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Network Effects on Platform Markets. Revisiting the Theoretical Literature

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Abstract: The characteristics of the bilateral network markets were already studied before 2003, but they focused on specific markets (credit cards or newspaper advertising) without relating implications with third parties. But since the emergence of new business models based on digital platform markets, especially since 2007 with the arrival of the smartphone, business scalability and network effects have skyrocketed. In this article, we carry out a review of the main contributions on network effects in the markets and their implications for the governance of platforms, which is of vital importance to understand the regulatory impacts when trying to limit the effects. negative effects of the market power. In the end, we found that in most studies, same-sided negative network effects are rarely considered, so despite multiple analyzes and empirical studies, there may still be some blind spots in the analysis of the network effects for the platform economies that can be transcendental for the understanding of all the market variables affected by the governance of platforms in monopolistic competition.

Keywords: network effects; platform economy; governance; market power; bilateral market.

JEL classification: D47; L12; Y30.

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1. INTRODUCTION

The rapid development of digital platforms is currently at the heart of the issues analyzed by industrial organization theory. These intermediary platforms provide a transaction cost solution that blurs the traditional boundaries between the two predominant forms of organization. of economic activity and causes the alteration of costs enabled by new digital technologies (Sundararajan, 2016).

In the last two decades, a new current of study has emerged around what is already a paradigm within the economic field: the so-called "Platform Economies based on digital environments". We specify the term “digital”, because prior to the emergence of smartphones, and with it, the vertiginous development of platform economies, other types of economic platforms existed and persist, such as electronic payment platforms (Visa, Mastercard, or American Express) which are echoed in the first two articles collected in this study (Rochet & Tirole, 2002; Caillaud & Jullien, 2003). In a certain way, those authors launched the theoretical foundations allowing us to understand the functioning of the mechanisms that have led these economic platforms to develop spectacular and very rapid growth over time.

After examining multiple papers on the subject, the underlying question seems to be the following: the new competitive scenarios in digital markets are generating situations of market monopoly power as if the scenario generated through the mechanism of the platform economy, would necessarily lead to a situation of natural monopoly. There are currently many examples, without a doubt the most notorious is the conglomerate formed by the American company "Meta" (Facebook, Instagram, WhatsApp) which tries to unite, in the West, the monopoly of social networks. But there are many more examples, even without considering China, of digital companies that try to impose themselves as companies with monopoly power in the market (Google, Uber, Amazon, and a long, etc.). This leads us to a new problem: how to raise the fight of state regulatory bodies against the negative effects derived from monopolistic behavior or contrary to free competition, which is exercised in the field of new digital platforms? In this sense, it is highly instructive to read the report prepared by Motta and Peitz (2020) for the European Commission concerning intervention triggers and underlying theories of harm, in which they outline the difficulties that regulatory bodies encounter when it comes to detecting collusive behavior and monopolistic practices in digital markets. Also, Katz (2019) or Evans (2019) identify that there are critical aspects in which the body of academic knowledge does not provide useful advice to the agencies and courts in charge of enforcing competition law.

All this has led us to try to achieve a greater understanding of the fundamental element that underlies this "new" economic system and where there is academic consensus when determining that network effects are the true catalyst source of the growing market power.

Notwithstanding, from our point of view after analyzing several case studies, it is not entirely easy to understand the implications of this complex mechanism in which direct and indirect cross-network effects are intertwined with respect to other complementary markets, adding to other effects difficult to determine.

There are numerous studies such as Armstrong (1998), Berry *et al.* (1999), Spulber and Yoo (2002), Roson (2005), Rysman (2009), Katz (2019) or Halaburda and Yehezkel (2019) that affect issues related to network markets in platform economies, but the vast majority focus on certain aspects and characteristics that affect only part of the framework of network

effects that underlie each of the markets. In this article we assemble these investigations into three thematic fields that are influenced by these network effects.

Our effort to bring together articles of a theoretical nature as opposed to empirical ones is what causes most of the selected articles to be "older", the research production after them being focused on empirical studies on certain specific topics. Even so, these also offer us interesting theoretical advances, such as Chen *et al.* (2022). Another selection criterion for the articles has been their influence on the number of citations by other researchers. Although that has not been our main selection criterion, its own theoretical interest, it has guided us when deciding on one or another author when it was a coincident topic.

As we have commented previously, it was not until the publication of the article "Platform Competition in Two-Sided Markets" by Rochet and Tirole (2003), as well as "Chicken and egg: competition among mediation service providers" by Caillaud and Jullien (2003), that a wide variety of articles have emerged focusing on the study of network effects applied to bilateral platforms in the digital market.

The purpose of this article is to present a critical review of the existing literature, on how, the measurement, and implications of network effects in the so-called platform markets in the digital have been treated. We take advantage of this introduction to justify the selection of the articles that we have used in this review. Although they all deal, with one approach or another, with issues that affect or are affected by network effects in platform economies, we have found it convenient to include in this review those that have been cited most frequently in numerous subsequent investigations. In the following chapter we will make a detailed summary of the analysis and argumentation used by these researchers around network effects, and we end with an outline of the approaches that are the subject of this review. Our goal is to facilitate the understanding of theoretical advances in the field of market competition on digital platforms and to understand the implications for current competitive models characterized by increasingly frequent development of monopolistic behavior and market failures. Moreover, this also seems to be of general importance to policymakers.

