group B agents. μ_{12} is the intrinsic value to group B agents after subscribing both platforms;

ρ_1 and ρ_2 - the subscription prices that each platform sets to agents from group B. More precisely, ρ_1 is the price platform 1 sets to agents of group B and ρ_2 is the price set by platform 2 to agents B;

τ - the transportation cost of travelling, on this side, that has to be multiplied by the distance agents incur in order to join the platform, either x or $(1 - x)$;

β - the network intensity in the side B of the market measuring the strength of the benefit obtained by an agent from group B when participating in a market that allows him to interact with other agents;

η_1 and η_2 - the number of exclusive group B agents from platform 1 or 2, respectively;

Γ - the number of agents B who multihome, meaning that they pay to be on the two platforms;

As we can see, the utility of a group k agent located at x depends on a set of different variables, whose characteristics differ and represent something diverse to the agents. Some of them require a further description and examples.

The stand-alone value, (v_1,v_2, v_{12},μ_1, μ_2 and μ_{12}) is an intrinsic benefit. In this version of the model, agents see this intrinsic value as differentiated, instead of homogenous. This value can be seen as the quality of the service/product a platform has to offer in the absence of any network effects. The higher the difference between platforms' intrinsic values, the more differentiated the platform with a higher value will be on *vis-à-vis* the lower quality platform. Hence, if a platform decides to increase its intrinsic value, it is generating a superior added value to its customers.

The unit transportation cost (t or τ depending on the market side we are studying) can be interpreted as a horizontal differentiation parameter. It can be related to the platforms' usability features such as information needed to register on a platform, the costs of transferring data, given that many online platforms require users to create an account with their personal data, or the eventual set-up costs of learning about the service.

Regarding the benefit agents get by participating in a market that allows them to interact with other agents (b and β), taking an e-commerce platform as an example, the users (the buyers) benefit from its huge user network, giving the possibility to have more interactions and possibly find good deals. On the other side, the sellers, benefits from the huge network of buyers since their products or services will be shown to a greater range of potential consumers.

The utility of agents contemplates cross-network effects, meaning that each agent benefits from the presence of agents from the other group in the same platform. For example, given the first equation, we can notice that the utility of an agent joining platform 1 will be higher as the number of B users who only use this platform (n_1) and the number of users that multihome (N). Apart from the intrinsic value, users take a marginal benefit from an additional user equal to b, in case of agents A, or equal to β, in case of agents B.

Without loss of generality, we normalize marginal production costs to zero. This is a standard assumption in the literature and our results can be generalized without loss of generality to any market with constant and symmetric marginal production costs (in that case, our equilibrium prices must be reinterpreted as price-cost margins in equilibrium).

Accordingly, the profit functions for platform 1 and 2, are respectively:

$$\pi_1 = \eta_1 p_1 + n_1 \rho_1$$

$$\pi_2 = (1 - \eta_1) p_2 + (1 - n_1) \rho_2$$

We analyse the platforms' strategic interaction within a game with the following timing: platforms start by choosing their prices for each group of agents, followed by agents' decisions on which platform should they subscribe. In the next chapter, we will analyse two specific cases: the first case studies a game without multihoming by setting a value for t and τ so high that makes every consumer want to singlehome, meanwhile we also guarantee that every agent subscribes at least one platform (which can be assured by assuming sufficiently high stand-alone values); we then analyse a game with multihoming.

Throughout the analysis, we follow the standard literature by assuming fulfilled expectations *à la* Katz & Shapiro (1985). Therefore, consumers have similar expectations towards the size of the competitive network. These expectations are formed even before they know platforms' output, meaning that agents make correct expectations about the future network size. Under Nash equilibrium, all agents have their expectations fulfilled. Nash equilibrium represents a situation in which every agent is playing its best response and no player desires to deviate from it. Every agent belief about the other agents' responses will be confirmed as explained in detail by Belleflamme & Peitz (2010). Moreover, given agents' fulfilled expectations, in equilibrium, everyone should be playing its best response, taking as given the actions of the other players.

3.1. Case 1: Strong product differentiation on both sides

The objective of this section is to test the situation in which agents on both sides decide to buy exclusively from one of the platforms. We consider horizontal differentiation is sufficiently strong to assure that the values of t and τ are large enough to guarantee that no agent desires to multihome. This assumption guarantees that no agents wants to multihome. Naturally, we assume that all agents are rational about their decisions and their expectations regarding other agents' decisions. Therefore, the model is solved without multihoming. Following Armstrong & Wright (2007)[17] the subsequent assumptions are made:

Assumption 1 v_1, v_2, v_{12}, μ_1, μ_2 and μ_{12} are sufficiently high such that all agents wish to subscribe at least one platform equilibrium. Therefore, all agents will subscribe one platform.

Assumption 2 $t>b$ and $\tau>\beta$ meaning that no agent wishes to multihome under non-negative prices.

Assumption 3 $4t\tau > (b+\beta)^2$ assures a concave profit function.

Since all agents singlehome, it is important to mention that $N = \Gamma = 0$. It is also important to stress that we will look at equilibrium outcomes in which the market is fully covered, guaranteeing that $n_1 = 1 - n_2$, therefore every agent subscribe at least one platform and the sum of the exclusive customers of platform 1 with those of platform 2 equals to the unit. On the other side, the same result arises, thus $\eta_1 = 1 - \eta_2$ given that the sum of exclusive customers of each platform equals to the unit.

In each side of the market, the indifferent consumer location is given by the location in which he gets the same utility, either from choosing platform 1 or 2. We have to find this value by equalizing the utility functions of both platforms for this consumer. We have to calculate the indifferent consumer on side A and B. Having this in mind, the indifferent consumer on side A is given by the following expression:

[17] Please note that we are considering the same assumptions as those of Armstrong & Wright (2007).

$$v_1 - p_1 - tx + b(n_1) = v_2 - p_2 - t(1-x) + b(n_2)$$

$$\Leftrightarrow x_A = \frac{t - p_1 + p_2 + v_1 - v_2 + b(n_1 - n_2)}{2t}$$

Upon this location, an agent A has the same utility, either if he chooses to go for platform 1 or for platform 2. Thus, x_A corresponds to the indifferent location for group A agents.

On side B, we apply the same reasoning:

$$\mu_1 - \rho_1 - \tau x + \beta(\eta_1) = \mu_2 - \rho_2 - \tau(1-x) + \beta(1-\eta_1)$$

$$\Leftrightarrow x_B = \frac{\tau - \rho_1 + \rho_2 + \mu_1 - \mu_2 + \beta\eta_1 - \beta(1-\eta_1)}{2\tau}$$

$$\Leftrightarrow x_B = \frac{\tau - \rho_1 + \rho_2 + \mu_1 - \mu_2 + 2\beta\eta_1 - \beta}{2\tau}$$

Situated on this location, an agent B gets the same utility with both platforms, which means he is indifferent between platform 1 and platform 2.

As we have seen, in this model, we have two categories of agents, who value more interactions with the other type of agents rather than interactions with agents from the same group. This implies that agents need to formulate expectations about the number of users in the other side of the market. Under fulfilled expectations, we have:

$$x_A = \eta_1$$
$$x_B = n_1$$

Now, we can plug in the equations above, the expressions of the indifferent consumers' locations, x_A and x_B, which were determined above in order to compute the amount of exclusive consumers of platform 1 on each side. As it is usually the case in two-sided markets models, we get that a platform will have more exclusive consumers of one group, as much as it is able to attract more exclusive consumers on the other side. These results express the cross-network effects or the idea of interdependent demands. Following this way, we guarantee in this model that a high presence of group A agents creates value and attracts more of the group B agents and vice-versa.

