Competition in high technology markets: multi-sided platforms and Google antitrust case

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Introduction

Over the last few decades, digital markets have been forcing their presence and peculiar features into the traditional economic space of *brick and mortar* businesses.

Nowadays, high technology markets seem to be jointly dominated by few large digital platforms, the so-called *Internet giants*: Amazon, Apple, Facebook, Microsoft and Google.

The subsequent dissertation intends to attentively analyze digital markets and their distinctive characteristics, offering a comprehensive overview of their functioning.

Together with an analytical evaluation, the study also qualitatively characterizes some typical welfare and competition policy implications within the technology space.

Chapter I offers a theoretical presentation of markets for network goods and their competitive dynamics. A market for a single network good is used as a starting point to examine the role of *network effects* in affecting users' utilities through the creation of an interconnected scheme of incentives.

The implications of compatibility choices in markets for several network goods are then depicted, both from a demand-side and a supply-side perspective, within which various standardization strategies are presented.

Afterwards, a public policy analysis of network markets is carried out. In particular, the new challenges faced by regulators and antitrust authorities are underlined, together with the necessity of an approach that would safeguard the competitive dynamics and the persistence of innovation incentives.

Chapter II narrows the focus on multi-sided platform businesses and two sided-markets.

The concept of market intermediation is firstly introduced, and the main roles fulfilled by intermediaries while entering transactions are described with their feasible business models.

The determinants of the peculiar pricing structure in two-sided markets are then carefully investigated through the presentation of some relevant literature in this respect.

The drivers of the pricing asymmetries are shown to be powerful cross-side externalities and differences in demand elasticities among the two sides.

Finally, two simple theoretical settings are modeled and discussed. The first relates to the platform's decision of price-discriminating among the two sides, based on the respective demand elasticities and the magnitude of the effect they exert on each other. Despite total welfare may increase in case of price discrimination, the distribution of costs between the two sides becomes increasingly uneven.

The second model aims to describe the composition, and possible evolution, of the advertisers' and users' sides in a media platform market.

After the stability analysis of the three possible equilibria, the model predicts that the solution with a positive number of participants on both sides becomes stable as soon as the content provided to users by the media platform is large enough. Therefore, it seems to exist a critical amount of content to attract an adequate mass of users that would trigger advertisers' participation. In addition to content capacity, the model also underlines the crucial importance of the search algorithm quality in determining profitability.

Chapter III consists in a more qualitative analysis of two-sided markets and their competition policy implications. The triparty antitrust investigation, currently being carried out by the European Commission against Google, is presented in detail.

Google business is disentangled in its most profitable components and its alleged anti-competitive practices are submitted, both from the European Commission perspective, and from the firm's defensive one.

Afterwards, the importance of the stock of data regarding past clicking behavior in search engine markets is scrutinized, not only in relation to market dominance but also to barriers to entry.

A further analysis of the role of big data in shaping competitive dynamics is offered through the work of Argenton and Prufer. Their policy proposal of a mandatory sharing of data to contrast concentration in search engine markets, is carefully examined and criticized, both from a modeling perspective and from a competition law one.

In the final section of the present study, the importance of prosecuting manipulation and abuse, rather than mere dominance is firmly underlined. Moreover, the traditional EU competition law framework, conceived for *brick and mortar* businesses, is called into question relatively to its capability to effectively deal with the new challenges imposed by Internet platforms.

Chapter I

Network markets and their characterization

With the term *network goods,* we define a category of products purchased by a community of users whose mutual benefits of employing them are somehow interdependent.

Differently from most traditional products, while consuming network goods, customers consider not only the intrinsic utility they extract from that specific good, but also all other users' behavior, which ultimately determines the size of the network. The source of the intrinsic utility is called *standalone benefit*, the factor related to other users is the *network benefit*.

Thus, the most important feature of network goods is that the benefit of an individual user increases with the number of other users of the same service, both directly and indirectly.

If we take *instant messaging* (IM) as an illustrative example of network good, the above distinction becomes very clear. On the one hand a larger base of users directly increases the number of potential contacts consumers can have, enhancing their communication capability. On the other hand, a larger base of customers induces providers to supply more and better features to be combined with the IM service, which in turn raises its attractiveness to buyers, further increasing their benefit indirectly.

As instant messaging services, a large majority of information and technology products exhibit the so-called *network effects*, that cause each user's utility to increase in the number of other users of the same product or of compatible ones. Consequently, other things being equal, the bigger the network the better for users.

The presence of network effects is observed in two different types of markets: communication markets and system markets.

Communication markets exhibit *direct* network effects. As consumers connect with each other via the network, the more agents in the network the larger their communication opportunities and the greater the incentive for other agents to join in turn the same network.

In system markets products are obtained by the combination of complementary components. Here network effects are *indirect*, virtual rather than physical, and come from the chain of interconnected incentives provided to each user that is active in the system. In the market for hardware and applications for example, the more hardware are sold, the more developers will be willing to write applications that are compatible with the hardware, which in turn raises the incentive for consumers to purchase the system.

Examples of goods exhibiting direct network effects are telephone, instant messaging, fax, email and even languages (people from all over the world learn English because many other people speak English in various environments). Indirect network effects are generally present in "two/multi- sided markets" such as Operating System (OS) markets, payment systems, dating websites, shopping malls.

As will be analyzed in *Chapter II*, these types of markets can be interpreted as platforms serving distinct groups of customers who value each other's participation and likelihood of concluding transactions.

Most information technology products exhibit also *switching costs,* which refer to the concept that buyers must bear some costs while switching from one product to another one that is functionally similar but supplied by a different firm. These costs arise from the fact that consumers engage in firm-specific investments. This implies that after having bought one product from a company, it is more valuable to keep on purchasing products from the same one due to consolidated brand awareness and time spent learning how to use the chosen product.

In case of Information and Communication Technology (ICT) products, these investments are either physical, involving complementary equipment and devices, or informational, meaning time spent in learning about products' characteristics and usage.

Despite both network effects and switching costs relate to the idea of compatibility, this concept is shaped differently in the two cases. When switching costs are present, compatibility may allow consumers to take advantage of the same investment between their own purchases.

With network effects instead, compatibility is intended as the opportunity to communicate directly with other consumers or to enjoy the same complements as them.

Given that, the larger the network, the larger consumers' willingness to pay to join it, network effects can be seen as "collective switching costs". Suppose there many different network and consumers choose to join the biggest one, switching to another network would entail not only the cost of losing the intrinsic functionality of the chosen service, but also the loss of the benefit deriving from belonging to a big network together with lots of other users.

In both situations, meaning markets characterized by either switching costs or network effects, history of past purchasing choices play a key role in predicting future dynamics, making prior market shares a highly valuable asset for suppliers.

In particular, switching costs may create rigidities that permit sellers to extract high rents from *locked-in*[1] consumers, charging them prices above the competitive level.

Network effects on the other hand may cause the so-called "snowball effect", meaning a large network self-fostering by creating positive expectations on its future size. The mechanism that trigger this amplifying effect, through which network effects exacerbate success as much as failure of competing firms, is called *market tipping*[2].

Despite the stickiness of switching costs has a more physical nature, while the rigidities caused by network effects derive from the lack of coordination tools among consumers, both switching costs and network effects are able to create market power.

Modeling the demand for a single network good

As we said above, consumers' willingness to pay for network goods depends positively on the number of other consumers purchasing compatible products. The typical utility function[3] for this type of goods is the following:

$$U_{ij} = a_i + f_i(n_j^e) \tag{1.1}$$

where U_{ij} is the utility that consumer i gets from belonging to network j. This utility formulation depends on two terms. The first is the standalone benefit, a proxy of the technology's intrinsic quality as perceived by consumers, while the second is the network benefit, that captures consumers' utility from being part of a big network.

It is assumed that $f(0) = 0$ and $f_i' > 0$, meaning that consumers get null network benefit in a network of size zero, but this benefit increases with the expected number of consumers that are joining the network (n_j^e).

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[1] With the term ***lock-in effect*** we refer to a practice companies use to make it extremely hard or disadvantageous for customers to stop purchasing from them, even willing to do so. This commonly happens in the presence of switching costs (either physical or informational) or network effects.

[2] We call ***tipping point*** the critical point in an evolving system that leads to a new and irreversible development. In network markets a tipping point is eventually reached when network effects of one player dominate those of the all the other ones. Usually, in the long run, the first player is the unique that remains active in the market, while the others are gradually forced to exit to avoid negative profits.

[3] The theoretical analysis presented in this chapter mainly follows Paul Belleflamme and Martin Peitz exposition in the manual "*Industrial Organization – Markets and Strategies*", 2nd edition, July 2015.

This utility expression strongly relies on the expectations about the size of the network, which are formed following the *fulfilled-expectations approach*, this implying that consumers base their current purchasing decision on their expectations about future network size. Thus, the focus of the model is restricted to equilibria in which the formed expectations turn out to be correct (i.e. *rational expectations*).

The model further assumes that network benefits increase linearly with the expected network size: $f_i\left(n_j^e\right) = v_i n_j^e$, with $v_i > 0$. Given that we focus our attention on the demand for a single network good the technology index *j* can be momentarily ignored.

The demand may be formed in two different ways, depending on the scenario we decide to analyze: (i) consumers value the network benefit differently but have the same standalone benefit ($a_i = a_k = a$ and $v_i \neq v_k$ for all i, k); (ii) consumers differ in their valuation of the standalone benefit but equally value the network benefit ($a_i \neq a_k$ and $v_i = v_k = v$ for all i, k).

In both scenarios, it is assumed to exist a continuum of consumers of mass one identified by a taste parameter θ. The taste parameter is uniformly distributed on the interval $[0,1]$ and its interpretation changes under the two scenarios.

Most electronics products are characterized by sequential adoption, meaning that there is a minority of early adopters with high θ that immediately purchase the product and a majority of mainstream consumers with lower θ that take a wait-and-see approach until the product has a consistent *installed base*[4]. Early adopters are keener in purchasing the network good either for the network benefit they get, or simply for the standalone benefit.

A textbook example of the first type of adopters are the buyers of early smartphones like BlackBerry. These were generally business people, way more attracted by the network benefits of staying connected anytime and anywhere, rather than by the standalone benefit individually derived from the device. On the contrary, early adopters of HDTV are mainly interested in the standalone benefits of enjoying high definition images and do not need to wait for too much content to be broadcasted or set for HDTV before buying.