2. THEORETICAL FRAMEWORK

2.1 Introduction

The study of network effects is important, in economic terms, because its design generates the adhesion of many users, charging a potential economic value due to the implications of managing a channel of communication, dissemination, and exchange among its members.

One must go back to Euler (1736) (Nielsen, 1999) to find the first introduction to the study of these connections, with his magnificent mathematical solution to the "seven bridges of Königsberg" dilemma, orchestrating the first graph theory to solve these problems. Mathematically, a graph G is defined as the pair of sets $G = (V, E)$, where $V$is a set of nodes $\{v_1, \dots, v_n\}$ and E is a set of links $\{e_1, e_2, \dots, e_m\}$ between pairs of nodes of V, $e_k \equiv e_{ij} = \{v_i, v_j\}$ (that is, $E \in VxV$).

From this approach, many contributions have emerged to try to determine the potential scope of network effects. For example, the well-known Metcalfe's Law (Nielsen, 1999), established a network evaluation rule considering the number of users that a network has, as

well as the subjective evaluation of everyone for belonging to said network. It is a linear assessment in which the user values positively the fact that there are other users connected to the network, and benefits from it, which will result in a multiplicative value for the number of existing users (except in the assessment of himself).

However, Nielsen (1999) proposes that if a very large network is partitioned into N disconnected components, considering p = 1, then the value of that subnetwork will be (following Metcalfe's law)

$$V_{subred} = \frac{1}{N(N-1)} = \frac{1}{N^2 - N}$$

Existing N subnets in the partition, we would have: $V_{N\ subredes} = \frac{N}{N^2-N} = \frac{1}{N-1}$

That is, from a network that is worth n^2we are left with a sum of networks that in total are worth $1/n$.

Newman (2003), establishes another method to obtain a global value of the grouping from the fraction of existing triangles in the graph with respect to the total number of possible triangles of contiguous nodes that can be defined in a graph with the same number of nodes.

$$\text{Clustering coefficient: } C = \frac{number\ of\ triangles\ in\ the\ network}{maximum\ number\ of\ possible\ triangles}$$

But Euler's solution and the ones that followed, like Newman (2003) that preceded it, do not explain the mechanism by which a network, which generates the adhesion of many users, has a potential economic value by itself. In what way does it serve as a catalyst for the information it generates, and what are the implications for dissemination and exchange among its members.

There is consensus in the academic field that the enhancement of network effects in digital markets has introduced new competitive scenarios with a tendency to concentrate market power. It is not possible to regulate a market trying to prevent anti-competitive conduct without a good understanding of the operation and dynamics of network effects in these markets.

The most recurrent themes in these articles speak, for the first time, of "bilateral markets" (network effects and the chicken-and-egg problem had already been discussed for decades), mixing in many cases the literature on the " network economics" and the "multiproduct pricing". These authors observed that the platforms that operate in the bilateral markets focus on the structure of their prices rather than on their total level. Among the many problems analyzed, in this paper we observe three axes around which our work is developed. In the following Section 2.2 we expose both the approach by Belleflamme and Peitz (2015) and the one proposed by Caillaud and Jullien (2003) where they analyze the model from the point of view of competition price imperfection between intermediary service providers. In Section 2.3 we identify the different approaches to one of the platform markets that raises the most debates: "competition between matchmakers". For this, we have selected authors such as Hagiu and Wright (2015), Galeotti and Moraga-González (2009), and Haucap and Heimeshoff (2014). In this section, we derive a subject as relevant as Multihoming, from which apparently contradictory conclusions are drawn regarding pricing strategies for brokerage platform owners. In Section 2.4 we address one of the critical aspects of the design of the digital platform. Here, in the hands of Caillaud and

Jullien (2003), Rochet and Tirole (2003), Hagiu and Wright (2015), and Haucap and Heimeshoff (2014), we see the characteristics that platform governance must have to optimize its performance and how it affects the surplus of users or the benefit of the platform. To conclude, we propose how these three sections come together when explaining how the platforms internalize the Indirect Network Effects to gain greater shares of market power, even when the calculation of the maximization of benefits can generate the establishment of prices. negative (a form of subsidy) on one of the sides, even above the Marginal Cost, which raises concern in the antitrust authorities (Jullien, 2004). And if negative prices cannot be established on the one hand, rates are reduced on the other. The result is a profit-maximizing monopoly platform that internalizes Indirect Network Effects, which is in line with the social criterion of total welfare maximization.

Table no. 1 – Summary of selected articles arranged chronologically

Selected articles	Description	Conclusion	Issue for research paper
"**Chicken and egg: competition among intermediation service providers"** Caillaud and Jullien (2003)	*"They lay the foundations for the study of network effects in two-sided markets"*	*"It is proved that, under the assumption that any generated matching surplus is shared efficiently, the efficient market structure can be either monopolistic or duopolistic, and that equilibrium always exists with the efficient market structure. But inefficient trade-offs also exist, especially when matching technology is effective or the ability to rely on transaction fees is limited."*	*Modeling the demand for a network good / Platform Governance*
"Platform competition in two-sided markets" Rochet and Tirole (2003)	*"Analyzes the different effects on the price and consumer surplus according to the type of governance of the platform and its user subsidy policy"*	*"A market with network externalities is bilateral that platforms can subsidize even by discriminating between different categories of end users. It also highlights reasons why platforms may be unable to cross-subsidize."*	*Modeling the demand for a network good / Platform Governance*
"Platform intermediation in a market for differentiated products" Galeotti and Moraga-González (2009)	*"They carry out a study of how sellers of differentiated products compete for consumers within the platform, and how the platform manager must price their services to buyers and companies to maximize profits."*	*"If the platform was limited and for example positive subscription fees could not be established for consumers, then it would increase the offer fees and result in an inefficient number of offers. An increase in the number of retailers increases the degree of variety on the platform, but at the same time increases competition. Anticipating that the equilibrium price of goods will fall, the platform lowers the rates paid by companies and increases the rates paid by consumers."*	*Competition between matchmakers*