The previous reasoning leads us to a system of two equations, which will allow us to determine the demand for each platform when agents formulate fulfilled expectations about the number of agents of the other category participating in each platform:

$$\begin{cases} \eta_1 = \dfrac{t - p_1 + p_2 + v_1 - v_2 + b(n_1 - n_2)}{2t} \\ n_1 = \dfrac{\tau - \rho_1 + \rho_2 + \mu_1 - \mu_2 + 2\beta\eta_1 - \beta}{2\tau} \end{cases}$$

Solving the two-equation system for platform 1, with respect to η_1 and n_1, yields the following reduced-form demand functions. Respectively:

$$\begin{bmatrix} \eta_1 = \dfrac{b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)}{2(b\beta - t\tau)}, \\ n_1 = \dfrac{b\beta - t\tau - t(\mu_1 - \mu_2) + t(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)}{2(b\beta - t\tau)} \end{bmatrix}$$

These particular two equations tell us how many agents, from each side, are willing to join platform 1 as a function of the parameters of the model (which depend on the features of the problem) and the equilibrium prices in each side of the market (which are a strategic choice by the firms). As we said previously, every single agent subscribes exclusively one platform. Thus, with respect to its competitor, platform 2, we can apply the principle of $n_2 = 1 - n_1$ and $\eta_2 = 1 - \eta_1$ to find their demand functions:

$$n_2 = 1 - \frac{b\beta - t\tau - t(\mu_1 - \mu_2) + t(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)}{2(b\beta - t\tau)}$$

$$\eta_2 = 1 - \frac{b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)}{2(b\beta - t\tau)}$$

In the original model $v_1 = v_2$ since there is a single stand-alone value. This version of the model, considers that consumers see the intrinsic value of different platforms as differentiated. In this context, it will be interesting to see if the conclusions of Gabszewicz *et al.* (1979) still hold. These authors found that in a set-up with vertical differentiation, contrarily to the classical Hotelling model of the horizontal differentiation, in equilibrium there is a tendency for firms to maximize their differentiation, resulting in a high-quality offer opposed by a low-quality offer from the other seller. The firms are interested in maximizing the quality gap in order to soften the intensity of price competition (one of the firms tries to have a competitive advantage by higher quality and the other by lower prices).

Using the specification of the indifferent consumer locations derived above, we can express the profit function of platform 1 as follows:

$$\pi_1 = p_1\eta_1 + \rho_1 n_1$$

$$\Leftrightarrow \ \pi_1 = \begin{pmatrix} \frac{p_1}{2(b\beta - t\tau)}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \frac{\rho_1}{2(b\beta - t\tau)}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix}$$

In regard to platform 2, we just apply the same reasoning:

$$\pi_2 = p_2(1 - \eta_1) + \rho_2(1 - n_1)$$

$$\Leftrightarrow \ \pi_2 = \begin{pmatrix} \frac{p_2}{2(b\beta - t\tau)}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \frac{\rho_2}{2(b\beta - t\tau)}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix}$$

With these profit functions, each platform will find the prices that maximize their profits. So, the next step is to calculate, for each platform, the derivative for each price. The following proposition summarizes equilibrium prices, the proof can be found in the Appendix:

Proposition 1. In equilibrium with fulfilled expectations, when firms are allowed to offer goods with differentiated stand-alone value, equilibrium prices are equal to:

$$p_1^* = -\frac{2\beta^3-2b^2t+5b\beta^2+2b^2\beta-2t\beta^2+9t^2\tau-\beta^2(v_1-v_2)-5bt\beta+bt(\mu_1-\mu_2)-9t\beta\tau-t\beta(\mu_1-\mu_2)-2b\beta(v_1-v_2)+3t\tau(v_1-v_2)}{5b\beta-9t\tau+2\beta^2+2b^2}$$

$$\rho_1^* = -\frac{2\beta^2+5b^2\beta-2b^2\tau+9t\tau^2-b^2(\mu_1-\mu_2)-2\beta^2\tau+2b^3-9bt\tau-5b\beta\tau-2b\beta(\mu_1-\mu_2)+3t\tau(\mu_1-\mu_2)-b\tau(v_1-v_2)+\beta\tau(v_1-v_2)}{5b\beta-9t\tau+2\beta^2+2b^2}$$

$$p_2^* = -\frac{2\beta^3-2b^2t+5b\beta^2+2b^2\beta-2t\beta^2+9t^2\tau+\beta^2(v_1-v_2)-5bt\beta-bt(\mu_1-\mu_2)-9t\beta\tau+t\beta(\mu_1-\mu_2)+2b\beta(v_1-v_2)-3t\tau(v_1-v_2)}{5b\beta-9t\tau+2\beta^2+2b^2}$$

$$\rho_2^* = -\frac{2\beta^2+5b^2\beta-2b^2\tau+9t\tau^2+b^2(\mu_1-\mu_2)-2\beta^2\tau+2b^3-9bt\tau-5b\beta\tau+2b\beta(\mu_1-\mu_2)-3t\tau(\mu_1-\mu_2)+b\tau(v_1-v_2)-\beta\tau(v_1-v_2)}{5b\beta-9t\tau+2\beta^2+2b^2}$$

Corollary 1. If we consider a symmetric model, with $v_1 = v_2 = \mu_1 = \mu_2 = v$; $b = \beta$ and $t = \tau$, the following equilibrium prices are obtained:

$$p_1^* = \rho_1^* = p_2^* = \rho_2^* = t - b$$

Proof: Follows directly Proposition 1, letting $v_1 = v_2 = \mu_1 = \mu_2 = v$; $b = \beta$ and $t = \tau$.

Hence, using this symmetric configuration, we have the same standard two-sided marketing price as in Armstrong (2006). This paper also shows that the price-cost margin displays the existence of cross-network effects and changes optimal prices in a set-up with pure horizontal differentiation *à la* Hotelling. In this benchmark model, the equilibrium price corresponds to the difference between the degree of the platform's horizontal differentiation to each specific group (measured by t) subtracted by the intensity of the externalities to the other group agents who joined this platform (measured by b). The author also mentions that, when some degree of asymmetry is allowed, the platforms will have incentives, to target further the most competitive side and the group that bring more benefits to the other group, in line with the conclusions of the seminal works by Rochet & Tirole (2003, 2006).

Some platforms, such as Amazon want to have more buyers than sellers. Its greatest strength comes from having a large network of users/buyers. Then, they charge less on buyer's side and charge more on the other side. This type of platform tries to avoid charging more sellers and buyers, they have to charge almost zero to buyers and charge more to sellers, who benefit from having a broader network of potential buyers to their products.

In regard to profits in the benchmark model, platforms make the optimal price-cost margin:

$$\pi_1 = \frac{1}{2}(t - b) + \frac{1}{2}(t - b) = t - b$$

$$\pi_2 = \frac{1}{2}(t - b) + \frac{1}{2}(t - b) = t - b$$

When we allow for platforms' asymmetry (both in terms of the transportation cost and in terms of the stand-alone value parameter) price equilibrium expressions are rather complex and it is difficult to make an intuitive judgment about them. As a consequence, we have to study each of them upon the effects that are more relevant to the present study. This is analysed in the section below, which presents some comparative statics results.

3.1.1. Comparative statics

In this section, we present a comparative static analysis in order to better understand how prices can change as a result of possible deviations on the exogenous variables corresponding to the parameters of the model.

Analysis of stand-alone value's impact on prices

Herein, we consider the impact of changes on firms' stand-alone values in equilibrium prices. We will analyse in detail the previous four-equation system, more precisely the impact that deviation on the value of v_1, v_2, μ_1 and μ_2 can have on the final equilibrium prices p_1, ρ_1, p_2 and ρ_2. This four-equation system contains the final expression for each price. The aim is to understand how the value added by platforms trades-off with the level of prices, not only with those of the respective platform, but also with those of its rival. Since the focus of our analysis lies on the study of the effect of platforms' investment to enhance their value offers to consumers, we will consider a benchmark model in which platforms exhibit similar transportation costs in both sides of the market, as well as similar network intensities, i.e. $\beta = b$ and $\tau = t$. By restricting our analysis to this benchmark model (in which there are less sources of asymmetry than in the baseline model but still firms are allowed to provide consumers with differentiated value offers), the analysis becomes much simpler and intuitive.