In the first scenario, the taste parameter is related to the valuation of network effects that are consequently said to be heterogeneous. The utility function becomes:

[4] The ***installed base*** (or *user base*) measures the number of units that are present in a system, that is usually a platform or a generic network good. This measure is considered particularly relevant in the market for Information and Communication Technology (ICT) due to its superior informative content with respect to mere market shares, which only reflect sales over a specific period of time. The current installed base is a key determinant of the expected future size of a network and frequently includes a substantial portion of locked-in consumers.

$$U(\theta) = a + \theta v n^e \tag{1.2}$$

with n^e denoting the expected size of the network.

All consumers share the same valuation of the standalone benefit derived from purchasing the technology, while the importance assigned to the size of the network ranges between 0 and 1.

If technology is sold at a price p the net utility is defined as $U(\theta) = a + \theta v n^e - p$.

The "indifferent consumer", whose utility from purchasing the product can be normalized to zero, is identified by $\hat{\theta}$ such that

$$a + \theta v n^e - p = 0 \Leftrightarrow \hat{\theta} = \frac{p-a}{vn^e}.$$

Therefore, since all consumers with higher valuation than $\hat{\theta}$ will buy the technology, the size of the network can be written as $n = 1 - \hat{\theta}$. Substituting $\hat{\theta}$ with $1 - n$ we get the willingness to pay for having an additional nth participant to the network when n^e is its expected size:

$$p(n, n^e) = (a + \theta v n^e) - v n^e n. \tag{1.3}$$

This function decreases in n, as any well-behaved downward-sloping demand, but increases with n^e, due to the positive impact of network effects. Under the fulfilled-expectations approach, we can say that rational expectations formed by consumers turn out to be correct in the end, that is $n = n^e$. Then the willingness to pay becomes:

$$p(n, n) = a + vn(1 - n) \tag{1.4}$$

The above fulfilled-expectations demand curve matches each price p with an adoption level n, such that when buyers expect n as adoption level, only n of them will actually adopt the technology at price p. **Figure 1** below illustrates the construction of a typical fulfilled-expectation demand $p(n, n)$.[5]

[5] This formulation belongs to the paper *"The Economics of Networks"* – Economides (1996).

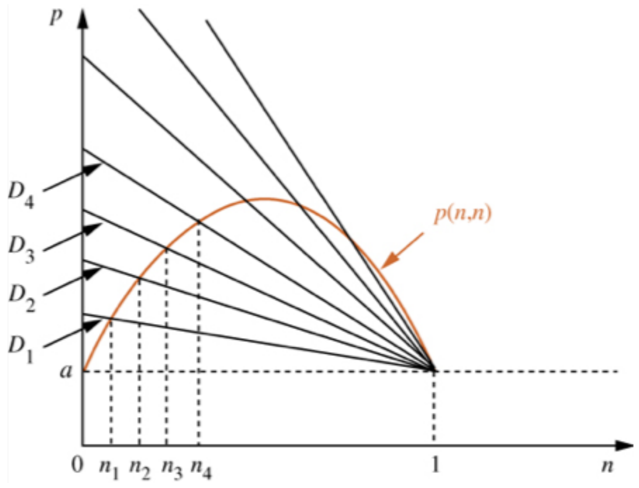

Figure 1 – Fulfilled-expectations demand when consumers value network benefits differently.
Source: *"Industrial Organization – Markets and Strategies"* by P. Belleflamme, M. Peitz.

Each curve $D_i = p(n, n_i)$ represents the willingness to pay for a varying quantity n, given an expected network size of $n = n_i$. At $n = n_i$ the expectations are fulfilled and the point belongs to $p(n,n)$. There may be more than one n, meaning more one network sizes, satisfying the equilibrium condition for a given price. **Figure 2** below illustrates this case:

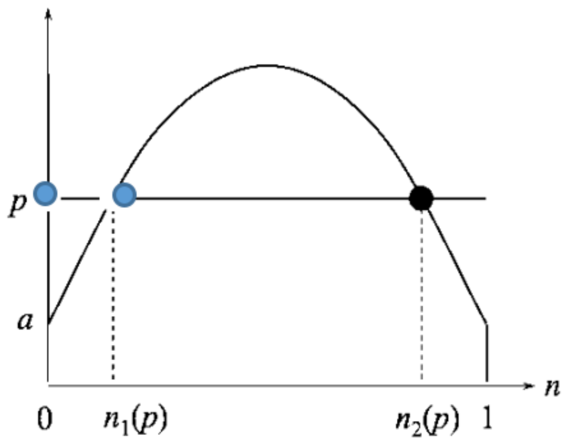

Figure 2 – Multiple equilibria for a given price in the network industry.
Source: *"Industrial Organization – Markets and Strategies"* by P. Belleflamme, M. Peitz.

In particular, there are 3 network sizes that are consistent with the price p: (i) a zero-size network in which no buyer buys the technology at $p > a$ due to pessimistic expectations relatively to the network size ($n^e = 0$); (ii) a small-size network in which, due to the expected small n, only a number $n_1(p)$ of buyers with large θ buys the technology; (iii) a large-size network, where a large fraction of buyers $n_2(p)$ expects a large n and consequently buys the good. In this case the last buyer purchasing the network good has a small valuation θ.

Since network effects influence consumers' utility differently, there often exist multiple consumer equilibria for a given selling price in the network industry. Each equilibrium relies on *self-fulfilling prophecies*[6] and the multiplicity follows directly from the lack of coordination and the presence of network effects. For instance, if consumers expect that no one will adopt the technology ($n^e = 0$), then their willingness to pay for the technology will be no larger than $a < p$. It follows that not joining the network is a Nash equilibrium for each consumer, which in turn fulfils their previous expectations about the future network size ($n_0 = n^e = 0$). Similarly, the other two equilibria are also determined by fulfilled expectations. In the first one there is a small portion of consumers that joins the network. Since the commonly shared expectation is that the network will not be very large in the end, not many consumers are willing to pay much to connect to the network, that will remain small as a result.

The same rule applies to the third equilibrium in which the same price gives rise to a larger network due to more optimistic expectations about the future number of technology adopters.

As multiple equilibria may occur, it may be necessary to develop a rule allowing to choose among them. The introduction in the model of some dynamic adjustment processes may help suggesting a possible solution.

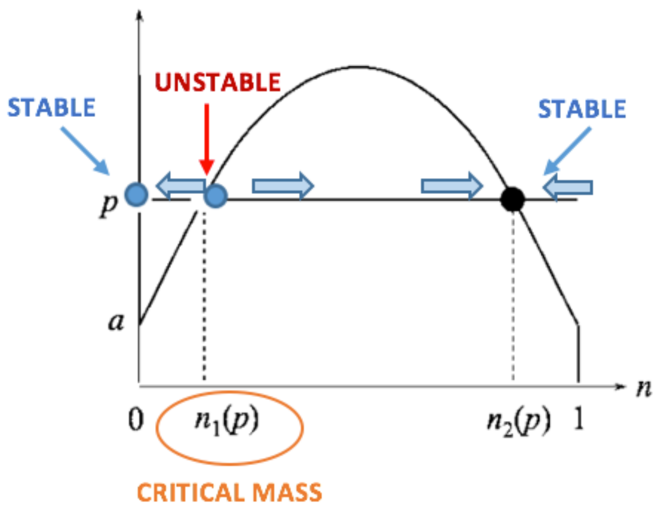

Figure 3 – Dynamic adjustment process with multiple equilibria in the network industry.
Source: *"Industrial Organization – Markets and Strategies"* by P. Belleflamme, M. Peitz.

[6] A ***self-fulfilling prophecy*** is a prediction that directly or indirectly causes itself to occur, due to a positive interdependence between agents' beliefs and behavior.

Starting from one of the three equilibria and then introducing a small price distress (or a slightly different choice by consumers) we can observe that only two of the three are stable equilibria. In particular, the small-network equilibrium $n_1(p)$ is the unstable one.

While analyzing $n_1(p)$ there are two scenarios to be considered. If the price slightly increases or some consumers withdraw from the network, we end up with a demand curve lying below the price line, which implies that consumers are willing to pay less than the price charged for the technology adoption. In this case it is plausible to assume that the market will gradually contract until it reaches the zero-size equilibrium.

Similarly, if the price is slightly reduced or an extra consumer joins the network of size n_1, the demand curve will be above the price line, meaning that consumers are willing to pay more than the effective cost of the product. Therefore, the market is likely to expand until it reaches the large-size equilibrium $n_2(p)$. The previous reasoning can be extended to conclude that once the network reaches the size $n_1(p)$, it is virtually certain that at some point it will reach a larger size $n_2(p)$. Consequently, the size $n_1(p)$ is called the *critical mass* of the network, meaning the required consumer base the network needs for a continuous expansion.

Applying the same exercise to both n_0 and $n_2(p)$ we conclude that they are equally stable.

To select between them we can opt for the *Pareto criterion*. This means that, if at a given price there exist more than one size satisfying the equilibrium condition and one of these sizes Pareto-dominates[7] the others, consumers expect this allocation to prevail in equilibrium.

In our case everyone would be better off by coordinating on the large-size equilibrium where consumers attribute a larger value to the network good.

The model can be slightly modified to illustrate the second scenario with heterogeneous standalone benefits. In this case θ measures the heterogeneous preference for the intrinsic benefit derived from the technology itself, that is its perceived quality.

The utility expression can be rewritten as $U(\theta) = \theta a + vn^e$. Following a similar analysis as the one carried out above, the specification with heterogeneous standalone benefits provides the same results as the one with heterogeneous network benefits, as long as network effects are sufficiently strong. If this is the case even in this second scenario there might exist multiple consumer equilibria for a given price of the network industry. If network effects are not too strong instead, the fulfilled-expectations demand is monotone and strictly decreasing.

[7] In game theory, an outcome is ***Pareto dominant*** if there is no other outcome that would make at least one player better off without hurting any other player. In other words, there is no outcome that is weakly preferred by all players and strictly preferred by at least one player.

Market for several network goods: competition between incompatible products

We now present a setting where several competing network goods are available in the market and consumers must choose which one they are willing to adopt.

The above choice problem becomes relevant if firms make products incompatible between one another, meaning that they compete *for* the entire market rather than *in* the same market. Incompatibility makes network effects "good-specific", this implying that network benefits arise only among consumers purchasing the same good.

Compatibility can be assessed from both a demand-side perspective and a supply-side one. On the one hand, consumers may try to coordinate their actions in order to make their choices compatible, using their concerted behavior as a compatibility surrogate.