Selected articles	Description	Conclusion	Issue for research paper
"Two-sided platforms: Product variety and pricing structures" Hagiu (2009)	*" Indirect network effects are determined endogenously, by variety and competition between producers, pointing to three important characteristics of platform markets"*	*"The result of the study is the obtaining of three key ideas about the behavior of the prices of the bilateral platforms. It first identifies the intensity of consumer preferences for variety as a key factor driving platform pricing structures. Second, it demonstrates that cross-platform competition can create counterintuitive dynamics and run counter to conventional wisdom derived from earlier models. Third, it rationalizes platform usage fees as a result of a conflict between two objectives: to provide appropriate investment incentives to producers and to reduce a platform retention problem that arises when producers make their decisions. of platform adoption before consumers."*	*Competition between matchmakers*
"Marketplace or Reseller?", Hagiu and Wright (2015)	*"They try to explain the reasons that motivate an intermediary to become a "marketplace" (bilateral market) or a "reseller" (unilateral market)."*	*"Intermediaries should choose the market model for the following types of products: (1) products for which providers have a significant (respectively small) information advantage about how best to market products relative to the intermediary, (2) products whose prices and marketing activities have limited (respectively, large) indirect effects on other products, (3) long-tail (respectively, short-tail) products when the market mode has a marginal cost disadvantage (respectively, advantage) and (4) products provided by late-stage (respectively, early-stage) ventures."*	*Platform Governance*
"**Industrial Organization. Markets and strategies"** Belleflamme and Peitz (2015)	*"Indirect Network Effects Arising from Product Variety in the Context of Monopolistic Competition"*	*"Indirect network effects can arise in a buyer-seller context due to the effect of consumer participation on quality, price, and variety. But, in the reduced form, the consumer's utility ultimately depends directly on the number of consumers"*	*Modeling the demand for a network good*

Selected articles	Description	Conclusion	Issue for research paper
"Google***, Facebook, Amazon, eBay: Is the Internet driving competition or market monopolization?*** **"** Haucap and Heimeshoff (2014)	*"They highlight how the different types of network effects affect and determine the monopolistic tendencies of digital platforms as opposed to traditional platforms."*	*"The existence of a single large market from an economic point of view is usually efficient since it allows to reduce search costs for consumers, which could not happen if there were many small markets. This situation would occur in the case of a centralized market. To conclude, the authors affirm that the success and market power obtained by the platforms are based on two main axes: high switching costs and enormous externalities or network effects."*	*Platform Governance*
"Platforms and Network Effects" Belleflamme and Peitz (2018)	*"They highlight that in most markets, user benefits depend on the participation and usage decisions of other users that result in network effects. Being the intermediaries that manage these network effects and, therefore, act as platforms that bring users together."*	*"They explain the functioning of the platform structures depending on whether they act as singlehoming (as would be the case of the "Amazon Marketplace" platform) or as Multihoming (real estate portals). Multihomed sellers have access to all buyers but pay the switching cost that buyers have. Buyers are better off in the multihoming environment because they benefit from higher seller participation and lower fees. As for sellers, they prefer the singlehoming environment."*	*Modeling the demand for a network good*
"Platform governance design in platform ecosystems: Implications for complementors' multihoming decision" Chen *et al.* (2022)	*"It explains the multilateral interdependence between different producer groups within a platform ecosystem. We theorize about how the governance design of platform owners can create friction between platform providers"*	*"The resulting complexity of the new ecosystem created on the platform not only counteracts the rival's ability but also discourages the practice of multihoming by users. On the contrary, the study shows that in the case of an open governance design, it is the complementors who must bear the cost of misalignment and the resulting frictions."*	*Competition between matchmakers*

Sursa: own elaboration

2.2 Modelling the demand for a network good

To quantify the network effects subject to a wide variety of markets in the current boom of the so-called Platform Economy, multiple methods have emerged in the economic literature that start from the axiom that the demand for any good or service affected by network effects, tends to increase as the size of the network to which it is associated expands. Amazon, PayPal, Microsoft, Apple, Twitter, and Salesforce are some of the most

impressive and relevant companies in the world and specifically in the digital economy. Although quite different in many ways, there is a single property that defines them all and is behind their success: how they manage the network effect.

Therefore, using the demand for a good as an econometric predictor can generate difficulties due to correlations with unobserved attribute variables, and even -from a dynamic point of view- due to learning effects. Its execution is further complicated by the appearance of new products and services generated in this context, forcing us to carry out a more elaborate analysis of indirect network effects (Belleflamme & Peitz, 2015).