Next, we present the calculations and an economic explanation to the exogenous determinants of equilibrium prices and their business implications. Given this, it is worth recalling that the derivative of each equilibrium price with respect to each stand-alone value expresses how a variation in the stand-alone value can change the price to each group of consumers, *ceteris paribus*.

We now show how these results were calculated and further explain its main implications. Due to similarity, we specifically analyse the case for the price impact of changes in v_1' the stand-alone value of platform 1 to group A agents, and then we extend this analysis to other similar parameters.

$$\frac{dp_1}{dv_1} = \frac{\beta^2+2b\beta-3t\tau}{5b\beta-9t\tau+2\beta^2+2b^2}$$

Everything else the same, we would expect the equilibrium price of platform 1 to increase in side A, when the perceived quality of the platform for agents in this side increases (for example: v_1 goes up). We will have a positive effect if $\beta^2 + 2b\beta - 3t\tau$ and $5b\beta - 9t\tau + 2\beta^2 + 2b^2$ share the same signal, meaning if either both are positive or both negative. Otherwise, the effect on v_1 of increasing p_1 would be negative.

If we consider an almost full symmetric version to this model, meaning that $\beta = b$ and $\tau = t$, we can easily see that the effect is positive, since the present result would become $\frac{3b^2-3t^2}{9b^2-9t^2} = \frac{1}{3}$. Therefore, an increase in v_1 will lead to an increase in p_1, the price platform 1 sets to agents of group A, the sellers. Platform 1 increases its prices appropriating (at least some of) the surplus resulting from the increase in agents A's willingness to pay for its good.

We can apply the previous reasoning and extend this analysis to the case of $\frac{dp_2}{dv_2}$, $\frac{d\rho_1}{d\mu_1}$ and $\frac{d\rho_2}{d\mu_2}$. It is also interesting to investigate how the increase in the consumers' willingness to pay for the platform in one side of the market may affect the price of the platform in the other side of the market. For example, if we focus on the case of platform A, this amounts to compute $\frac{d\rho_1}{dv_1}$. Considering the expressions for the equilibrium prices derived in *Proposition 1*, we obtain:

$$\frac{d\rho_1}{dv_1} = \frac{b\tau - \beta\tau}{5b\beta - 9t\tau + 2\beta^2 + 2b^2}$$

If b is greater than β the numerator will be positive. So, if the signal of the denominator is the same, the effect is also positive. As long as the numerator and the denominator share the same signal, the effect is positive. Otherwise, it is negative.

Consider the more restricted version of the model in which we impose symmetric transportation costs and cross-network intensities in both sides of the market, we can see that, under symmetry, the numerator equals to zero, therefore the final result is zero: $\frac{b\tau - b\tau}{9b^2 - 9t^2} = 0$. So, an increase in v_1 will not have an effect on ρ_1, the price platform 1 sets to group B agents. So, an increase in the intrinsic value fixed by platform 1 to group A agents, the sellers, does not change the price offered by the same platform to group B agents, the buyers, in a model with symmetric transportation costs and symmetric intensity of network effects in both sides of the market.

If there is market asymmetry (on the top of the intrinsic stand-alone values, v_1 and v_2), then the result depends on the intensity of cross-network effects in each side of the market. Considering a positive denominator, if side A exhibits stronger network effects (with $b > \beta$), an increase in the willingness to pay for platform 1 in side A agents will lead to an increase in the equilibrium price charged by platform A on side B. However, if the intensity of network effects is stronger in side B than in side A, an increase in v_1 will actually result in a reduction of ρ_1, since firm 1 will try to attract more consumers on side B in order to magnify cross-network effects to users in side A. On the other hand, if $5b\beta - 9t\tau + 2\beta^2 + 2b^2 < 0$ the opposite effects of those previously described will be registered.

Using the same logic, the previous analysis also applies to the cases of $\frac{dp_1}{d\mu_1}$, $\frac{d\rho_1}{dv_2}$ and $\frac{dp_2}{d\mu_2}$, since the derivatives show symmetric results.

Let us now consider the effects of a change in consumers' willingness to pay for a given platform in a given side of the market (e.g. v_1, representing users A willingness to pay for platform 1) on the rival's price (e.g. p_2, in the case under analysis). Considering the expressions for the equilibrium prices obtained in *Proposition 1*, we have:

$$\frac{dp_2}{dv_1} = \frac{-\beta^2 - 2b\beta + 3t\tau}{5b\beta - 9t\tau + 2\beta^2 + 2b^2}$$

For the case in which $-\beta^2 - 2b\beta + 3t\tau > 0$ the effect is positive if $5b\beta - 9t\tau + 2\beta^2 + 2b^2 > 0.$ If they have different signals, the effect will be negative. If we consider the model with symmetric transportation costs and network intensities in both sides of the market, the previous derivative becomes simply $-\frac{1}{3}$ under asymmetry, since $\frac{-3b^2+3t^2}{9b^2-9t^2} = -\frac{1}{3}$. It is the same derivative as $-\frac{dp_1}{dv_1}$. A positive deviation on v_1 has a negative impact on p_2. Hence, when, *ceteris paribus,* firm 1 increases its stand-alone value to group A agents, its competitor, platform 2, decreases its price to the same group of agents. An increase by platform 1 on its intrinsic value offered to group A agents increases differentiation to its product/service, platform 2 decreases its price to these agents in order to differentiate from the rival by lower prices.

Analogously, we can apply the same reasoning and extend this analysis to the case of $\frac{dp_1}{dv_2}$, $\frac{d\rho_2}{d\mu_1}$ and $\frac{d\rho_1}{d\mu_2}$.

It remains only to study the effect of changes in the stand-alone variable of a given platform (for a given size of the market) in the price set by the rival firm in the other side of the market. Considering for example, the effect of $\frac{d\rho_2}{dv_1}$, for the equilibrium prices described in *Proposition 1*, we would obtain:

$$\frac{d\rho_2}{dv_1} = \frac{-b\tau+\beta\tau}{5b\beta-9t\tau+2\beta^2+2b^2}$$

In the case of symmetric network intensities and symmetric transportation costs, we have again the neutral effect, since $\frac{-b\tau+b\tau}{9b^2-9t^2} = 0$. If b is greater than β the numerator will be negative. So, if the the denominator is also negative, the effect is positive. As long as the numerator and the denominator share the same signal, the effect is positive. If we set the same transportation cost and network intensity on both sides of the market, we get that an increase in v_1 will not affect ρ_2, the price platform 2 sets to group B agents. So, an increase in the intrinsic value fixed by platform 1 to group A agents, the sellers, does not change the price offered by platform 2 to group B agents, the buyers.

Analogously, we can apply the same reasoning and extend this analysis to the case of $\frac{d\rho_1}{dv_2}$, $\frac{dp_2}{d\mu_2}$ and $\frac{dp_1}{d\mu_1}$.

The subsequent table, summarises the impact that deviations on each stand-alone value has on each final price, for the model with symmetric transportation costs and symmetric network intensities. A positive sign means that an increase on this stand-alone value, will increase the correspondent price. A negative sign, represents the opposite situation, an increase on that stand-alone value, will decrease this price.

	p_1	ρ_1	p_2	ρ_2
v_1	+	Neutral	-	Neutral
v_2	-	Neutral	+	Neutral
μ_1	Neutral	+	Neutral	-
μ_2	Neutral	-	Neutral	+

Table 1. Synthesis of the results for the singlehoming case

The table shows that in a model with symmetric network effects and symmetric transportation costs, a change in the platforms' quality in a given size of the market only has a direct effect on the prices charged in that side of the market. The equilibrium prices in the other side of the market remain unchanged.