On the other hand firms can themselves provide deliberately some degree of compatibility between the offered products.

Following Belleflamme and Peitz exposition[8] we present a simple sequential model where two incompatible network goods are competitively supplied.

Each period a new consumer must choose a good to adopt. Using this framework, it can be easily shown that network effects are able to translate into a self-reinforcing process that ultimately leads to the dominance of a unique network good.

A and B are two goods exhibiting network effects and their standalone benefits are valued differently by consumers. In particular, we assume that "A fans" derive larger standalone benefits from good A than from good B while "B fans" derive larger standalone benefits from good B than from good A.

Both types of consumers are equally represented in the population and have *myopic expectations*, meaning that they base their decisions just on the current size of the network.

Recalling the utility expression with heterogeneous standalone benefits (i.e. $U(\theta) = \theta a + vn^e$) we can adapt that formulation to the sequential nature of the model.

Consumers arrive in the market sequentially and decide each period whether to adopt good A or good B. The "preference type" of the consumer that gets to choose is random (with probability $1/2$ is a A fan, with probability $1/2$ is a B fan).

The table below presents consumers' utilities at some date t deriving from their consumption of good A or good B.

[8] P. Belleflamme, M. Peitz – "*Industrial Organization – Markets and Strategies*", 2nd edition, July 2015.

	Good *A*	**Good *B***
A fans	$\theta_A + vn_A^t$	$\theta_B + vn_B^t$
B fans	$\mu_A + vn_A^t$	$\mu_A + vn_A^t$

We now define the sequence $\{\delta^t\} \equiv n_A^t - n_B^t$ as the difference in installed base between good A and good B after t consumers have chosen, that is the current number of adopters after t periods.

Absent network effects ($v = 0$), the sequence δ^t becomes a *random walk*[9] and the difference $\delta^t \equiv n_A^t - n_B^t$ tends to 0 as t tends to infinity. In this case the model is said to be "ahistorical", meaning that historical events have just a minor transitory effect, while the equilibrium is ultimately driven by long-run forces of supply and demand.

If network effects are positive instead ($v > 0$), the process becomes an *ergodic system.*[10] In particular, this peculiar system may be defined as a "random walk with absorbing barriers".

To illustrate the meaning of the latter expression we focus our attention on the adoption decision of the $(t+1)th$ consumer. If the consumer is an A fan, she will adopt her preferred good (A) if and only if

$$\theta_A + vn_A^t \geq \theta_B + vn_B^t \Leftrightarrow \delta^t \geq \Delta_A \equiv -\frac{\theta_A - \theta_B}{v}.$$

She will prefer good B otherwise. Similarly, if the consumer is a B fan, she will prefer to adopt her preferred good B if and only if

$$\mu_B + vn_B^t \geq \mu_A + vn_A^t \Leftrightarrow \delta^t \leq \Delta_B \equiv \frac{\mu_B - \mu_A}{v}$$

while she will prefer to adopt good A otherwise. The cut-off values Δ_A and Δ_B are the so-called "absorbing barriers" which means that once the sequence falls below the barrier value Δ_A (i.e. $\delta^t < \Delta_A$) all subsequent consumers will adopt good B. On the contrary, once the sequence goes

[9] A ***random walk*** is a stochastic process where changes of the involved variables do not follow any discernible pattern or trend. Therefore, previous values are unsuitable as a basis for speculation regarding future ones, since random walks are unpredictable series.

[10] A time series δ_t is defined **ergodic** if δ_{t+k} does not depend on δ_t for t large enough. Ergodicity can be described as a sort of "asymptotic independence" among values that are sufficiently far from each other, despite belonging to the same series. The underlying meaning is that historical events may affect variables, but their impact vanishes as time goes by.

above the barrier value Δ_B (i.e. $\delta^t > \Delta_B$) all subsequent consumers will end up adopting good A (with $\Delta_B > 0 > \Delta_A$ by definition).

Figure 4 below illustrates the above dynamics depicting the sequence $\{\delta^t\}$ on the vertical axis and plotting it against time (on the horizontal axis).

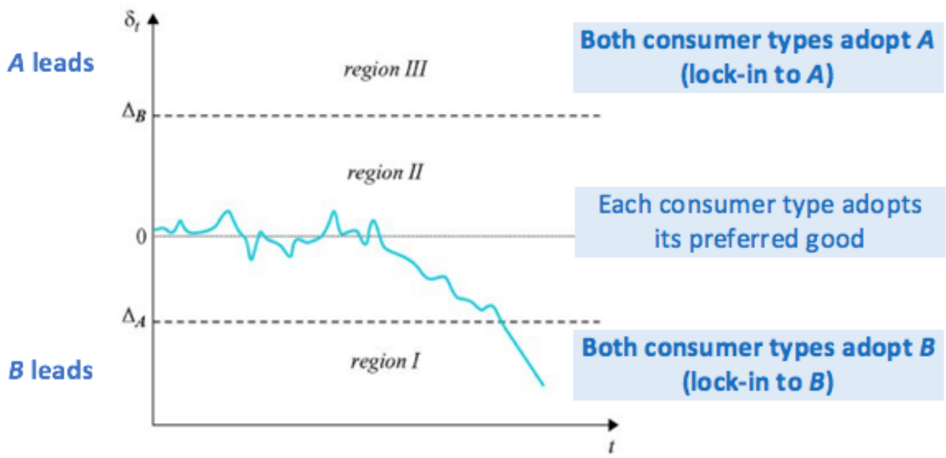

Figure 4 – Technology adoption with network effects.
Source: *"Industrial Organization – Markets and Strategies"* by P. Belleflamme, M. Peitz.

There are three different regions that can be defined: (i) *region I*, where $\delta^t < \Delta_A$ and consequently all consumers adopt good B; (ii) *region II*, where $\Delta_A \leq \delta^t \leq \Delta_B$ and consumers adopt their preferred good; (iii) *region III*, where $\delta^t > \Delta_B$ and all consumers adopt good A.

For a first-time interval, as long as the difference δ_t stays within the band $[\Delta_A, \Delta_B]$, each consumer chooses her preferred good. However, the model predicts that at some point in time, with probability 1, a dynamic process will start in *region II*, following which the sequence δ_t will eventually cross one or the two barriers. The process will end either in region I or in region III, where technology B or A is unanimously adopted, without any possibility to predict which region will be reached.

At that stage, the process is said to be *self-reinforcing* because every consumer arriving in the market will choose, without respect of her own preferences, the leading good, which in turn will increase its advantage over the other.

The barriers Δ_A and Δ_B are defined "absorbing barriers", because when the sequence δ_t crosses one of them the industry is *locked-in* into one of the two goods, whose market dominance finally prevails.

Summing up, the model allows to derive some meaningful implications. First, market dominance seems to be the long-run outcome of competition between incompatible network goods (competition *for* the market rather than *in* the market). Furthermore, as the evolution of δ_t in *region II* is random and determined by small and subsequent historical events (i.e. the evolution is *path dependent*), the long-run winner cannot be predicted beforehand. The process finally locks-in to monopoly into one of the two goods and the outcome depends on how the adoptions build up over time. Even if chosen, the left-behind good will need to bridge a widening gap.
Another key insight of the model is that installed base is fundamental in determine the relevant competitive dynamics for this kind of markets.
Moreover, the above market dynamics might lead to a potential inefficiency, since the good preferred by the majority (i.e. with the longer-term higher payoff) might not be the same that “takes” the whole market, which is ultimately determined by the preferences of the early movers.
With another stylized model Belleflamme and Peitz highlight the coordination problems possibly arising when consumers have to choose among incompatible network goods.
The model consists of two users having to choose simultaneously whether to keep an “old” good or to replace it by a “new” one. The analysis of the above model shows that market failures and potential inefficiencies are very likely to happen, especially when users have incomplete information about other users’ preferences for the available technologies.
First, the complete information setting is analyzed, where each user knows the preferences of the other user about the two goods. This first version shows that the market mechanism may lead either to *excess inertia*, meaning that users do not adopt the new good despite its intrinsic superior quality, or to *excess momentum*, that is users adopting the new good even if they would be better off sticking to the old one.
These results crucially depend on the assumption of simultaneous choices. If users could move sequentially, they would inevitably coordinate on the Pareto-dominating equilibrium. However, moving to a second setting of incomplete information (i.e. each user knows only her own preferences) the model confirms that *excess inertia* and *excess momentum* can become a real possibility when users’ preferences conflict without them knowing.
In this particular scenario, each user is uncertain as to whether she would be followed if she switched to the new good. This uncertainty is likely to lead to excess inertia even in presence of sequential moves. Since every user fears the loss of benefits she would incur turning out to be the only adopter of the new good, no one will take the risk of moving first. Due to this widespread

behavior, no one would ever switch, failing to achieve the higher benefits of a superior technology.
In system markets with indirect network effects excess inertia is likely to be even more severe. A new hardware product, like a game console for instance, may fail to succeed on the market because consumers are reluctant to buy a product without being sure there will be enough compatible applications available in the future (games in this case). Similarly, software providers (game developers) are not willing to write many applications until the console has a significant installed base. This is referred as the "chicken and egg phenomenon" and is mainly due to each side's incomplete information about the other side's preferences.

Market for several network goods: compatibility choices on the supply side

We now move to the supply side of network markets. It can be reasonably argued that firms' decisions with respect to the degree of compatibility between the provided products ultimately determine the nature of competition.
When goods are *incompatible* each firm builds its own network and network effects generate a self-reinforcing process in which success feeds itself and failure worsens failure. In the long-run, large networks become even larger and naturally dominate the market, while small networks and their incompatible goods are likely to disappear. Similarly to the section above, in this case firms compete from the very beginning *for* the market rather than *in* the market, seeking to become the future monopolist.
When goods are *compatible*, network effects are no longer limited to the adopters of that specific good, since there virtually exists a single network for all versions of the goods. In this case compatible goods coexist and firms compete in the market rather than for the market.
Firms are aware that competition between incompatible network goods is likely to lead to a "winner-takes-all"[11] situation. Therefore, they opt for incompatibility if and only if the profits that derive from competing for the entire market are higher than the ones from competing within the same network market.

[11] A "winner-takes-all" market is a market where the best performers are able to capture a very large share of the profits and the remaining competitors are left with almost nothing. In this markets wealth disparities are enhanced because the majority of left-behind firms face a widening gap, while the few others extract increasing amounts of income that would otherwise be more widely distributed throughout the population.