The mechanism of the game would be sequential: first *n* consumers buy the hardware, for example, a smartphone (they do not know the number of applications that will be available in the second period). The programmers observe the adoption decision of the consumers and provide *m* variety of software (APP) in the second period.

Consumers have the following utility function (Belleflamme & Peitz, 2015):

$$U = q_0 + \mu\left[\left(\int_0^m q_j^{\rho}\, dj\right)^{1/\rho}\right]^{\beta} \tag{1}$$

where, q_0 is the amount of the external good,

μ denotes the type of consumer

$q_j$the amount of software j.

As far as software utility is concerned, Belleflamme and Peitz (2015) employ a CES utility function to capture the idea that the software service level increases proportionally with the variety of software packages available. To do this, they impose a standard restriction that ensures the operation of monopolistic competition: $0 < \rho < 1$ and $\beta < \rho$ (Which implies that the marginal benefit of an additional variety of software is decreasing).

Let be $I$the numeraire amount of income of all consumers, which they will be able to spend either on the competitively supplied external good, or on hardware sold at price $p_h$and each variety j of software sold at price p_j.

Let be $E = \int_0^m p_j q_j\, dj$the total spending on software,

We can express the consumer's budget constraint as:$q_0 + p_h + E = I$

Combining the last expression with (1), we can write the consumer's indirect utility in purchasing the hardware/software combination as:

$$v = I - p_h - E + \mu\left[\left(\int_0^m q_j^{\rho}\, dj\right)^{\frac{1}{\rho}}\right]^{\beta} \tag{2}$$

The approach that emerges from this formulation only indicates that users obtain the utility of a system that combines hardware and software, but the purchase of hardware independently does not offer any utility to the user.

In this market structure, the number of firms adjusts so that each software firm's profit equals zero, given that the firms face negatively sloping demand with zero equilibrium profit due to the free entry of competitors.

The CES utility function implies that firms have a price elasticity of $1/(1-\rho)$ and a constant monopoly margin of $(1-\rho)/\rho$. The monopoly price for each variety j is, therefore, $p_j = \frac{c}{\rho}$ and the zero-profit condition implies

$$(p_j - c)q_j - f = 0 \Leftrightarrow q_j = \frac{\rho}{1-\rho}\frac{f}{c} \equiv q \tag{3}$$

Considering this condition valid for all companies in the industry, we equate the total fixed costs to the total income within the industry (mf). While the total income comes from the n buyers who jointly demand the combination of software/hardware (nE). Therefore: $mf = nE$, which means that the number of computer programs is determined endogenously as$m = nE/f$.

Now we can plug qy $m$into expression (2) and get:

$$v = I - p_h - E + \mu q^{\beta}\left(\frac{nE}{f}\right)^{\frac{\beta}{\rho}} = I - p_h - E + \mu A n^{\alpha} E^{\alpha} \tag{4}$$

With $\alpha \equiv \frac{\beta}{\rho}$and $A \equiv \frac{q^{\beta}}{f^{\alpha}}$maximizing expression (4) for the optimal spending E on software, we find:

$$E^{*} = (\mu\alpha A n^{\alpha})^{\frac{1}{1-\alpha}} \tag{5}$$

Substituting (5) into (4), we get the "**indirect utility of a consumer based on the number of consumers who buy the hardware/software combination":**

$$v = I - p_h + \mu^{\frac{1}{1-\alpha}} K n^{\frac{\alpha}{1-\alpha}}, \quad (6) \tag{6}$$

with

$$K \equiv (1-\alpha)(\alpha A)^{\frac{1}{1-\alpha}}$$

The corollary drawn from this reasoning is that "indirect network effects can arise naturally from the interrelationship between buyers and sellers due to the effect of consumer influence on product variables such as quality, price, and variety. But, that consumer's utility ultimately depends directly on the total number of consumers. The more consumers, the greater influence.

This corollary is a good argument for why hardware companies try to include software applications in their devices, so by internalizing the demand for them by linking it to their devices, they manage to seize the consumer surplus that was available to purchase the devices. device apps independently. In other words, manufacturers take advantage of the complementarity of both services to package the final product and thus achieve a greater increase in demand without having to lower the price of the device.

Graphically would like this:

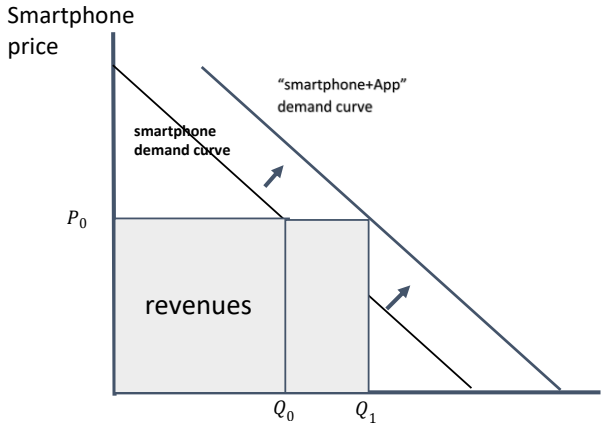

Figure no. 1 – Extension of demand holding the price constant
Source: author's elaboration

We have just seen how providers of two complementary services take advantage of synergies within the network industry and the corollary is quite intuitive. However, this model already anticipates the preponderant role played by the intermediary platform. In this case, Caillaud and Jullien (2003) analyze the model from the point of view of imperfect price competition between intermediary service providers.