3.2. Case 2: Multihoming

Differently from Case 1, we consider now that consumers have the possibility to multihome. The parameters of the model are the same. On the other hand, it is important to recall *Assumption 2*, meaning that we must assure that τ and t are high enough so that demand will be negatively sloped guaranteeing that as prices go up, demand decreases (otherwise there could be demand scale economies leading to market tipping, a well-known phenomenon in network industries, whose analysis is beyond the scope of this Thesis). Furthermore, in this chapter we are considering the domain of parameters under which agents have interest to multihome. This implies that the analysis presented in this section is restricted to the domain of parameters for which v_{12} is high enough in relation to v_1 and v_2 in order to guarantee that some agents do have incentives to multihome.

In the case of multihoming, we will consider the variable N and Γ representing the consumers who multihome the two rival platforms. As a consequence, in each side of the market, now we have consumers who singlehome platform 1, consumers who singlehome platform 2 and consumers who subscribe both platforms and enjoy both at the same time. They prefer to subscribe the two over subscribing just one. So, we have for side A and side B, the following identities:

$$n_1 + n_2 + N = 1$$

$$\eta_1 + \eta_2 + \Gamma = 1$$

Given this, the first point is to find the indifferent consumers' locations under this new set-up. Here, we have to look for the location of a consumer indifferent between singlehoming platform 1 and multihoming; and a consumer indifferent between singlehoming platform 2 and multihoming. The consumers who multihome are in the centre, whereas the others are close to the ends, being closer to platforms 1 and 2 (which means they bear a large "transportation cost" when participating in the most distant platform. In the case of group A agents, we have the following equalities defining the position of the indifferent consumers referred above:

$$\begin{cases} v_1 - p_1 - tx + b(n_1 + N) = v_{12} - p_1 - p_2 - t + b(n_1 + n_2 + N) \\ v_2 - p_2 - t(1-x) + b(n_2 + N) = v_{12} - p_1 - p_2 - t + b(n_1 + n_2 + N) \end{cases}$$

Here, we have to find two expressions for the location of those group A agents who are indifferent between joining platform 1 and multihoming $(x_{A,12})$ and those indifferent between platform 2 and multihoming $(x_{A,21})$. Furthermore, we also need to guarantee full-filled expectations, in the same way we have done for Case 1. Solving the system above, we are able to find the two expressions that dictate the indifferent consumers' locations, more precisely:

$$\begin{cases} x_{A,12} = \frac{1}{t}(t + p_2 + v_1 - v_{12} - bn_2) \\ x_{A,21} = -\frac{1}{t}(p_1 + v_2 - v_{12} - bn_1) \end{cases}$$

In these locations, group A agents get the same utility either from singlehoming the closest platform and multihoming. Having in mind the cross-network effects present in this type of market, we can state that $\eta_1 = x_{A,12}$ and $\eta_2 = 1 - x_{A,21}$, therefore:

$$\Leftrightarrow \begin{cases} \eta_1 = x_{A,12} \\ \eta_2 = 1 - x_{A,21} \end{cases} \Leftrightarrow \begin{cases} \eta_1 = \frac{1}{t}(t + p_2 + v_1 - v_{12} - bn_2) \\ \eta_2 = \frac{1}{t}(t + p_1 + v_2 - v_{12} - bn_1) \end{cases}$$

Using these expressions, we are able to write the multihomers (Γ) relevant for this side:

$$\Gamma = 1 - \eta_1 - \eta_2 = 1 - \left(\tfrac{1}{t}(t + p_2 + v_1 - v_{12} - bn_2)\right) - \left(\tfrac{1}{t}(t + p_1 + v_2 - v_{12} - bn_1)\right)$$
$$= \frac{1}{t}(-t - p_1 - p_2 - v_1 - v_2 + 2v_{12} + b(n_1 + n_2))$$

This previous expression represents the agents on side A who will multihome both platforms, as a function of the number of agents who singlehome on the other side. These agents are better off using both platforms at the same time. They get more utility from it rather than singlehoming.

Differently from Case 1, in respect to the total demand of a platform, we count, not only those who singlehome the specific platform, but also those who multihome. So, in this case, for platform 1, we will have the following demand:

$$\eta_1 + \Gamma = \frac{1}{t}(t+p_2 + v_1 - v_{12} - bn_2) + \frac{1}{t}(-t - p_1 - p_2 - v_1 - v_2 + 2v_{12} + b(n_1 + n_2))$$
$$= \frac{1}{t}(-p_1 - v_2 + v_{12} + bn_1)$$

We can point out, on side A, the only price from which the total demand of platform 1 depends on it's their own p_1, the price set by them to group A agents. The smaller this price is, the bigger demand they will have, *ceteris paribus*. This translates that, in a set-up with multi-homing, no strategic interaction in prices are visible, only through n_1.

From its rival point of view, platform 2, we will have the following expression:

$$\eta_2 + \Gamma = \frac{1}{t}(t + p_1 + v_2 - v_{12} - bn_1) + \frac{1}{t}(-t - p_1 - p_2 - v_1 - v_2 + 2v_{12} + bn_1 + bn_2)$$
$$= \frac{1}{t}(-p_2 - v_1 + v_{12} + bn_2)$$

Analogously, after having the set up on side A, we are now focusing on the side where group B agents who are indifferent between: *(i)* participate only in platform 1 or multihoming, *(ii)* participate only in platform 2 or *(iii)* multihoming are analytically defined by the two equalities below:

$$\begin{cases} \mu_1 - \rho_1 - \tau x + \beta(\eta_1 + \Gamma) = \mu_{12} - \rho_1 - \rho_2 - \tau + \beta(\eta_1 + \eta_2 + \Gamma) \\ \mu_2 - \rho_2 - \tau(1-x) + \beta(\eta_2 + \Gamma) = \mu_{12} - \rho_1 - \rho_2 - \tau + \beta(\eta_1 + \eta_2 + \Gamma) \end{cases}$$

$$\Leftrightarrow \begin{cases} x_{B,12} = \frac{1}{\tau}(\tau + \mu_1 + \rho_2 - \mu_{12} - \beta\eta_2) \\ x_{B,21} = -\frac{1}{\tau}(\mu_2 + \rho_1 - \mu_{12} - \beta\eta_1) \end{cases}$$

From these, following the same procedure as before, we have the exclusive demands that translate singlehomers. In case of platform 1, it has this amount of exclusive agents:

$$n_1 = \frac{1}{\tau}(\tau + \mu_1 + \rho_2 - \mu_{12} - \beta\eta_2)$$

Whereas, for platform 2:

$$n_2 = 1 - x_{B,21} = 1 - \left(-\frac{1}{\tau}(\mu_2 + \rho_1 - \mu_{12} - \beta\eta_1)\right) = \frac{1}{\tau}(\tau + \mu_2 + \rho_1 - \mu_{12} - \beta\eta_1)$$

Similarly, we have also to express the multihomers on side B market, which are obtained residually, so from the total agents we remove the singlehomers:

$$N = 1 - n_1 - n_2 = 1 - \frac{1}{\tau}(\tau + \mu_1 + \rho_2 - \mu_{12} - \beta\eta_2) - \frac{1}{\tau}(\tau + \mu_2 + \rho_1 - \mu_{12} - \beta\eta_1)$$
$$= \frac{1}{\tau}(-\tau - \mu_1 - \mu_2 - \rho_1 - \rho_2 + 2\mu_{12} + \beta(\eta_1 + \eta_2))$$

With the exclusive demands and also with the multihomers, we are capable of understanding how the total demands are on side B of the market. For platform 1 and Plafrom2 we have respectively a total demand of:

$$n_1 + N = \tfrac{1}{\tau}(\tau + \mu_1 + \rho_2 - \mu_{12} - \beta\eta_2) + \tfrac{1}{\tau}(-\tau - \mu_1 - \mu_2 - \rho_1 - \rho_2 + 2\mu_{12} + \beta\eta_1 + \beta\eta_2)$$
$$= \frac{1}{\tau}(-\mu_2 - \rho_1 + \mu_{12} + \beta\eta_1)$$

$$n_2 + N = \tfrac{1}{\tau}(\tau + \mu_2 + \rho_1 - \mu_{12} - \beta\eta_1) + \tfrac{1}{\tau}(-\tau - \mu_1 - \mu_2 - \rho_1 - \rho_2 + 2\mu_{12} + \beta\eta_1 + \beta\eta_2)$$
$$= \frac{1}{\tau}(-\mu_1 - \rho_2 + \mu_{12} + \beta\eta_2)$$