We now introduce a general model of competition between incompatible networks and we use comparative statics to illustrate how compatibility affects the equilibrium profits. This exposition is taken from **Crémer, Rey and Tirole (2000)**[12].

The demand side of the market is characterized by a continuum of consumers (of mass one), identified by a taste parameter $\theta \in [0,1]$, which measures the heterogeneous valuation of the standalone benefits deriving from the network good. Network benefits are assumed to be valued equally by all consumers.

Consumer's utility is therefore $U(\theta) = \theta a + vn^e$, with $a, v > 0$. To simplify the presentation, we set $a = 1$ and assume the strength of network effects to be less than one half (i.e. $v < 1/2$)[13].

In the supply side of the market there are two different firms (A and B) producing respectively good A and good B. The chosen degree of compatibility between A and B, the two different network goods available, determines the magnitude of network effects.

The level of compatibility between the two goods is described by $\gamma \in [0,1]$. Each consumer enjoys "full" network effects from all consumers belonging to the same network as hers and a fraction γ of network effects from consumers belonging to the other network. Being n_A^e and n_B^e the expected sizes of the networks for good A and B, then the actual network benefit for a consumer adopting good A is $v(n_A^e + \gamma n_B^e)$ with good B only partially compatible with good A.

Both goods have already an *installed base* of customers from past competition and now compete for new consumers. Each network's installed base is denoted by $\beta_i \geq 0$, $i = \{A, B\}$. It is assumed that the installed bases are locked into previously signed contracts. The expected size of the network for good i is then $n_i^e = q_i^e + \beta_i$, with q_i^e denoting the number of new customers that a consumer expects firm i to get "on board".

The net surplus a consumer obtains from adopting the good of firm i at price p_i is equal to

$$U_i(\theta) = \theta + g_i - p_i, \tag{1.5}$$

where g_i represents the expected network benefit from purchasing good i. Formally:

$$g_A = v[(\beta_A + q_A^e) + \gamma(\beta_B + q_B^e)]. \tag{1.6}$$

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[12] Crémer, Rey and Tirole (2000) – "*Connectivity in the Commercial Internet*". The model presented in this paper is itself an extension of the seminal model proposed by Katz and Shapiro (1985) – "*Network Externalities, Competition and Compatibility*".

[13] This assumption is made in order to avoid full market coverage and tipping effects.

Firms compete à la Cournot, choosing simultaneously their capacities for market expansion. The model focuses on subgame-perfect Nash equilibria in which consumers observe capacities before making their consumption choices and their beliefs about other consumers' behavior turn out to be confirmed.

Consumers view the two goods as perfect substitutes. Therefore, they face the same "quality-adjusted prices":

$$p_A - g_A = p_B - g_B = \hat{p}. \tag{1.7}$$

The indifferent consumer (which derives utility zero from buying the technology, irrespective of its type) has valuation

$$\theta_0 + g_A - p_A = \theta_0 + g_B - p_B = 0 \Leftrightarrow \theta_0 = \hat{p}.$$

Therefore, the expected total number of consumers $(q_A^e + q_B^e)$ is equal to the mass with a valuation larger than θ_0, meaning $1 - \theta_0$. If we restrict our analysis to fulfilled-expectations equilibria (i.e. $q_A = q_A^e$ and $q_B = q_B^e$) we can express the total demand for both technologies as:

$$q_A + q_B = 1 - \hat{p} \tag{1.8}$$

Combining (1.6), (1.7) and (1.8) the equilibrium prices (p_A, p_B) can be determined as functions of the two capacities (q_A, q_B):

$$\begin{aligned} p_A &= 1 - (q_A + q_B) + g_A \\ &= 1 + v(\beta_A + \gamma\beta_B) - (1 - v)q_A - (1 - \gamma v)q_B \end{aligned} \tag{1.9}$$

The profits that firm A and firm B gain from their locked-in installed bases are fixed, thus they choose their capacities (q_A, q_B) to maximize their profits over the new customers.

With c_A representing the unit cost for providing network good A, we have the following profit function:

$$\pi_A = (p_A - c_A)q_A = [1 + v(\beta_A + \gamma\beta_B) - (1 - v)q_A - (1 - \gamma v)q_B - c_A]q_A \tag{1.10}$$

whose first-order conditions for profit maximization yield the equilibrium quantities and profits:

$$q_A^* = \frac{2(1-v)[1-c_A+v(\beta_A+\gamma\beta_B)] - (1-\gamma v)[1-c_B+v(\beta_B+\gamma\beta_A)]}{4(1-v)^2-(1-\gamma v)^2} \tag{1.11}$$

$$\pi_A^* = (1-v)(q_A^*)^2 \tag{1.12}$$

It can be immediately noticed that an increase in compatibility (i.e. a higher value of the parameter γ) has a *demand expansion effect*. If we take the first derivative with respect to γ of the expression for the total demand below, we can clearly see that this is positive.

$$q_A^* + q_B^* = \frac{2-c_A-c_B+v(1+\gamma)(\beta_A+\beta_B)}{2(1-v)+(1-\gamma v)}$$

$$\frac{d(q_A^*+q_B^*)}{d\gamma} = \frac{2-c_A-c_B+(\beta_A+\beta_B)(3-v)}{[2(1-v)+(1-\gamma v)]^2}v > 0.$$

Since consumer surplus can be computed as follows

$$CS = \frac{1}{2}(q_A^*+q_B^*)^2 \tag{1.13}$$

we can conclude that in a market with network effects and two competing networks, enhanced compatibility not only leads to a market expansion, but also results in a larger consumer surplus. The model further underlines that enhanced compatibility also entails a *quality differentiation effect*. As compatibility improves, the perceived difference in quality between the two networks gradually decreases. We can use as a proxy for higher quality either a cost advantage (i.e. $c_A < c_B$) or a larger installed base (i.e. $\beta_A > \beta_B$). These two assumptions will enable us to model the hypothesis that A is better than B, meaning that its perceived quality is higher.
First, we compute the difference between the equilibrium capacities of firms A and B, which depicts the variation in provided supply (i.e. how much firm A produces with respect to firm B):

$$q_A^* - q_B^* = \frac{c_B-c_A+v(1-\gamma)(\beta_A-\beta_B)}{2(1-v)-(1-\gamma v)}. \tag{1.14}$$

Then we assume that the two firms have the same installed base, $\beta_A = \beta_B$, but firm A has a cost advantage, $c_A < c_B$, that is firm A is more efficient than firm B. In this case (1.14) becomes

$$q_A^* - q_B^* = \frac{c_B - c_A}{2(1-v) - (1-\gamma v)} > 0$$

and its derivative with respect to the compatibility parameter γ is

$$\frac{d(q_A^* - q_B^*)}{d\gamma} = \frac{v(c_A - c_B)}{[2(1-v) - (1-\gamma v)]^2} < 0.$$

This means that if A enjoys a cost advantage, and therefore its production is higher than B's, enhanced compatibility constitutes a disincentive to quantity provision, affecting negatively the difference in equilibrium capacities.
Similarly, if we assume that A has same cost as B, i.e. $c_A < c_B$, but a larger installed base, $\beta_A > \beta_B$, the difference between the equilibrium capacities becomes

$$q_A^* - q_B^* = \frac{v(1-\gamma)(\beta_A - \beta_B)}{2(1-v) - (1-\gamma v)} > 0$$

and its derivative with respect to the compatibility parameter γ is

$$\frac{d(q_A^* - q_B^*)}{d\gamma} = \frac{v(1-v)(\beta_B - \beta_A)}{[2(1-v) - (1-\gamma v)]^2} < 0.$$

The above results suggest that enhanced compatibility reduces quality differentiation, being consequently less desirable for a firm that is more efficient (i.e. enjoys a cost advantage) or whose brand is better established (i.e. has a larger installed base). Therefore, incentives with respect to compatibility might be misaligned between customers and firms, or even among firms themselves, affecting differently both adoption and provision decisions.

Strategies for network goods: standardization vs. incompatibility

After having highlighted the relevance of firms' choices with respect to compatibility, in this section we further explore the strategic dimension of decision making on the supply side of network markets. Due to the peculiar features that network effects ascribe to the demand, firms' behavior involves specific strategic instruments aimed to impose their presence and eventually dominance in these markets.

Would firms choose to compete *in* the market rather than *for* the market, they can make their goods compatible through *standardization*, that is adhering to a common standard and produce the same version of the good. On the contrary, if they opt for incompatibility they engage in a so-called "standard war", a challenge to affirm their network as the long-run dominant and unanimously adopted at the expenses of the others'.

We use a simple standardization game based on **Besen and Farrell (1994)**[14] to illustrate the different outcomes that can arise when firms have to make compatibility choices.

We assume there are two firms (1 and 2) that can choose between two possible versions of the good (A and B). The two versions are incompatible and compatibility can be achieved only through standardization, which entails both firms agreeing on producing the same version of the good.

The matrix below summarizes the reduced-form payoffs from the adoption of either good A or good B by the two firms:

		Firm 2	
		A	B
Firm 1	A	π_1^{AA}, π_2^{AA}	π_1^{AB}, π_2^{AB}
	B	π_1^{BA}, π_2^{BA}	π_1^{BB}, π_2^{BB}

The form of competition resulting from the game depends on the firms' compatibility strategies. In the above case, with two firms and two goods, there are four combinations of such strategies:

1. *Straightforward standardization* (or *cooperative standardization*), meaning that the two firms agree to choose one particular version of the good. There is straightforward standardization on version A for example, if (A, A) is the only Nash equilibrium of the game (i.e. $\pi_1^{AA} > \pi_1^{BA}$, $\pi_2^{AA} > \pi_2^{AB}$ and either $\pi_1^{AB} > \pi_1^{BB}$ or $\pi_2^{BA} > \pi_2^{BB}$).

[14] S. M. Basen, J. Farrell (1994) – "*Choosing How to Compete: Strategies and Tactics in Standardization*".