Perhaps one of the most interesting findings they make is that intermediaries have incentives to offer non-exclusive services, since this moderates competition and allows them to exercise market power. they study the competition between intermediaries observing that platforms act as matchmakers, even using sophisticated prices such as registration fees, and transaction fees whenever the intermediaries carry out transactions. In fact, another contribution is to show that the dominant intermediary companies, when they want to prevent entry, are better off charging transactions instead of registration prices. They also show that competition is more intense when platforms fail to deter *multihomer*.

The authors' approach not only highlights the relevance of indirect network externalities for an intermediation platform but also reveals the importance of the possibility for users to use the non-exclusive services of different intermediaries. Given that the new digital platforms operate in multilateral markets, serving at least two different groups of users, who expect higher profits the greater the number of users on the other side of the market, this is known as market externalities. indirect network. Indirect externalities give rise to a "chicken and egg" problem: to attract buyers, the intermediary must have a large base of registered sellers, but they will only be willing if they expect many buyers. So, what comes first: the chicken or the egg? (For example: "On Tinder", a user will register on the platform if they know that there is a wide variety of users on the other side of the market and, for them, it will be attractive to participate in this app if they know that there will be more users each time, otherwise it would be of no use to them).

Another existing network effect and, in addition, from which digital platforms generally also benefit, is the direct. That is, the value of a product increases when the number of its users on the same side of the market increases. (Instagram, the value of this

social network increases as registered users increase, that is, as an Instagram user I will only use this app if I know that my friends will also use it).

Throughout the article, various propositions are developed, considering in the first place a basic model (framework) with exclusive services, that is: "a simple pairwise matching model, with two homogeneous populations, labeled as $\{i = 1\ y\ 2\}$, each of which consists of in a mass of ex-ante identical agents. For a given broker, there is only one pairing on the other side of the market with whom the trade is valuable; the total gross profit from trade between matching partners is normalized to one." Matching partners follow an efficient trading process until the transaction price is reached. The efficient negotiation process determines the optimal price of the transaction, linearly distributing the trade surplus between the two agents ($1\ y\ 2$). Although we have normalized the participation surplus to 1, u_1, u_2, the truth is that if we consider a better negotiating position for agents of type 2 (for $u_1 + u_2 = 1$), makes $u_2 \geq \frac{1}{2} \geq u_1$, then the intermediary's technology identifies the coincident matches, effectively reducing the costs of search associated with the exchange process. Let us remember that the Belleflamme and Peitz (2015) proposal established the utility of users as a function that depended on two complementary goods (2). However, now we are witnessing the confrontation of the utilities of two types of users who simply exchange goods or services through an intermediation platform, and we verify that the network effects are used by the matchmaker to deploy its profit-maximizing strategy.

2.3 Competition between matchmakers

Two matchmakers, $k \in \{I, E\}$, compete using the same intermediation technology, each of them assuming a cost c_i. We assume that intermediation is efficient if $\lambda > c \equiv c_1 + c_2$. The two options for intermediaries are: a) charge each user a connection fee; b) charge each user a registration fee. In both cases, the matchmaker can apply a subsidy that would translate into a negative price, with the aim of stimulating adherence to its exchange platform.

It should be borne in mind that the option of applying a transactional fee means that the net profits of the trading users will depend on the sum of the transaction fees, that is, the cost of the total transaction, under the conditions of a trading solution of Nash or a price that equals the net utilities of the users. Thus, in this basic model, a first proposition is proposed in which it is established that with exclusive intermediation services, an intermediary (which would be the dominant company) captures all the users, simply subsidizing the registry and charging the maximum transaction price. But for the rule general, the services of intermediation, especially those based on the Internet, are not exclusive. So, users could use several platforms simultaneously, which we call "multihoming". Also, we assume that the processes of the pairing of the " matchmakers" are independent. Then, when $j - users$ they do " multihoming ", a $i - user$ could have two reasons for doing it: first, increases the probability of pairing Y, second, in the case of a double pairing, the $i - users$ can save money in the rates transaction, since, can conclude the transaction a through of intermediary with the rates of the transaction plus low.

But most Internet services are not exclusive, and therefore users can use the services of both matchmakers simultaneously looking for the best option. It is what is called in the jargon: " multihoming ", which allows the user to conclude the transaction through the

intermediary that offers the lowest transaction fee. Then the market allocation is defined, in the case of multihoming, as $N = \{n_i^I, n_i^E, n_i^M\}$, where $n_i^I \; o \; n_i^E$, are the masses of users $i$that are associated with one or the other platform, exclusively, and n_i^Mcorresponds to that mass of users that are associated with both platforms simultaneously (doing multihoming). When $\lambda(1-\lambda) < c$, market efficiency requires a single operator for everything i; but when $\lambda(1-\lambda) > c$, it will be more efficient to multi-home globally. We thus reach the second proposition, which it analyzes the two possible best responses for the platform depending on whether the players perform multihoming or grant exclusivity to the platform.

An interesting implication of these propositions, in relation to the network effects of the intermediation platform, is the one related to the exclusivity of choice and entry. And it is that exclusivity exacerbates competition between providers of intermediation services reducing profits to zero, while non-exclusivity (multihoming) allows a full range of strictly profitable equilibria.