Using these expression, as well as equivalent ones to the other side, described in appendix, we will have a final system of four equations, under self-fulfilled demands by consumers who singlehome, express the following solution for each:

$$\begin{bmatrix} \eta_1 = \frac{1}{b\beta - t\tau}(b\tau - t\tau + b(\mu_2 - \mu_{12}) + b\rho_1 - \tau p_2 - \tau(v_1 - v_{12})), \\ \eta_2 = \frac{1}{b\beta - t\tau}(b\tau - t\tau + b(\mu_1 - \mu_{12}) + b\rho_2 - \tau p_1 - \tau(v_2 - v_{12})), \\ n_1 = \frac{1}{b\beta - t\tau}(t\beta - t\tau + \beta(v_2 - v_{12}) + \beta p_1 - t\rho_2 - t(\mu_1 - \mu_{12})), \\ n_2 = \frac{1}{b\beta - t\tau}(t\beta - t\tau + \beta(v_1 - v_{12}) + \beta p_2 - t\rho_1 - t(\mu_2 - \mu_{12})) \end{bmatrix}$$

With the previous results, the total demands can be now seen in its final form.

$$n_1 + N = \frac{1}{b\beta - t\tau}(b\beta - t\beta + t(\mu_2 - \mu_{12}) + t\rho_1 - \beta p_2 - \beta(v_1 - v_{12}))$$

$$n_2 + N = \frac{1}{b\beta - t\tau}(b\beta - t\beta + t(\mu_1 - \mu_{12}) + t\rho_2 - \beta p_1 - \beta(v_2 - v_{12}))$$

$$\eta_1 + \Gamma = \frac{1}{b\beta - t\tau}(b\beta - b\tau - b(\mu_1 - \mu_{12}) - b\rho_2 + \tau p_1 + \tau(v_2 - v_{12}))$$

$$\eta_2 + \Gamma = \frac{1}{b\beta - t\tau}(b\beta - b\tau - b(\mu_2 - \mu_{12}) - b\rho_1 + \tau p_2 + \tau(v_1 - v_{12}))$$

Using the demand expressions, we will be capable of studying the profits for each platform.

So, the profit functions can now be expressed as a function of firms' strategic choices (their respective prices in each side of the market) and parameters of the model. Differently from Case 1, for the multihoming framework, we must have into account, not only the consumers who singlehome, but also the ones who multihome. So, for platform 1, group A agents who multihome (Γ) pay the same price (p_1) as the agents who singlehome. The same for group B agents, both N and n_1 end up paying the same price, in this case ρ_1. The agents who multihome will also pay the price for platform 2. They are better off subscribing the two.

Hence, for platform 1, we have:

$$\pi_1 = (\eta_1 + \Gamma)p_1 + (n_1 + N)\rho_1$$

$$\Leftrightarrow \ \pi_1 = \begin{pmatrix} p_1\left(\dfrac{1}{b\beta - t\tau}(b\beta - b\tau - b(\mu_1 - \mu_{12}) - b\rho_2 + \tau p_1 + \tau(v_2 - v_{12}))\right) + \\ \rho_1\left(\dfrac{1}{b\beta - t\tau}(b\beta - t\beta + t(\mu_2 - \mu_{12}) + t\rho_1 - \beta p_2 - \beta(v_1 - v_{12}))\right) \end{pmatrix}$$

In the same manner, in platform 2, group A agents who multihome (Γ) pay the same price as singlehomers pay, more precisely p_2. The same for group B agents, both N and n_2 end up paying the same price, in this case ρ_2. The profits for platform 2 can be expressed by:

$$\pi_2 = (\eta_2 + \Gamma)p_2 + (n_2 + N)\rho_2$$

$$\Leftrightarrow \ \pi_2 = \begin{pmatrix} p_2\left(\dfrac{1}{b\beta - t\tau}(b\beta - b\tau - b(\mu_2 - \mu_{12}) - b\rho_1 + \tau p_2 + \tau(v_1 - v_{12}))\right) + \\ \rho_2\left(\dfrac{1}{b\beta - t\tau}(b\beta - t\beta + t(\mu_1 - \mu_{12}) + t\rho_2 - \beta p_1 - \beta(v_2 - v_{12}))\right) \end{pmatrix}$$

When looking for the profit-maximizing pricing strategies of each platform, an important information about a profit function is to know whether it is concave or not. Being concave means that profits will increase as prices increase till a point in which the firms make the maximum profits. If prices keep increasing after this point, profits will decrease. This profit function is concave, as proved in appendix. This happens, because in the domain of parameters we are looking at here, the more platforms increase their prices, the less demand they will have. Since, the utility of consumers decreases and as a consequence they become less interested in subscribing the platform.

The group of equilibrium prices are obtained by calculating the first order condition of each price, as described on appendix.

Proposition 2. In equilibrium with fulfilled expectations, when firms are allowed to offer goods with differentiated stand-alone value and agents allowed to multihome, equilibrium prices are equal to:

$$\begin{cases} \rho_1^* = \dfrac{1}{b\beta - 4t\tau}(b\beta^2 + b\beta\tau - 2t\beta\tau + 2t\tau(\mu_2 - \mu_{12}) + b\beta(\mu_{12} - \mu_2) + \beta\tau(v_{12} - v_1)), \\ \rho_2^* = \dfrac{1}{b\beta - 4t\tau}(b\beta^2 + b\beta\tau - 2t\beta\tau + 2t\tau(\mu_1 - \mu_{12}) + b\beta(\mu_{12} - \mu_1) + \beta\tau(v_{12} - v_2)), \\ p_1^* = \dfrac{1}{b\beta - 4t\tau}(b^2\beta + bt\beta - 2bt\tau + 2t\tau(v_2 - v_{12}) + b\beta(v_{12} - v_2) + bt(\mu_{12} - \mu_1)), \\ p_2^* = \dfrac{1}{b\beta - 4t\tau}(b^2\beta + bt\beta - 2bt\tau + 2t\tau(v_1 - v_{12}) + b\beta(v_{12} - v_1) + bt(\mu_{12} - \mu_2)) \end{cases}$$

Corollary 2. If we apply symmetry to these equations, meaning $v_1 = v_2 = \mu_1 = \mu_2 = v$; $\mu_{12} = v_{12} = w$; $b = \beta$ and $t = \tau$ we will have the following expression as the equilibrium price:

$$p_1^* = p_2^* = \rho_1^* = \rho_2^* = \frac{b^2 + (b - t)w + (-t - v)b + vt}{b - 2t}$$

Proof: Follows directly *Proposition 2*, letting $v_1 = v_2 = \mu_1 = \mu_2 = v$; $\mu_{12} = v_{12} = w$; $b = \beta$ and $t = \tau$.

Corollary 3. If restrict our symmetric approach to the situation in which platforms are only equivalent in terms of transportations costs and the benefits of being part of the network, more precisely $b = \beta$ and $t = \tau$, our equilibrium price will be instead:

$$\begin{cases} \rho_1^* = -\dfrac{1}{4t^2 - b^2}(bt(v_{12} - v_1) + \mu_{12}(b^2 - 2t^2) + \mu_2(2t^2 - b^2) + b^3 + tb^2 - 2bt^2), \\ p_1^* = -\dfrac{1}{4t^2 - b^2}(bt(\mu_{12} - \mu_1) + v_{12}(b^2 - 2t^2) + v_2(2t^2 - b^2) + b^3 + tb^2 - 2t^2 b), \\ \rho_2^* = -\dfrac{1}{4t^2 - b^2}(bt(v_{12} - v_2) + \mu_{12}(b^2 - 2t^2) + \mu_1(2t^2 - b^2) + b^3 + tb^2 - 2bt^2), \\ p_2^* = -\dfrac{1}{4t^2 - b^2}(bt(\mu_{12} - \mu_2) + v_{12}(b^2 - 2t^2) + v_1(2t^2 - b^2) + b^3 + tb^2 - 2t^2 b) \end{cases}$$

Proof: Follows directly *Proposition 2*, letting $b = \beta$ and $t = \tau$.