2. *Battle of the Sexes*[15], namely that firms agree that standardization is the best option but they disagree about which good should be the standard. Here both (A, A) and (B, B) are Nash equilibria (i.e. $\pi_1^{AA} > \pi_1^{BA}$, $\pi_2^{AA} > \pi_2^{AB}$, $\pi_1^{BB} > \pi_1^{AB}$ and $\pi_2^{BB} > \pi_2^{BA}$) but firms rank them differently (for instance $\pi_1^{AA} > \pi_1^{BB}$ and $\pi_2^{BB} > \pi_2^{AA}$).
3. *Standards war*, that is when both firms compete to become the de facto standard. For instance, if firm 1 wants to impose the version A while firm 2 wants to impose the version B, then (A, B) is the only Nash equilibrium of the game. Similarly, if firm 1 wants to impose the version B while firm 2 wants to impose the version A, then (B, A) is the only Nash equilibrium of the game.
4. There is one last situation to be analyzed which is the one in which firms have contrasting strategies, meaning that one firm prefers incompatibility, while the other firm would like to be compatible with the rival's good. In Besen and Farrel (1994) the latter firm is referred to as *Pesky Little Brother*. If this is the case (for instance if $\pi_1^{AA} > \pi_1^{BA}, \pi_1^{BB} > \pi_1^{AB}$, $\pi_2^{AB} > \pi_2^{AA}$ and $\pi_2^{BA} > \pi_2^{BB}$) there is no Nash equilibrium in pure strategies.

Belleflamme and Peitz (2015) further exploit Katz-Shapiro model (1985), in its version adapted by Crémer, Rey and Tirole (2000)[16], in order to derive endogenously the payoffs of the previous matrix. This analysis is aimed to characterize more precisely the different circumstances under which each of the four combinations of strategies may arise as equilibrium. Two extensions to the general framework are presented. First the two competing firms have both a preferred good, either because they developed it themselves or because they already use some complementary inputs. This assumption is introduced in the model through a diversification of the unit costs: firm i's marginal cost is assumed to be zero if the firm adopts its most preferred good and to be $c > 0$ otherwise, with $i = \{1,2\}$. A second modification to the general model consists in making γ a binary parameter allowing either total compatibility $(\gamma = 1)$ or total incompatibility $(\gamma = 0)$ without intermediate cases of partial compatibility.

[15] In game theory, the ***Battle of the Sexes*** (BoS) is a famous two-player coordination game in which a couple wants to spend the night together but do not agree on the favorite show they want to attend. The husband would prefer to go to the football game, the wife would rather go to the opera. Both would prefer to go to the same place as the other and would get zero utility going alone to the preferred show. They make simultaneous choices without communicating. Solving the game we get two different Nash equilibria. In both equilibria the couple is in the same place but one is attending the least preferred show.

[16] To ease computations the authors posit that consumers' valuation of network effects, v, is equal to $1/4$. In addition, to guarantee always positive equilibrium prices and quantities, it is assumed that β_i and $c \in [0, 1/2]$.

This adjusted exposition is examined under two different scenarios: (i) only one firm can enjoy the benefits of an existing installed base; (ii) both firms have the possibility to enjoy the benefits of a common installed base.

We start presenting the **first scenario**, which focuses on the effects of asymmetry in brand strength and established profits on the consequent equilibrium decisions about standardization. The firm that is able to enjoy the benefits of an existing installed base is called by convention the "large firm", the other is the "small firm".

If both firms agree on standardization over the same good (either A or B), the only difference in their profits steams from their cost function, with the firm producing its preferred good having a zero-unit cost while the other incurring in a cost of $c > 0$.

The two compatibility situations (A, A) and (B, B) are Nash equilibria in pure strategies if and only if the cost of not adopting one's preferred good and the installed base advantage of the large firm are relatively low. In particular, if the small firm is willing to incur in a slightly higher production cost in order to access the large firm's installed base and for the large one the *demand expansion effect* that derives from standardization dominates the *quality differentiation effect*, (A, A) is the unique Nash equilibrium of the game.

When the installed base advantage becomes much larger, with still a relatively low cost of adopting the rival's good, we are in a *Pesky Little Brother* situation, in which the small firm would like to have compatibility, while the large one would not, in order to keep the benefits of its installed base just for itself. In this setting, the firms pursue opposite compatibility strategies, therefore there are no Nash equilibria in pure strategies.

Finally, when the cost of adopting the rival's technology is sufficiently high, firms are willing to compete for the establishment of their preferred technology as the de facto standard. In the *standard war* scenario the only possible Nash equilibrium is (A, B).

The above results suggest that pre-market standardization has more chances to emerge as equilibrium if firm 1 and firm 2 are relatively symmetric and do not have particularly strong preferences for a specific good. On the contrary, if the preferences diverge markedly over the technology they are willing to adopt, the standard war is more probable to emerge as an equilibrium.

If the eventual resulting standard comes from a pre-market standardization agreement we talk about a *de jure* standard, while if it comes after the win of a standard war it is called a *de facto* standard.

In the second scenario, it is assumed to exist a common installed base, made up of consumers of an existing network good that have to decide whether to switch to a new one (either A or B).
In this setting, the consumers of the existing network good may refrain from switching even if a collective switch would make everyone better off. This excess inertia is even more likely to occur if the new goods provided by firm 1 and firm 2 are incompatible with each other.
Even anticipating that one of this two incompatible goods will eventually dominate the market at some point, consumers of the existing good cannot predict which one will be the winner and stick to the old technology (i.e. adopt a "wait and see" approach).
The presence of collective switching costs is likely to ruin the potential developments of the new goods, unless firm 1 and firm 2 agree on standardization.
Providing compatible versions of the new goods the two entrants can convince consumers of the existing one to switch, because they face a lower lock-in prospect and can benefit from higher network effects between technologies A and B.
Both previous scenarios show the existence of a relevant trade-off between compatibility gains and performance efficiency.
While standardization gives both firms access to a common installed base, thereby increasing demand of new users and likelihood of switching by the old ones, adopting one good instead of the other means that one firm will end up producing its less preferred good, which in turn raises its production cost.
For the reasons set above the key strategic variables in standardization games within network markets are the cost of producing each network good (and eventually adopting the rival's one) and the magnitude of the potentially gained installed base.
In case of a standard war there are some specific strategic instruments that firms can resort to increase their chances of winning.
The first one consists in building an early installed base of users in order to pre-empt current rivals and potential entrants. The early-mover advantage of a firm that manages to successfully build a consistent installed base before its rivals is likely to lead to a long-lasting dominant position in the market, especially due to the self-reinforcing power of network effects. Through another extension of the Katz Shapiro model it can be shown that in a market with two potential networks competing, entry can be deterred if network effects are strong enough, if goods are incompatible enough or if the installed base built by the incumbent is large enough.
Furthermore, incompatibility not only enhances the relevance of the incumbent's installed base, it also creates incentives to lower the products' price in the first period for raising it again once

the consumers are locked-in[17]. The incumbent will commit to low first-period prices in order to deter entry and raise them again shortly afterwards.

Another very common strategy in network markets, not really aimed to win standard wars but to overcome the collective switching costs that network effects may create, is to opt for *backward compatibility*. This implies that a new entrant in a network market may try to soften its natural entry barrier by offering a network good which is compatible with the existing ones. While on the one hand this allows the newcomer to virtually enjoy the same installed base as the incumbent, the above strategy suffers from two important drawbacks. First, due to some necessarily fixed characteristics, backward compatibility restricts both horizontal and vertical differentiation. This implies that not only potential quality improvements are affected, but also possible technological advancements. Similarly to the above analysis, there is an evident trade-off between the benefits of backward compatibility and the entrant's performance. In case of owning a superior network product, the entrant will make it incompatible with the existing ones if and only if the rents extracted by selling a higher-quality good are larger than the loss of network effects caused by incompatibility.

A third strategy a firm can put into practice to win a standard war or to firmly establish itself in a network market consists in managing consumers' expectations in its favor. Since expectations formed by not only consumers but also developers of complementary goods are crucially relevant for a network to succeed, firms usually try to shape them through three main commercial tactics: (i) self-fulfilling advertising; (ii) FUD (i.e. fear, uncertainty and doubt) and (iii) product preannouncement.

To implement the first tactic (i.e. self-fulfilling advertising) it is enough to advertise the product very positively: as the inevitable winner of an eventual standard war. If the firm manages to convince consumers about the magnitude of network effects deriving from the unanimous adoption, this massive success will result in a self-fulfilling prophecy and the product will be the final winner in the end.

The name of the second listed tactic, FUD, stands for fear, uncertainty and doubt and consists in disseminate misinformation about rivals' products to generate pessimistic consumers' expectations.

[17] The practice of setting a low price in the first period to get consumers on board in the network and then to raise it once there is a consistent installed base, is called ***penetration pricing***. It can be easily related to the "bargain-then-rip-off" strategy, very common in markets with switching costs.

The last tactic, product preannouncement, consists of enthusiastically announcing a product well in advance of its actual market availability in order to freeze the sales of competing goods. Due to the presence of collective switching costs, this tactic is very common and often successful in network markets. If consumers are persuaded enough by the superiority of the future product or even just curious, they may actually delay their purchases until this product will be available in the market (think about Apple's early announcement of each new version of iPhone). Similarly, developers of complementary products could delay their work until the awaited product is out.

However, preannouncements may be risky for the firm that put them into practice. First, if a firm wants to pursue this tactic its credibility is a key issue, meaning that in case of a product failure the firm's reputation ends up being severely affected. In addition, the sales freezing may involve not only rivals' products but also existing products sold by the same firm, that would experience a sort of self-cannibalization.

Public policy in network markets

Undeniably technology markets are not the exact proxy for perfect competition.

The above presentation clearly shows that network effects may be responsible for some kind of market failures. Sometimes for instance, consumers fail to coordinate on the best network good available, being locked-in on inferior standards. Firms on the other hand may opt for keeping their products incompatible, despite the welfare improvements that would derive from compatibility. In addition, network effects exacerbate the strength of possible entry barriers, the magnitude of any early-mover advantage and the significance of switching costs.

Over the last two decades scholars fiercely argued about what the suitable extent of public intervention should be in technology and network markets, without any commonly shared opinion. Indeed, the academic discussion among economists on the role of regulation and antitrust in the market for Internet services has not reached any final conclusion, without even a univocal agreement on the sign of the relation between competition and innovation[18].

[18] For the large fraction of ***pro-intervention literature*** competition affects positively the rate of innovation. Because of the incumbent's fear of being eventually surpassed, its incentives to innovate will remain high as long as there are enough potential entrants threatening its business. ***Anti-intervention literature*** on the other end stresses the fact that monopolization can effectively secure the incumbent's profits and therefore incentivize innovation. The stable condition of a monopolist would in fact induce him to invest even more in

While interventionists claim that technology markets are highly concentrated and have high barriers to entry, others underline their contestability features. As technology changes rapidly, new entrants carrying radical innovation can easily surpass the existing barriers and the incumbent advantages may be quickly depreciated. Following a sort of *Shumpeterian approach*[19] one could argue that dominant positions in this type of markets are not much dangerous because just temporary and subject to a constant replacement of obsolete technologies by the new ones. However, technological progress is endogenous and at least partially shaped by the current market structure. Therefore, its size, speed and direction may not always be naturally optimal.