In conclusion, we find that certainly, here network effects can favor market concentration, but they do not necessarily lead to a higher price or lower quality. On the contrary, in the presence of network effects, the existence of a single platform could maximize the welfare of consumers. Also, the transfer of these efficiencies is likely when at least one of the user groups can subscribe to several platforms by performing multihoming.

Hagiu (2009) extends this analysis by extracting key insights into the price behavior of two-sided platforms under network effects. It is really a combination of the two previous studies, in which consumers are interested in buying on a platform for a variety of products, and where producers compete together.

First, the intensity of consumer preferences for product variety has been identified as a key factor driving the pricing structure. If consumers have a high concern for this variety, the platform will take better advantage of the suppliers' side.

In addition to considering the preference for the variety of products, it is necessary to look at the bargaining power of the producers. Where, if the measure to reduce prices is ineffective, the strategies on the consumer side will be aimed at driving producers away from the platform because they bear a higher price. All this decreases if we introduce economies of scale. But for Hagiu (2009), network effects influence the economic factors that determine whether platforms should try to extract more benefits from consumers relative to producers or vice versa. To do this, the platform adjusts its price structure according to the bargaining power of the providers, which is determined by the network effects implicit in their incorporation to the platform, but this, in turn, is also determined by the intensity of consumers when joining the platform based on their preferences.

Galeotti and Moraga-González (2009) propose a game between three types of agents: the administrator of an exchange platform, N sellers and M consumers. In this game, the platform tries to attract the maximum number of vendors, with differentiated products, to incorporate the maximum number of consumers and vice versa. The first option that arises would be to apply an advertising fee for sellers and a subscription fee for consumers. With this approach, 2 stages arise in the game. In the first stage, the platform advertises its product and the price at which it is offered. In the second, it is the consumer who chooses the option that is most useful to him.

The problem arises to the extent that by increasing the number of sellers, the products become closer substitutes from the point of view of consumers and, therefore, the competition of the companies becomes fiercer, reducing profit margins of the companies.

The authors explain this result based on how it is related to the network effects that the two groups of participants exert on each other. Since the platform will now become more attractive to buyers, ceteris paribus, an increase in the subscription price for buyers will not decrease the participation of buyers since they obtain higher profits. Sellers, for their part, must increase the frequency of their ads, and pay the corresponding fee to the platform administrator, so that consumers can find (on average) a better match.

Therefore, a higher engagement rate from businesses would only be consistent with the expectation that consumers would also join the platform more frequently.

This argument is because the positive cross-network effects that characterize the trade-off between consumer share and firm share imply that monopoly platform profits are increased strictly by subscription fees. On the contrary, greater product differentiation softens the competition of companies within the platform, so prices will rise. As a result, business rates increase, and consumer charges also increase. The explicit model of interaction within the platform has been the focus of this article. When the platform administrator can charge businesses and consumers to participate, platform prices fully internalize the network externalities present in the market.

Chen *et al.* (2022), take a different approach when considering the interdependence between different producers within an ecosystem, in a multilateral way.

The hypothesis of Chen *et al.* (2022) is that the governance design of the platform can create friction between providers and developers within the platform. Governance that is more open to vendor autonomy can lead to a more complex ecosystem for software developers. This would be due to the fact that the complexity of the open system causes an increase in the cost of customization of the product by the developers. Let's take as an example the case of an application developer that must make the same application compatible for two operating systems as different as iOS or Android, or a game that could be available for the Switch or PlayStation platform.

This is an interesting proposal aimed at dissuading multihoming, by proposing that investments be made to customize the platform interface with a more complex ecosystem but one that includes complementary services that prevent the user from having to change platforms.

So far we have seen platform scholars argue that a platform owner should strive to make their platform more focused through quality-enhancing investments or advertising investments (Halaburda & Yehezkel, 2019), Chen *et al.* (2022), specify in their research that the platform must strive to attract an increasing number of complementors, which are the source of indirect network effects while preventing them from supplying the same complementary product to rival platforms, thus undermining the advantages derived from network effects, as well as its differentiated position in the market.

The result of the study by Chen *et al.* (2022), highlights that the resulting complexity of the new ecosystem created on the platform not only counteracts the rival's ability but also discourages the practice of multihoming by users. On the contrary, the study shows that in the case of an open governance design, it is the complementors who must bear the cost of misalignment and the resulting frictions.

2.4 Platform Governance

While Caillaud and Jullien (2003) focus their analysis on the possibilities of users having access to platforms with exclusive services or being able to access several platforms with the same service (multihoming), Rochet and Tirole (2003) focus their analysis on the management o platform governance by establishing a platform competition model with two-sided markets that determines pricing and sharing of end-user surplus based on different governance structures (profit-maximizing platforms versus non-profit joint ventures); that is, those platforms that are made up of a monopolist versus a platform made up of a planner that adopts the Ramsey price.

In most markets with network externalities, their main characteristic is the presence of two different sides whose final benefit derives from the interaction through a common platform. Platform owners must address the famous chicken-and-egg problem raised by Caillaud and Jullien (2003). Taking as an example that of video game platforms such as Sonic-Sega and Nintendo, which earn money for game developers through royalties per game unit, while on the side of the players it indicates fixed fees for kits or consoles of game; On the contrary, software development platforms for PCs and other devices have adopted an opposite business model, trying to maximize profit on the consumer side by marking the vendor side as the loss leader. Therefore, the choice of the business model seems to be the key to the success of a platform, since, as we have observed in different strategic approaches throughout history, we obtain totally different results.