The previous four equation equilibrium prices, specifically *Corollary 2*, are now the object of our analysis, where we allow for asymmetric stand-alone values, investigating how variations on the stand-alone value can affect equilibrium prices.

3.2.1. Comparative statics

In this section, following the same structure as for Case 1, we present a comparative static analysis in order to better understand how prices can change as a result of possible deviations on the exogenous variables corresponding to the parameters of the model.

Analysis of stand-alone value's impact on prices

As we did for case 1, here we are analysing the impact of deviations on platform 1's stand-alone values in equilibrium prices. We will analyse, using the four equilibrium prices equations, calculated under symmetry among $b = \beta$ and $t = \tau$,to measure the impact that deviation on the value of v_1 can have on the final equilibrium prices $\rho_1^*, p_1^*, \rho_2^*$ and p_2^*. For simplicity, we are focusing our study on effect of v_1 only:

$$\frac{d\rho_1^*}{dv_1} = \frac{-bt}{b^2 - 4t^2}$$

If b^2 is greater than $4t^2$ the denominator will be positive. So, since the signal of the numerator is negative, given $b > 0$ and $t > 0$, the effect is depending on the signal of the denominator. Considering *Assumption 3,* if we impose the symmetry restriction it, we will see that the denominator is negative, given that: $4t\tau > (b + \beta)^2 \Leftrightarrow 4t^2 > b^2$ making the effect of increasing v_1 on ρ_1^* positive, meaning that this price will increase. Thereby, in a multihoming framework with the characteristics described above, an increase in the intrinsic value that platform 1 offers to group A agents will increase the price offered by this platform to group B agents. For instance, if Facebook make a significant increase in its intrinsic value and improve its platform functionalities to its users, they will likely charge the less sensitive side: advertisers. This last group will pay the bill for an improvement on the value offered in the other side. The platform aims at having as many users as it can. This is very relevant for social networking platform, for instances. These compete not only for registration of new users but also for their attention, meaning that, in order to be a strong network, they need active users (at least one access per month) who spend more and more time on the platform. Furthermore, the more active they are, the more data the platforms gets, allowing to have a better understanding about the consumers they have. In a market where almost, every platform offers its services for free, having a differentiated value becomes important. This will help the platform increasing its revenues from the other side.

$$\frac{dp_1^*}{dv_1} = 0$$

Here, we can see that an increase in v_1 will not make a deviation on the price offered by platform 1 to group A agents. This means that, even though the platform is improving its offer to these agents by increasing their utility through v_1, they are not asked to pay a higher price. Like described on the previous case, this is usual for the less price-sensitive side in a two-sided market. The platform is trying to make loyal group A agents and try to attract more of them, subsidizing this strategy by increasing the price offered to group B agents.

$$\frac{d\rho_2^*}{dv_1} = 0$$

An increase in the intrinsic value offered by platform 1 to group A agents does not deviate the price platform 2 ask on group B side. So, these two are related. Hence, the strategy taken by platform 1 will not affect this particular price of its rival.

$$\frac{dp_2^*}{dv_1} = \frac{2t^2-b^2}{b^2-4t^2}$$

Regarding the denominator, as said before, if b^2 is greater than $4t^2$ it will be positive, otherwise negative. Under asymmetry, *Assumption 3,* implies that the denominator is negative. Regarding the numerator is not so clear, and its signal will depend on the values attributed to the transportation costs (t) and to the benefits of being part of the two-sided network (b). So, under asymmetry, in the case where $2t^2 > b^2$, we will have a positive numerator and a negative denominator, making a final negative effect. Meaning that an increase in v_1 would have a negative impact on p_2^*. On the other hand, if $2t^2 < b^2$, platform 1 increasing its intrinsic value to group A agents, would make platform 2 increase its price to the same agents. Thirdly, it is also possible that $2t^2 = b^2$, which would produce a neutral effect, meaning that this strategic move by platform 1 would not affect the price set by its rival to the same group of agents.

For the present set up, it is also relevant to analyse and understand what are the implication for prices after deviations on the intrinsic value for those who multihome. We have followed the same procedure but this time in respect to v_{12}, the intrinsic value delivered to group A agents who multihome.

Additionally, since we are dealing with a different case of the model, exploring a set up with multihoming, we have also measured the effects on v_{12}:

$$\frac{dp_1^*}{dv_{12}} = \frac{dp_2^*}{dv_{12}} = \frac{b^2-2t^2}{b^2-4t^2}$$

We have found the same result in respect to the prices offered by both rival platforms. So, when v_{12}, the intrinsic value to multihomers on side A is increased, the prices from both platform 1 and 2 will change in the same mode. When everything is asymmetric, the final result depends on how much b and t differ one from another. If $b^2 > 2t^2$ the numerator will be positive, meaning that prices will increase if b^2 is also greater than $4t^2$. Prices increase as well, if both numerator and denominator are negative ($b^2 < 2t^2$ and $b^2 < 4t^2$). The effect will be neutral in case b^2 has the same value as $2t^2$. We will have a negative effect, in case they have the opposite signal, for instance if $b^2 > 2t^2$ but $b^2 < 4t^2$. Considering the symmetric approach, *Assumption 3* turns the denominator into negative, since $4t\tau > (b+\beta)^2 \Leftrightarrow 4t^2 > b^2$. So, an increase on v_{12} will increase prices if $b^2 < 2t^2$. If the opposite condition verifies, prices will decrease. When $b^2 = 2t^2$, prices do not change.

$$\frac{d\rho_1^*}{dv_{12}} = \frac{d\rho_2^*}{dv_{12}} = \frac{bt}{b^2-4t^2}$$

From this result, we can infer that an in increase in the intrinsic value for multihomers on side A will have an impact in the same manner on prices offered on the other side. Given that b and t are both positive, when the denominator is positive ($b^2 > 4t^2$), an increase on v_{12} will increase prices offered on B side. When the numerator is negative, meaning that $b^2 < 4t^2$, these prices will decrease. Bearing in mind the symmetric approach, since the denominator is negative, the final effect will also be negative, given that the numerator is positive. So, when multihomers on side A get more intrinsic value on their utility, platforms will offer to group B agents lower prices.

3.3. Case 1 vs Case 2: comparison of results

In the following table, we summarise and compare the results obtained in Case 2, multihoming allowed, to those of Case 1, only singlehoming. For simplicity, the table only shows the results for the effects of deviation in the value of v_1 on the equilibrium prices. These effects translate are only those under asymmetry among variables, meaning that $\beta = b$ and $\tau = t$.

		p_1	ρ_1	p_2	ρ_2
v_1	$Case\ 1$	+	Neutral	-	Neutral
	$Case\ 2$	Neutral	+	- /+/Neutral	Neutral

Table 2. Synthesis of the results for case 1 versus those of case 2

We can see that for ρ_2 the same results were obtained. In both cases, either with or without multihoming, an increase in v_1 does not change the price offered by platform 2 to group B agents. In regard to p_1, we can see different results. When there is no multihoming, the effect will be positive over this price. So, when agents are not able to multihoming, if platform 1 increases its intrinsic value to group A agents, this group will face a higher price in exchange. On the other hand, when agents can maximize their utility by multihoming, if platform 1 increases v_1 this group of agents will not face a price increase, but group B agents will face instead, as the results for ρ_1 tell. On the singlehoming case we have experienced the opposite results. To sum up, when platform 1 increases v_1 for group A agents, in the singlehome framework, group A agents will face a price increase and not group B agents; whereas, in the case for multihoming, group B agents face the price increase, while the other group stay unaffected. In relation to p_2 we can see a negative deviation for the singlehoming framework, whereas for multihoming, the results are not so clear. The estimation of this effect for case 2, will depend on how $2t^2$ compares to b^2. If the first is bigger, the effect will be negative, if the opposite registers, the effect is positive; in case of equality $(b^2 = 2t^2)$, the effect we get is neutral.