Public interventions may try to correct or at least to alleviate some market failures of technology markets in two distinct ways: (i) *ex ante* interventions, in which public authorities take an active part in the competitive process among networks and (ii) *ex post* interventions, in which they intrude only once competition already took place, in order to verify the fairness of the involved firms' conduct.

Regulatory interventions are usually *ex ante* interventions. Regulators can tangibly control supply and demand forces, manage entrance in the market through taxes or subsidization, fix prices to be charged to consumers or use their consistent buyer power to influence competitive dynamics. Regulation is common for markets that are considered natural monopolies,[20] meaning industries where infrastructural costs and high barriers to entry give to the largest (or first arrived) supplier an overwhelming advantage over potential competitors. The markets for telecommunications and public utilities such water, gas and electricity exemplify this kind of markets.

On the contrary, competition policy interventions are considered *ex post* interventions and have lesser power with respect to regulatory ones. Their aim is to ensure that competition is not restricted in a way that is detrimental to society and their tools are antitrust enforcement, control of State aids, sector regulation and competition advocacy.

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innovation and further developments. The economic literature has not reached a unanimous conclusion about which of the two effects actually prevails.

[19] In "Capitalism, Socialism and Democracy" (1942) **Joseph Schumpeter** coined the term *creative destruction* to describe the *"process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one."* This process occurs when innovation deconstructs long-lasting industrial arrangements and frees resources to be deployed elsewhere. This idea of economic development ultimately resulting from endogenous forces that are internal to the market, may support a non-interventionist approach, especially in technology markets, where the constant innovative process should guarantee a frequent turn over between different technologies.

[20] **Natural monopolies** were first analyzed as a potential source of market failure by John Stuart Mill, who advocated government regulation to make them serve the public good.

As highlighted in the previous sections, compatibility is a fundamental determinant of the potential total value creation within technology markets, mainly because of the incentives to innovate it generates for network providers, developers and equipment suppliers.

Since standardization is the most successful practice to reach compatibility, public policy has a particularly strong interest in supervising and participating to harmonization processes.

Through ex ante interventions, public authorities may try to influence both *de facto* standardization and *de jure* standardization.

We start presenting interventions in the *de facto* standardization process, usually carried out through subsidies or taxes. First, we recall the model of sequential adoption decisions analyzed in one of the previous sections. There are two different network goods available to consumers that arrive in the market sequentially and must decide, each period, whether to adopt good A or good B. The model predicts that, in the long-run, market dominance of either A or B is the natural outcome of competition between incompatible network goods. More specifically, this dynamic is path-dependent and the winning technology, that all users will end up adopting despite their idiosyncratic preferences, cannot be predicted in advance. According to **David (1987)**[21], public intervention within the framework of de facto standardization processes faces three main policy dilemmas. The first is called *Narrow Policy Window Paradox* and refers to the fact that there may be only narrow windows of time for an effective public intervention before the market locks-in a standard or that the private and social costs of intervening to force a switch may be prohibitive. A second problem is that, at the time in which public authorities are likely to have the most influence on the market, they also have the least amount of information about the appropriate action to perform. David calls this uncertainty the *Blind Giant's Quandary*. One possibility for public authorities is to subsidize the lagging technology in order to maintain a balance in the competitive process before better information is available. Although this could seem a neutral intervention, the subsequent evolution of the market may give rise to social costs and is crucially linked with the third problem, termed *Technological Orphans Dilemma*. Encouraging the development of the "wrong" network (i.e. the one that will end up losing the standard war in the end) public authorities not only would leave a relevant amount of network effects unexploited, but also artificially boost consumers expectations relatively to that network. Therefore, consumers that adopted the subsidized network may end up as so-called *Technological Orphans* and might even question the credibility of public polices per se.

[21] P.A. David (1987) – *"Some new Standards for the Economics of Standardization in the Information Age."*

Public authorities could also get involved directly into the *de jure* standardization process and select standards through government agencies. Although the open and transparent nature of the *de jure* standardization procedures may avoid the social costs associated with de facto standards determinations, *de jure* standards defect in rapidity of adjustment. In a context of extremely fast technological progress the quick and natural emergence of a de facto standard may be more timely relevant than the slow pace of reaching an agreement over standardization.

Should public authorities prefer not to interfere directly in the standardization process, the main tool at their disposal is *antitrust policy*.

Nevertheless, the application of competition law is far from trivial in technology and network markets. Some of the most targeted issues such market share inequality, strong dominance and high profitability of a top firm are natural settings in network markets and are not necessarily related to an anticompetitive conduct by the active firms.

Therefore, competition authorities must judge this particular framework not against the benchmark of perfect competition (which is the theoretical reference for traditional *brick and mortar*[22] markets), but accounting for significant disparities and very high profits somewhere.

The attitude that competition authorities should have towards cooperation in standard settings is obviously a complex issue. Although cooperation may be sometimes indispensable to establish compatibility standards, the cooperative procedure cannot be immune from antitrust scrutiny.

Moreover, behind the decision by competition authorities whether to allow or not cooperative standard settings, a much more critical judgement is hidden, that is to promote either competition for the market or competition in the market. It is still unclear which one is the best outcome in terms of welfare benefits, considering that the two forms of competition possess opposite costs and benefits.

Competition *for* the market implies a very intense competition in the short term, when firms compete with price reductions and quality improvements to build a significant installed base. This lively competition and the improving incentives are bound to an end once one firm succeeds in monopolizing the market and starts earning higher profits.

Allowing for cooperative standard settings to maintain competition *in* the market entails incurring the opposite risk. Indeed, pre-market standardization, although granting competition

[22] The term ***brick-and-mortar business*** is used as reference to a company that possesses or leases retail stores, factory production facilities, or warehouses for its operations. Contrary to Internet companies and e-commerce businesses, brick-and-mortar firms are the ones that have a physical presence and offer face-to-face customer experiences.

in the future, significantly reduces competition and innovation incentives in the short term, due to the forced alignment between competing products.

This trade-off between competition in the short and in the long run can be considered solved in the presence of significant collective switching costs. In this case standardization is a prerequisite to overcome rigidities because consumers facing incompatible network goods would stick to the existing one, not allowing any better good to emerge from a standard war.

Would public authorities allow for cooperative standard settings, they should closely monitor firms' behavior and make sure that cooperation does not lead to harmful agreements, such price fixing, supply limitation or application of dissimilar conditions to equivalent transactions.

Private standard-setting organizations (SSOs)[23] policies are indeed carefully examined by public authorities, especially if related to disclosure and license of IP rights.

To this end, the Standardization Guidelines of the European Commission (adopted in 2001 and revised in 2010) provide a guidance for fair competition to SSOs in order to prevent restrictive agreements or locked-up standards.

[23] A **standard setting organization** (SSO) is usually in charge of developing, coordinating, promulgating, revising, amending, interpreting and producing technical standards that are intended to address the needs of the adopters.

Chapter II

Introduction to market intermediation and multi-sided markets

With the term *market intermediation*, we define a transaction in which products and services are not sold directly by producers to final consumers, but pass through intermediaries. These mediator agents generally fulfil four main roles: *dealer*, *platform operator*, *informational intermediary* and *trusted third party*.

A *dealer* is the typical intermediary that places itself between suppliers and buyers, purchasing from the first and reselling to the latter, usually charging a transaction fee for its service.

Platform operators provide an infrastructure where groups of agents with complementary businesses and commercial interests can interact and close transactions over products and services. An *informational intermediary* (or *infomediary*) acts as an information gatekeeper, processing data in a systematized way in order to provide users with an easy and efficient access to its managed databases. *Trusted third parties* work as certification agents, divulging information about products' quality or sellers' reliability.

Nowadays, intermediaries in digital markets are usually structured with hybrid business models and perform more than one role simultaneously. *Amazon* for example, the electronic commerce giant, started in 1995 as a pure online *dealer*. The American company first operated books and musical media, then extended its coverage to a wider range of product categories, from electronics to beauty items. In 2001, following the steps of the multinational auctioneer *eBay*, *Amazon* launched its marketplace service and turned into a *platform operator*. Via this new service, *Amazon* allows consumers and third-party sellers to interact and close transactions directly on its digital platform.

The structure of a marketplace perfectly exemplifies the functioning of *multi-sided markets*, in which each side's valuation of being part of the platform increases with the extent of participation on the other side. This feature of interdependence entails positive or negative cross-group network externalities between the involved clusters of agents. Indeed, the presence of an additional buyer affects positively each seller that is active on the platform. On the other hand, a market with more sellers may reduce buyers' searching costs, at least to a certain extent. The platform operator's role is to internalizes these effects by disciplining access and transactions on the marketplace. *Amazon* for instance, charges a commission rate, a transaction fee and a closing fee to one side or the other. In exchange, it takes care of the billing process, collects money and credits the seller's account.

Through its *certified reputation* system, *Amazon* plays also the role of a *trusted third party*. Customers are always invited to leave feedbacks on their transactions and to rate products on a scale from one to five stars. Due to the fact that it collects reviews and opinions, *Amazon* acts also as a sort of *infomediary*, providing customers with the possibility to access information about various aspects of the transaction: sellers' reliability, product performance, time and ease of shipping, compliance with the description.

Differently from *Amazon*, some intermediaries choose to specialize in fewer roles. *Facebook* for example is mainly a social media platform, providing an infrastructure for people to connect while selling them targeted advertising; *Wikipedia* acts primarily as *infomediary*, supplying users with a huge and interactive reference work; Apple's *iTunes Music Store* works as *dealer,* paying publishers for the right to distribute their music to users while charging its own price; *Alibaba*, like Amazon, works simultaneously as *dealer*, *platform operator* and *infomediary*.

As mentioned above, most horizontal and vertical search services fulfill the role of *platform operator* and *infomediary* at the same time. A vertical search service is an intermediary that provides information about a specific topic, such for example hotels (*Expedia*, *Booking.com*), flights times routes (*Ryanair*, *Skyscanner*), restaurants (*Tripadvisor*) and many more. Horizontal search services on the other hand give a cross-wide access to various types of information. Search engines like *Google Chrome*, *Yahoo* and *Bing* are the main examples of this latter search services' category.