Thus, a characteristic of these two-sided markets is that the platforms often treat one side as the center or support of their profits while the other side treats it as a leader in losses.

The interaction between the two sides gives rise to strong complementarities, which, according to the traditional oligopoly theory (Rochet & Tirole, 2003), are not assumed by the final users; On the other hand, in the theory of the network economy, these externalities are emphasized; and in the multi-product pricing literature, both monopolistic and competitive also emphasize cross-elasticities, which can also be affected by third-party intervention in the industry. We can see in the example proposed by Brunekreeft (2015), in which he raises the problem caused by the congestion of an electrical network. In this case, it refers to two possible solutions: either expand the network to relieve congestion or invest in a new storage facility (accumulators). But there would be a third solution that would allow it to maintain the installations without having to increase investments: the owner can choose to discriminate prices to different consumers and during different periods (consumption time slots) and obtain additional commercial income that would optimize the network while decongests the time slots most saturated by demand. Even so, he must consider the indirect effects caused by the strategy that he decides since that will determine the competitive strategy of his potential rivals in the market.

The analysis of bilateral markets becomes more complex in the presence of Multihoming, which is the possibility that several of the agents on one or both sides of the market can opt for different platforms, as would be the case of a credit card user credit that is available to pay with Visa or Mastercard, and in the same way the seller can make one means or the other available to you. “Multihoming on one side, therefore, intensifies price competition on the other side, as platforms use low prices to drive end users on the latter side into an exclusive relationship. Just as VISA would do to promote the use of its card against its rival AMERICAN EXPRESS”.

This working paper studies how the allocation of prices between the two sides of the market is affected by these six variables: platform governance, the end user cost of multihoming, platform differentiation, the ability of platforms to use volume-based pricing, the presence of externalities on the same side, and platform compatibility.

The starting point of the cross-analysis is a basic model in which it is assumed that end users do not incur fixed usage costs and that the price of the platform is linear, like that of credit cards. In this case, economic value is created through interactions or transactions between pairs of end users: buyers and sellers. These transactions are mediated by a platform. We assume in this model that the marginal platform cost of a transaction is denoted by $c \geq 0$. In the absence of usage costs and fixed fees, the demand of the buyers (sellers) will depend only on the price $P^b(P^s)$charged by the monopoly platform. There are network externalities in the sense that a buyer's surplus depends on the number of sellers. Thus, the buyers' demand function could be understood as a quasi-demand function (a function that is used to reflect the fact that, in a two-sided market, actual demand depends on the decisions of both buyer and seller users).

$$\pi = (p^b + p^s - c)D^B(p^b)D^S(p^s)$$

Maximizing the profit function of the monopolist as the owner of the network through the first-order condition, we obtain the following equality

$$(D^B)'^{D^S} = D^B(D^S)'$$

The volume of the impact of a small price change has to be the same on both sides. Introducing the quasi-demand elasticities, and $\eta^B = \frac{p^B(D^B)'}{D^B}$, $\eta^S = \frac{p^S(D^S)'}{D^S}$the monopolist's prices can be characterized by a two-sided formula that is reminiscent of Lerner's formula: $p^B + p^S - c = \frac{p^B}{\eta^B} = \frac{p^S}{\eta^S}$=> in effect, the total price $p = p^B + p^S$chosen by the monopolist is given by Lerner's classic formula: $\frac{p-c}{p} = \frac{1}{\eta}$or $p = \frac{\eta}{\eta-1}c$, where $\eta = \eta^B + \eta^S$is the total volume of elasticity.

Therefore, Proposition 1 is as follows: a platform monopoly price $p = p^B + p^S$is given by Lerner's standard formula for the elasticity of the sum of two elasticities$\eta = \eta^B + \eta^S$

Next, the development of the argument continues, comparing this situation with that of a Ramsey monopolist, and later with a situation of competition between platforms, again comparing the different results.

A different approach to platform governance is proposed by Hagiu and Wright (2015) by focusing on the key difference between “reseller” and “marketplace”: the control exercised by the platform over non-contractual decisions that occur (price, distribution, marketing…). A marketplace will have little or no control over them (they fall to individual sellers) and a reseller will have high or total control over them (individual sellers become suppliers in this case).

Hagiu and Wright (2015) affirm that the reseller internalizes the externalities present in a bilateral market, turning it into a unilateral one. They are both intermediaries, but only one of them is a platform.

“Local information” refers to the knowledge sellers and intermediaries have about optimal levels of marketing, which can be more or less perfect. They cannot know the

optimal levels of marketing, but they can compare who has the most information, which will allow them to get closer to the optimal level of marketing.