In the past, some authors have found that when one side multihomes, such as Belleflamme & Peitz (2010), the other side feels no incentive in multihoming. The reason lies on the lack of strategic interaction under multihoming. Agents are able to reach agents from the other side through one platform while multihoming, therefore, on the other side, they prefer to singlehome. They do not need to multihome in both sides to reach the same group of agents. As meantioned in the Literature Review chapter, Gabszewicz & Wauthy (2004) suggested that the price competition is often relaxed in a setup with multihoming. In opposition, under singlehoming, platform have to battle intensively for each agents on both sides. We explain it with a recent example. Let's only consider two social networks: Facebook and Instagram. Some users are only registed in one of the two, but many hold an account in both at the same time. On the other side, and advertiser may prefer to only invest in publicity in Facebook, given that it will reach many of Instagram users, since they multihome, instead of spending more money in advertising in both platforms.

4. Conclusion

The present dissertation represents an effort to enrich the economic study of two-sided markets. More precisely, it is aimed at better understanding the role of the intrinsic or stand-alone value that platforms offer to their users. As mentioned throughout the present work, network effects, cross and same-side effects, play truly a key role on the dynamics of two-sided markets and we made sure they were evident on the model.

Because it is so common to see platforms across different industries, we thought it would be important to study the incentives agents have to distinguish between their services. These two-sided platforms very often practice different prices to each side. Usually the most price sensitive side is charged less. Hereby, it is relevant to understand which are the economic consequences of increasing the stand-alone value offered to one group of agents.

The model that inspired this work, Armstrong & Wright (2007), found that exclusive contracts are a vital weapon on two-sided markets, providing strategic advantages to attract and keep buyers. Their equilibrium shows losses for platform on buyers' side and gains on the sellers' side that actually compensate those losses. We have seen authors, such as Belleflamme & Peitz (2010), defending that when one side multihomes, the other side does not need to multihome. For this reason, multihoming ends up lacking strategic interaction, since platforms do not need to work so hard to attract users like they have to in the singlehoming case.

On the other hand, our focus was on the effect of platforms' investment to enhance their value offers to consumers using a model that contemplates heterogeneity among variables. To do this, our methodology of analysis consisted on a comparative static analysis of stand alone value's impact on prices on the two cases we have studied. The first, represents strong product differentiation on both sides without multihoming, while the second case allows agents to multihome.

After, testing how the value added by platforms trades-off with the level of prices, we found different answers and issues in the two cases. On the singlehoming model, we saw that, with symmetric network effects and symmetric transportation costs, an increase in the stand-alone value to a group of agents will directly affect the price charged to those agents. In an opposite direction, in a two-sided market with multihoming, the same strategy will lead to changes on the price charged in the other side by the same platform. When the market is asymmetric, we have seen that the results depend on the relationship between some variable.

In the singlehoming case, we saw that some results would depend on the intensity of cross-network effects, meaning how b compares to β. If the first is greater than the second, an increase on the stand-alone value for that side would lead to an increase in the price offered to the other group of agents. Otherwise, we would have the opposite effect.

In regard the multihoming case, when a platform increases the stand-alone value to one group of agents, the other group will have its price increased by the same platform. As stated before, we have also experienced results that show lack of strategic interaction. For the case of testing how an increase in the stand-alone value to group A agents would affect the price offered by the rival to that same agents, we would need to know exactly how the value of $2t^2$ compares to that of b^2. For example, if the first surpasses the second, this price would decrease.

During the elaboration of this work, we have tried to develop a model to test how an investment in the intrinsic value can change consumers' consumption optimal choices, by transforming the intrinsic value from an exogenous variable into an endogenous choice of the platform. Platforms would have to decide either to increase the quality offered in one side of the market or not. We consider this question interesting for a future research with the aim to find out the level of ideal investment in the stand-alone value by one platform that would monopolize all agents and eradicate the rival.

Since most free platforms are now offering different types of subscription to agents, some are paid and others are not, that contain access to special functionalities. We can take Amazon Prime and LinkedIn Premium as examples. It would be interesting to study how much the stand-alone value for a paid service has to change from the stand-alone value for a free service in order to compensate the strategy.

5. Appendix

Proof of Proposition 1

Prices that maxime the profits of platform 1

We start by calculating the price for group A agents that maximizes the profits, given other price strategies taken by the platforms (i.e the platform's own strategy for the other side oft he market and the rival's pricing strategies in both sides oft he market). For this, we have to calculate the derivative of the profit function for platform 1 with respect to p_1:

$$\frac{d\pi_1}{dp_1} = \frac{d}{dp_1}\begin{pmatrix} \frac{p_1}{2(b\beta - t\tau)}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \frac{\rho_1}{2(b\beta - t\tau)}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix} = 0$$

$$\Leftrightarrow \frac{1}{2(b\beta - t\tau)}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta\rho_1 + \tau(2p_1 - p_2) - \tau(v_1 - v_2)) = 0$$

$$\Leftrightarrow p_1 = -\frac{1}{2\tau}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta\rho_1 - \tau p_2 - \tau(v_1 - v_2))$$

So, this is the expression that translates the price that platform 1 sets to group A agents, the sellers, in order to maximize its profits . In the game, it represents the best response for the variable p_1. On the other side, for group B agents, we make a similar calculation, so that we have the expression for the best response of ρ_1:

$$\frac{d\pi_1}{d\rho_1} = \frac{d}{d\rho_1}\begin{pmatrix} \frac{p_1}{2(b\beta - t\tau)}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \frac{\rho_1}{2(b\beta - t\tau)}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix} = 0$$

$$\Leftrightarrow \frac{1}{2(b\beta - t\tau)}(b\beta - t\tau - t(\mu_1 - \mu_2) + t(2\rho_1 - \rho_2) + bp_1 + \beta(p_1 - p_2) - \beta(v_1 - v_2)) = 0$$

$$\Leftrightarrow \rho_1 = -\frac{1}{2\tau}(b\beta - t\tau - t(\mu_1 - \mu_2) - t\rho_2 + bp_1 + \beta(p_1 - p_2) - \beta(v_1 - v_2))$$

The previous expression represents the price that platform 1 sets to group B agents, the buyers, with the objective of maximizing its profits.

Prices that maximise the profits of platform 2

For group A agents, we have to calculate the derivative of the profit function with respect to p_2. We ant to find the price this platform should offer to the sellers:

$$\frac{d\pi_2}{dp_2} = \frac{d}{dp_2}\begin{pmatrix} p_2(1 - \frac{1}{2b\beta - 2t\tau}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \rho_2(1 - \frac{1}{2b\beta - 2t\tau}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix} = 0$$

$$\Leftrightarrow \frac{1}{2(b\beta - t\tau)}(b\beta - t\tau + b(\mu_1 - \mu_2) - b(\rho_1 - \rho_2) + \beta\rho_2 + \tau(2p_2 - p_1) + \tau(v_1 - v_2)) = 0$$

$$\Leftrightarrow p_2 = -\frac{1}{2\tau}(b\beta - t\tau + b(\mu_1 - \mu_2) - b(\rho_1 - \rho_2) + \beta\rho_2 - \tau p_1 + \tau(v_1 - v_2))$$

Similarly, platform 2 has to understand what to do on the other side. So, for group B agents, the buyers, following an analogous method, we have the expression for ρ_2:

$$\frac{d\pi_2}{d\rho_2} = \frac{d}{d\rho_2}\begin{pmatrix} p_2(1 - \frac{1}{2b\beta - 2t\tau}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \tau(p_1 - p_2) - \tau(v_1 - v_2)) + \\ \rho_2(1 - \frac{1}{2b\beta - 2t\tau}(b\beta - t\tau - t(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \end{pmatrix} = 0$$

$$\Leftrightarrow \frac{1}{2(b\beta - t\tau)}(b\beta - t\tau + t(\mu_1 - \mu_2) - t(\rho_1 - 2\rho_2) + bp_2 - \beta(p_1 - p_2) + \beta(v_1 - v_2)) = 0$$

$$\Leftrightarrow \rho_2 = -\frac{1}{2\tau}(b\beta - t\tau + t(\mu_1 - \mu_2) - t\rho_1 + bp_2 - \beta(p_1 - p_2) + \beta(v_1 - v_2))$$

This is the best response function for platform 2 that maximize profits. We have now calculated the pair of prices for platform 2, p_2 and ρ_2.