Submitting advertisement to users while they are consulting the vertical (or horizontal) search service qualifies as the core business model of most media platforms. *Skyscanner* and *Tripadvisor* for instance, not only act as *infomediaries* with respect to plane travels and recommended restaurants, but also, sell advertising space to third parties. The same does *Google Chrome*, while providing users with vertical cross content.

We summarize below the main theoretical results with respect to intermediation markets, again following **Paul Belleflamme and Martin Peitz (2015)** exposition.

A fundamental feature of multi-sided markets is the fact that the famous result known as *Coase theorem*[24] does not apply to the transactions between the two sides, that are unable to

[24] In Law and Economics, the **Coase theorem** describes the economic efficiency of an allocation or outcome in the presence of externalities. The theorem states that, being possible to trade in externalities with sufficiently

compensate each other to reach a mutually beneficial outcome. The impossibility to attain a desirable outcome through bilateral compensations, assigned a sensitive role to the platform in remedying this failure. This drove both economic literature and policy makers to closely investigate the functioning of multi-sided markets and the related competition and welfare implications.

The existence itself of intermediated markets should suggest that at least some agents benefit from the action of intermediaries, preferring this type of transaction to direct trades with each other. Leaving aside potential explanations related to logistics, storage or inventory, Industrial Organization theory showed that buyers and sellers may be willing to trade via an intermediary in order to improve their matching opportunities.

In order to add value to the intermediated transaction and increase social surplus, the platform must internalize indirect network effects and inter-group externalities each side exerts on the other. The cross-dependence deriving from the fact that the valuation of one group increases when the platform is largely used by other groups, is the main driver of multi-sided platforms functioning. Individual decisions to join a particular platform depend on the number of users that are already affiliated to the platform and in turn generate indirect network effects to the agents on the other sides. There are countless types of intra-group externalities that a platform specialized in providing matching services may be called to internalize.

Usually, not only the valuation of the matching service increases with the mere participation of others, due to users' higher chances to find a desired match, but customers care also about their matching partners' identities. In this case, the intermediary internalizes the "sorting" externality by managing the composition of the various groups accordingly to their preference patterns in order to provide refined matches. The key factor of success for multi-sided platforms is indeed their ability to appropriately coordinate the demand coming from distinct groups.

Comparing rents and allocations deriving from transactions in a decentralized market with the ones created in dealer-managed ones, it can be shown that the intermediary is able to add value to the overall negotiation, at least for some market participants, even without affixing any practical supplement to it. This happens especially when the interacting agents are somehow affected by the type of their matching partner. In this case the intermediation activity may entail a valuable self-selection of types.

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low transaction costs, the free bargaining between the involved agents leads to the most efficient and beneficial outcome, regardless of the initial allocation of property.

Suppose that buyers and sellers are charged with no joining fees and are heterogeneous in their type: sellers can be *high cost* sellers or *low cost* ones and buyers are either *high valuation* buyers and *low valuation* ones.

If they interact in a decentralized way and are matched randomly, socially inefficient trades may take place. For instance, low valuation buyers may be matched with high cost sellers, with no one gaining from the transaction. This would generate too much trade and a sub-optimal amount of produced welfare, due to the loss in terms of searching costs and unsuccessful matches.

Welfare would be maximized if and only if high valuation buyers interact exclusively with low-cost sellers. The introduction of a market maker can correct this market failure allowing to reach the most efficient outcome.

The intermediary would set profit-maximizing wholesale and retail prices, aimed to improve allocation and implement the first best for both groups of customers. By buying and selling goods at price difference the mediator agent would make profit while still allowing consumers to participate in the matching mechanism for free.

If all the above conditions are met there is a free spot in the market structure that can be successfully occupied by an intermediary. The platform would facilitate a more efficient coordination compared to bilateral relationships, regulating transaction costs and safeguarding from potential free riding issues[25].

Therefore, in a random-matching market where buyers and sellers care about their matching partner, there are profitable opportunities for intermediaries to operate centralized exchanges and intermediated trade is likely to replace, at least partially, decentralized one.

However, evidence is mixed on which form of centralized exchange should be considered the most profitable.

As presented above, one possible business model for the intermediary is to participate directly in the transaction by buying and reselling goods as a dealer. Another option is to simply provide buyers and sellers with the opportunity to meet, while taxing their trades with a users' charge.

As shown in **Figure 5** below, these two business models correspond to two different pricing systems. If the platform acts as a dealer it takes the pricing decisions itself and applies a

[25] In economics, the **free-rider problem** occurs when consumers who benefit from resources, goods, or services do not pay for them. It is common when property rights are not clearly assigned or when the goods are non-excludable. Public goods often present this problem due to non-excludability. When a public service such street lightning is paid with citizens' taxes for instance, there is no way for the public authority to prevent the ones who did not pay from enjoining the service. Therefore, free-riding often results in under-provision of the goods and services.

centralized pricing structure. On the contrary, if the platform simply offers users the access and ability to interact, pricing is decentralized to the market participants. In this case the platform gains from taxing trade.

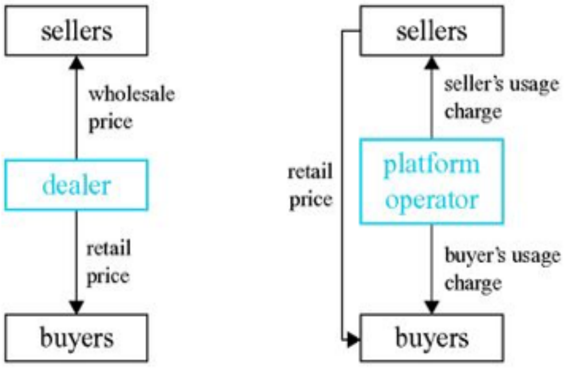

Figure 5 – Intermediaries' business models: dealer vs platform operator.
Source: "*Industrial Organization – Markets and Strategies*" by P. Belleflamme, M. Peitz.

Although buyer-seller relationships differ markedly between the two business models, there are no univocal results on which one grants the intermediary with higher trade volumes and profits. Therefore, Industrial Organization theory does not identify the preferred type of intermediation on the supply side.

In the following section, we deepen the analysis of multi-sided markets, in particular two-sided ones, presenting extensively their functioning and competitive dynamics.

Two-sided markets and their characterization

In two-sided markets, it is not enough for a seller or a service provider to convince an isolated group of customers to buy its own goods or join the platform he developed. For a full-regime functioning platform, the provider needs to get both market sides on board. **Figure 6** below lists some typical examples of two-sided markets.

Any portal, newspaper or TV channel wants to attract as many "eyeballs"[26] as possible in order to get more sellers buying advertising space on the infrastructure. Videogame platforms not only

[26] With the term **"eyeballs**" we refer to users of media platforms that are exposed to ads and commercials while using them. The platform usually provides content to users and sells advertising space to suppliers. The

have to make final customers buy their games, they also have to convince game developers to create entertainment content, with the grant that there will be a significant pool of final users willing to pay for it.

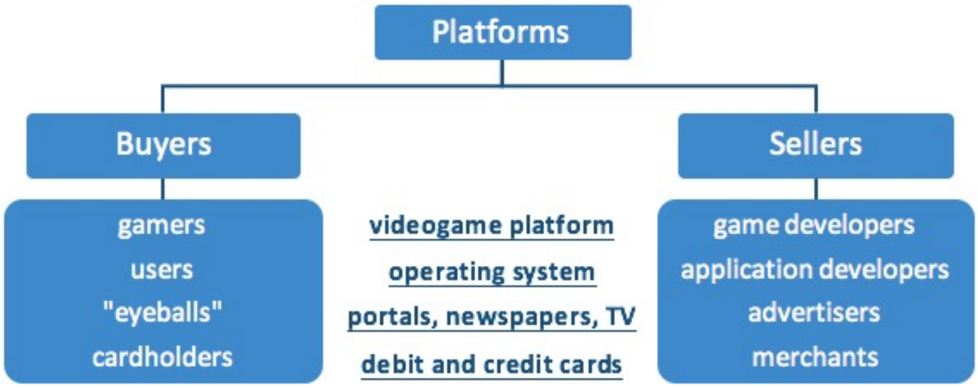

Figure 6 – Examples of two-sided markets.
Source: *J. Rochet, J. Tirole (2003) – "Platform competition in two-sided markets".*

The same holds in the OS market and in the payment card industry. Developers will engage in writing apps and software units only in the presence of enough users willing to buy the related hardware. Merchants in shops will accept electronic payments only if a substantial share of customers is demanding to pay through cards.

Clearly, firms' ability to attract the first group increases their chances to attract the second. Gamers willingness to pay depends on the amount of interesting content they are offered by an entertaining system; smartphones, tablets or PC users' valuation of the product and likelihood of buying it increases in the number of apps available on the device; cardholders subscribe debit or credit card contracts with the issuing bank only in view of the opportunity to pay electronically in many stores.

Firm's profits crucially depend on this interconnected system of incentives, targeted to both sides of the market. Moreover, platforms' degree of success in getting one group on board extensively impacts the other.

For the reasons set above, it is ultimately unclear on which side of a two-sided market firms should first launch their selling business. The above situation perfectly exemplifies the "chicken and egg phenomenon" we mentioned in Chapter I.

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latter's willingness to pay increases in the number of users the platform is able to cover, literally, the number of "eyeballs" that will be exposed to their ads.

The most rational strategy for a platform would be to classify the distinct groups of customers based on their willingness to pay for the offered product, collecting information on the extent of each side's valuation of joining.

Indeed, one of the main determinants of the pricing structure in two-sided markets is the magnitude of this difference in evaluations, ultimately translated in a difference in demand elasticities. Cardholders' demand while choosing where to buy is surely more elastic than the one of the merchants, which have significant interest in providing the possibility to pay electronically in their shop, employing it as a further incentive to buy.

However, there are additional dynamics beyond the difference in the distribution of the good's idiosyncratic valuation among the two sides of the market.

If one side brings more value to the other than vice versa, firms concentrate their efforts in attracting this side first, so that they can use it afterwards for attracting the other. This effect is referred to as cross-group externality and its magnitude has major impact on the pricing structure applied by two-sided platforms.

Cross-group externalities are generally positive. The more game developers write games for *Wii*, the more gamers will be purchasing that hardware. Same holds for dating websites and payment card industry. The only exception are media platforms that provide content while serving advertising at the same time, like search services, portals, newspapers, TV, radio.