Basic model

- They focus on the analysis of a single non-contractual relationship: promotional or marketing activities. They are carried out by the group that holds the control rights (marketplace sellers and reseller providers). The "local information" held by the vendors (marketplace) and the intermediary (reseller) is key.
- Demand: homogeneous consumers, must join the platform to consume. Marketing effects depend on private (not perfect) information and exhibit diminishing marginal returns. In the case of the marketplace, they do not pay an admission fee and do not have a surplus.
- Cost structure: in the base model it is assumed that the costs incurred by both models are equal, always having a positive benefit.
    - Marketplace: Sellers pay membership and transaction fees
    - Resellers: the platform incurs a fixed cost of quality control and inventory for each product it sells, in addition to its variable costs
    - Marketing: they are normalized with a cost 0
- Profit functions: the only difference between the profit functions of the two models is the variance of the "local information" of the individual sellers (marketplace) and the intermediary (reseller). In this way, the variance of this variable will determine the choice of one model or another based on the expected benefits.

The choice of one or the other model will be based on the "local information" of the intermediary and the sellers, defined through an inequality, which adds new terms that motivate the following results.

"Cross-product spillovers": marketing on one product affects others in its category. They are modeled linearly, and their presence motivates the choice of R over M. "Cost differences": the previous assumption of homogeneous cost structures is eliminated. If a model has lower costs, that will be chosen. In any other case, the results are ambiguous and may motivate the adoption of a hybrid strategy. "Network Effect with Unfavorable Expectations": ERIs are introduced for the first time in the model (in the form of vendor expectations). If they are unfavorable, their presence motivates the choice of R over M (due to the lower dependence of a reseller on Indirect Network Effects). This can also motivate the adoption of a hybrid strategy.

At the beginning of this chapter, we saw the analysis carried out by Rochet and Tirole (2003) on the behavior of a platform with monopoly power compared to one that applies Ramsey's social criteria. But what makes a platform able to obtain market monopoly power? Haucap and Heimeshoff (2014) analyze the different types of network effects that, in their opinion, affect and determine the monopolistic tendencies of digital platforms as opposed to traditional platforms.

For this, they distinguish between two types of Network Effects: Direct in which the utility of consumers increases directly with the number of other consumers on the platform (users benefit directly from the increase in users on their side of the market); and Indirect, in which the utility of consumers increases indirectly with the number of other consumers on the platform, as they attract more bidders.

In network effects, the following five points should be highlighted:

1. Degree of the strength of indirect network effects: the higher they are, the higher the concentration level. More users attract more providers, which makes the existence of a single platform more efficient than the existence of several.

2. Economies of scale (Degree of economies of scale): as we well know, those industries with economies of scale tend to present higher degrees of concentration.

3. Platform saturation (Capacity constraints): Traditionally it referred to the physical limitation of space, but nowadays it refers more to the advertising saturation that can occur when a single company dominates the market, saturating users and causing them to look for alternatives to it.

4. Degree of heterogeneity in the market (Scope of platform differentiation): the higher it is, the lower the concentration level. If we include several bidders and demanders with very different needs in a single platform, we increase transaction costs, so the platform loses its usefulness.

5. Platform change cost (Multihoming): the higher it is, the lower the level of concentration. If it is costly for the user to change platforms, they will tend to stay in the original one (loss of followers when you change social networks, the impossibility of transferring your good rating from one online sales platform to another...)

The externalities generated are also usually known as network effects that can be Direct when an increase in the use of a good causes its value to increase. It usually occurs in social networks, where access to valuable contacts translates into an increase in the recognition that social network receives.

But it is the Indirect ones that have great importance in the bilateral markets. It occurs when the increase in the use of a good causes the value and production of a complementary good to increase. An example would be eBay, where an increase in the number of potential buyers would attract a greater number of sellers as their chances of selling would increase.

The existence of a single large market from an economic point of view is usually efficient since it allows for reducing search costs for consumers, which could not happen if there were many small markets. This situation would occur in the case of a centralized market. In summary, the success and market power obtained by the platforms are based on two main axes: the high switching costs and the enormous externalities or network effects.

3. CONCLUSION

This review of the academic literature on how network effects work in platform markets shows that researchers have primarily focused on the cross-industry network effects of installed bases. They all start from the assumption that each unit sold adds one unit to the installed base and, therefore, remains active in the market indefinitely; however, intuition tells us that users can sign up for a platform and then become inactive after a while. Perhaps there is a potential gap in the actual number of subscribers in most networks that are often not considered when evaluating direct or indirect effects. This is a factor to consider when establishing market regulations that can sanction platforms based solely on their number of registered users.

We also find that in most studies, negative network effects on the same side are rarely considered, if adding more users to one side of the platform exerts positive network effects for adding more users. But in this review, which only includes a sample of what has been published so far, we have not found estimates of the possible negative effects that a possible

"saturation" could cause on the one hand. Think of an increase in Amazon buyers whose growth, initially, would positively influence the incorporation of more sellers (positive cross-effects), but a disproportionate growth in relation to the offer of buyers could result in a shortage of offers, and therefore in possible network congestion by buyers fed up with finding it difficult to match (direct negative network effects). This is perhaps most visible on social matchmaking platforms like Tinder, where an exacerbated increase in men relative to women would leave many of them dissatisfied, while the other side of the platform would need to attract more users to offset the imbalance. But for this, they must resort to negative rates (subsidies) to compensate the two sides of the market, which could be viewed with suspicion by a regulatory authority. This would be one more example of the difficulty in studying the mechanisms of action on a certain platform and explains why linear or rigid rules cannot be applied when detecting anti-competitive behavior.

Much remains to be investigated, and as more data becomes available, new empirical work may appear that helps to better understand the modeling of network effects in the platform economy.

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