Nash equilibrium in prices

As stated before, under a situation of Nash equilibrium, every agent is playing its best response given the expectations he has regarding other players' decisions. Agents decide having in mind others agents' incentives and do not desire to deviate from this strategy. In this case, after solving for each platform and for each price, we now have four linear functions:

$$\begin{cases} p_1 = -\frac{1}{2\tau}(b\beta - t\tau - b(\mu_1 - \mu_2) + b(\rho_1 - \rho_2) + \beta\rho_1 - \tau p_2 - \tau(v_1 - v_2)) \\ \rho_1 = -\frac{1}{2\tau}(b\beta - t\tau - t(\mu_1 - \mu_2) - t\rho_2 + bp_1 + \beta(p_1 - p_2) - \beta(v_1 - v_2)) \\ p_2 = -\frac{1}{2\tau}(b\beta - t\tau + b(\mu_1 - \mu_2) - b(\rho_1 - \rho_2) + \beta\rho_2 - \tau p_1 + \tau(v_1 - v_2)) \\ \rho_2 = -\frac{1}{2\tau}(b\beta - t\tau + t(\mu_1 - \mu_2) - t\rho_1 + bp_2 - \beta(p_1 - p_2) + \beta(v_1 - v_2)) \end{cases}$$

The solution to this system of four equations and four unkonws corresponds to the equilibrium prices represented in *Proposition 1*.

Proof of Proposition 2

Prices for platform 1 and for platform 2

After solving this system, we were able to get the final equations used in the main text. The total demands equations result from solving the following equations:

$$n_1 + N = \left[\frac{-\mu_2 - \rho_1 + \mu_{12} + \beta\eta_1}{\tau}\right]_{\eta_1 = \frac{1}{b\beta - t\tau}(b\tau - t\tau - b(\mu_2 - \mu_{12}) + b\rho_1 - \tau p_2 - \tau(v_1 - v_{12}))}$$

$$n_2 + N = \left[\frac{-\mu_1 - \rho_2 + \mu_{12} + \beta\eta_2}{\tau}\right]_{\eta_2 = \frac{1}{b\beta - t\tau}(b\tau - t\tau - b(\mu_1 - \mu_{12}) + b\rho_2 - \tau p_1 - \tau(v_2 - v_{12}))}$$

$$\eta_1 + \Gamma = \left[\frac{-p_1 - v_2 + v_{12} + bn_1}{t}\right]_{n_1 = \frac{1}{b\beta - t\tau}(t\beta - t\tau - t(\mu_1 - \mu_{12}) - t\rho_2 - \beta p_1 + \beta(v_2 - v_{12}))}$$

$$\eta_2 + \Gamma = \left[\frac{-p_2 - v_1 + v_{12} + bn_2}{t}\right]_{n_2 = \frac{1}{b\beta - t\tau}(t\beta - t\tau - t(\mu_2 - \mu_{12}) - t\rho_1 + \beta p_2 + \beta(v_1 - v_{12}))}$$

Given the relation between the agents' location variables, we can express them in the following way:

$$n_1 + N = 1 - n_2 = \frac{1}{\tau}(-\mu_2 - \rho_1 + \mu_{12} + \beta\eta_1)$$

$$n_2 + N = 1 - n_1 = \frac{1}{\tau}(-\mu_1 - \rho_2 + \mu_{12} + \beta\eta_2)$$

$$\eta_1 + \Gamma = 1 - \eta_2 = \frac{1}{\tau}(-p_1 - v_2 + v_{12} + bn_1)$$

$$\eta_2 + \Gamma = 1 - \eta_1 = \frac{1}{\tau}(-p_2 - v_1 + v_{12} + bn_2)$$

The concavity of the profit function was understood by the analyse of the second order differential:

$$\frac{d}{dp_1}\left(\frac{d}{dp_1}\begin{pmatrix} p_1\left(\frac{b\beta - b\tau - b\mu_1 - b\rho_2 + b\mu_{12} + \tau p_1 + \tau v_2 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_1\left(\frac{b\beta - t\beta + t\mu_2 + t\rho_1 - t\mu_{12} - \beta p_2 - \beta v_1 + \beta v_{12}}{b\beta - t\tau}\right)\end{pmatrix}\right) = 2\frac{\tau}{b\beta - t\tau} < 0 \text{ if } b\beta < t\tau$$

$$\frac{d}{d\rho_1}\left(\frac{d}{d\rho_1}\begin{pmatrix} p_1\left(\frac{b\beta - b\tau - b\mu_1 - b\rho_2 + b\mu_{12} + \tau p_1 + \tau v_2 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_1\left(\frac{b\beta - t\beta + t\mu_2 + t\rho_1 - t\mu_{12} - \beta p_2 - \beta v_1 + \beta v_{12}}{b\beta - t\tau}\right)\end{pmatrix}\right) = 2\frac{t}{b\beta - t\tau} < 0 \text{ if } b\beta < t\tau$$

Afterwards, using the profit function, we found the equilibrium prices by solving the system with the first order condition, more precisely:

$$\frac{d}{dp_1}\begin{pmatrix} p_1\left(\frac{b\beta - b\tau - b\mu_1 - b\rho_2 + b\mu_{12} + \tau p_1 + \tau v_2 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_1\left(\frac{b\beta - t\beta + t\mu_2 + t\rho_1 - t\mu_{12} - \beta p_2 - \beta v_1 + \beta v_{12}}{b\beta - t\tau}\right)\end{pmatrix} = 0$$

$$\frac{d}{d\rho_1}\begin{pmatrix} p_1\left(\frac{b\beta - b\tau - b\mu_1 - b\rho_2 + b\mu_{12} + \tau p_1 + \tau v_2 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_1\left(\frac{b\beta - t\beta + t\mu_2 + t\rho_1 - t\mu_{12} - \beta p_2 - \beta v_1 + \beta v_{12}}{b\beta - t\tau}\right)\end{pmatrix} = 0$$

$$\frac{d}{dp_1}\begin{pmatrix} p_2\left(\frac{b\beta - b\tau - b\mu_2 - b\rho_1 + b\mu_{12} + \tau p_2 + \tau v_1 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_2\left(\frac{b\beta - t\beta + t\mu_1 + t\rho_2 - t\mu_{12} - \beta p_1 - \beta v_2 + \beta v_{12}}{b\beta - t\tau}\right) \end{pmatrix} = 0$$

$$\frac{d}{d\rho_1}\begin{pmatrix} p_2\left(\frac{b\beta - b\tau - b\mu_2 - b\rho_1 + b\mu_{12} + \tau p_2 + \tau v_1 - \tau v_{12}}{b\beta - t\tau}\right) + \\ \rho_2\left(\frac{b\beta - t\beta + t\mu_1 + t\rho_2 - t\mu_{12} - \beta p_1 - \beta v_2 + \beta v_{12}}{b\beta - t\tau}\right) \end{pmatrix} = 0$$

Solving the four equations above for the equilibrium prices, we get the results in *Proposition 2*.

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