Historically, most economic literature agreed on an agnostic approach relatively to the effect of advertising on final users. Ads are generally considered a neutral entry on users' utility function, if not even detrimental (in fewer cases). This latter assumption comes from the belief that being interrupted by a commercial while experiencing a product or enjoying a service may diminish users' utility or, in the most fortunate event, not impact it at all.

However, the above condition does not necessarily hold for every user. One could argue that a "naïve" consumer, who does not have enough information on his type or tastes, may benefit from the informative content of advertising, extracting welfare from commercials rather than being distressed by them. Indeed, targeted advertising may spare consumers most of the searching cost they would incurred in its absence. We will expand this hypothesis in chapter III.

In general, it is the final users' side to be the one exerting the most intense externality on the other. Readers of newspapers or online contents for instance, do not care about the number of advertisers as much as the latter care about the number of readers and users.

Platform firms profitably exploit both the asymmetry in demand elasticities and the direction of the larger cross-group externality. They select one side to "court" and charge it very low prices, sometimes even zero prices), while extracting higher rents from the other side.

Given their demand elasticity and the large externality they exert on advertisers, media platforms' users are often completely subsidized to get on board. The trend of charging zero prices to one side has become very common in the digital industry.

Google Chrome users for example do not pay any price to *Alphabet* for utilizing the search engine and enjoy its service for free, which means that they pay a virtually negative price for it. On the other hand, *Alphabet* charges significant fees to advertisers that are willing to get some advertising space on *Google*. A similar asymmetry holds in payment card industry, where a higher discount is imposed to the merchant's side of the transaction, while a lower one is offered to cardholders.

As explained above the pricing pattern resulting from two-sided markets clearly exhibits some atypical features, being always very skewed towards one side. This uneven distribution of costs immediately attracted the attention of regulators and policy makers that often intervened seeking a re-balancing.

Over the last decade, Europe regulators developed lots of tools and procedures aimed to correct, at least to a certain extent, two-sided markets' asymmetries, especially the ones deriving from a disproportionate power of one side relatively to the other. They capped roaming[27] and termination charges[28] to avoid users' exploitation in the telecoms markets, they regulated "multilateral interchange fees"[29] between merchants' and customers' banks in order to

[27] **Roaming** is the ability for a cellular customer to make and receive voice calls, send and receive data, get access to Internet and other services, when outside the geographical coverage of his home network, by using a visited network. Since 2007, European regulators have steadily lowered the maximum roaming charges allowable. In December 2016, the Member States voted to abolish all roaming charges by June 2017.

[28] **Termination charges** (or Termination rates) are the charges which one telecommunications operator charges to another for terminating calls on its network. Traditionally three models of charging these fees are known: calling party pays (CPP), bill and keep (BAK, peering), receiving party pays (RPP).

[29] **Multilateral Interchange Fees** (or MIFs) are inter-bank fees paid for the acceptance of card based transactions. MIFs are agreed on a collective basis between the acquiring bank (the merchant's bank) and the issuing bank (the customer's bank). For sales/services transactions, MIFs are usually paid by the merchant's bank to the customer's bank, while for cash transactions the interchange fee is paid from the issuer to acquirer, often called reverse interchange. In December 2015, the European Commission regulated interchange fees across the EU with the *EC MIF Regulation* (also called the Interchange Fee Regulation / IFR). The regulation established caps for interchange fees and binding commitments for operators, such acquirer pricing transparency, separation of card schemes and processing and other supporting rules.

rebalance the uneven distribution of costs in the payment card industry, they enforced a broadcasting regulation and designed auctions for the radio spectrum.

Some relevant literature on two-sided markets and its main results

The **2003** paper[30] by **Rochet and Tirole**, *"Platform Competition in two-sided markets"*, is considered one of the earliest and most significant theoretical contributions to the topic.

The authors declared intention was in fact to fill the gap between the economists' attention with respect to markets with network externalities and the widespread strategy discussion of the chicken and egg phenomenon with a comprehensive paper on two-sided markets.

They start from the observation that "many if not most markets with network externalities are characterized by the presence of two distinct sides whose ultimate benefit stems from interacting through a common platform."

The paper builds a model of platform competition in two-sided markets aimed to unveil the logic behind their peculiar price structure and the determinants of the platform's choice for a specific business model. In particular, Rochet and Tirole disentangle the price allocation between the two sides of the market analyzing how it is affected by a various range of factors: the platform governance (for-profit or not-for-profit), the platforms' differentiation and compatibility and the presence of same-side externalities.

Moreover, the authors investigate also the relationship between the price structure and the extent to which both sides of the market are served by more than one platform. In economic terms this behavior is called *multi-homing*[31].

The paper starts with the analysis of a private monopoly platform, the sides of the markets are indexed by the letters S and B, standing for *sellers* and *buyers*.

[30] J.C. Rochet, J. Tirole (2003) – *"Platform competition in two-sided markets"*.

[31] In Information Technology, **multi-homing** is the practice of connecting a host or a computer system to more than one network. Usually this is done to increase the host's reliability or performance. Economists endorsed the term in order to define the common behavior adopted by network markets' users of connecting to more than one network at the same time. For instance, merchants usually accept various types of cards, cardholders may sign contracts with different issuing banks, Internet users often download more than one search engine on their PC, advertisers place ads and banners in many different search services.

The model assumes log-concave demands D^S and D^B and profits, these latter are defined as $\pi = (p^B + p^S - c)D^B(p^B)D^S(p^S)$, with p^B and p^S the prices charged to buyers and sellers respectively and c the platform's marginal cost for executing the transaction.

After maximizing the profits over p^B and p^S, the total price $p = p^B + p^S$ chosen by the private monopoly turns out to significantly resemble the classical Lerner result[32]

$$\frac{p-c}{p} = \frac{1}{\eta}$$

The crucial difference between the Lerner formula and the profit-maximizing prices can be found in the cost allocation among the two sides:

$$p^B = \frac{\eta^B}{\eta} p = \frac{\eta^B}{\eta - 1} c$$

$$p^S = \frac{\eta^S}{\eta} p = \frac{\eta^S}{\eta - 1} c.$$

The price structure is therefore given by the ratio of elasticities $\frac{p^B}{\eta^B} = \frac{p^S}{\eta^S}$.

The above result shows that a typical two-sided markets' price scheme does not correspond to a "fair cost allocation" but is primarily designed to get both sides on board, irrespective of the uneven distribution of costs.

Later in the paper's analysis, this asymmetric allocation of costs is proved to be independent from the platform's business model. In particular, the authors show that "the price structure is the same regardless of whether the industry is served by a private monopoly, competing proprietary platform or competing association."

Another among the paper's numerous interesting results is obtained by shaping the market through a variant of the Hotelling model with linear demands.

[32] The **Lerner index**, formalized in 1934 by Abba Lerner, is commonly used to describe a firm's market power. It is defined as: $L = \frac{P-MC}{P}$, which corresponds to the inverse of demand elasticity. P is the market price set by the firm and MC is its marginal cost. The index ranges from 1 to 0, with higher numbers implying higher market power. A perfectly competitive firm has $L = 0$, while a monopolist has $L = 1$.

Buyers' preferences for different platforms are represented by their location x on a line of length $(\Delta + 2\delta)$, where they are uniformly distributed. Platform 1 and 2 are symmetrically located at a distance $\frac{\Delta}{2}$ from the origin, i.e. $x = -\frac{\Delta}{2}$ for Platform 1 and $x = \frac{\Delta}{2}$ for Platform 2, with Δ representing platforms' degree of substitutability. Buyers incur in a quadratic transportation cost which is normalized to 1 and their outside options are constituted by two other symmetric platforms located further away from the origin, $x = (-\frac{\Delta}{2} - \delta)$ for Platform $1'$ and $x = (\frac{\Delta}{2} + \delta)$ for Platform $2'$. The outside options platforms charge the same exogenous price p_o.

The distance between each platform and its nearest outside option δ, serves as a measure of the so-called "unique consumers".

Within this setting, the authors define the buyer's single-homing index as the ratio between the platforms' degree of substitutability and the latter increased of the distance δ:

$$\sigma = \frac{\Delta}{\Delta + \delta}$$

In the authors' formulation, the buyer's single-homing index decreases when the platform becomes more substitutable.

Moreover, the ability of platforms to strategically undercut each other in order to discourage sellers' multi-homing, termed "steering", is decreasing in the buyer single-homing index.

Indeed, a small single-homing index on the buyers' side implies more substitutability between platforms and consequently, less undercutting margin for a steering practice.

At the same time, an increase in multi-homing on the buyers' side, implying less substitutability between the platforms, facilitates the application of a steering practice on the sellers' side and results in a favorable price structure to their benefit.

This above result can be generalized to the fact that price competition is centered on the side that multi-homes the least, due to the fact that once those consumers are lost to another platform, they are considered locked-in there to some extent.

Therefore, the platform should channel its efforts on the attraction of the side that does not multi-home, rather than on the one that does, whose presence on the platform is less "rival".

Another detailed analysis of the effects of multi-homing in two-sided markets has been developed by **Armstrong**[33] in **2006**.

In the paper titled "Competition in two-sided markets", Armstrong present three different models of two-sided markets' competition: (i) a model with a monopoly platform; (ii) a model of competing platforms where agents join a single platform; (iii) a model of so-called "competitive bottlenecks[34]" where one group of customers multi-homes and joins all platforms.

Similarly to the one carried out by Rochet and Tirole, Armstrong's analysis is aimed to identify the determinants of two-sided markets equilibrium prices, which are shown to be the magnitude of cross-group externalities, the levying type of fees (lump-sum or per-transaction basis) and the degree of multi-homing.

First, Armstrong analyzes a framework with a monopoly platform. Although the monopoly paradigm does not apply to many examples of two-sided markets, there are a few which may fit the presentation, like for instance yellow pages directories, nightclubs and shopping malls, provided that they are enough far away from each other.

The model hypothesizes the existence of two groups of agents, 1 and 2, that care about the number of the other group's participants. Inter-side externalities are ignored for simplicity.

The utilities of both groups of agents are formulated as follows:

$$u_1 = \alpha_1 n_2 - p_1 \text{ and } u_2 = \alpha_2 n_1 - p_2 \tag{2.1}$$

with n_1 and n_2 representing the number of each group's members who participate in the platform, p_1 and p_2 the platform's prices to the groups and α_1 and α_2 the parameters measuring the benefit each agent enjoys from interacting with one agent from the other group. In particular, n_1 and n_2 are defined as increasing functions of the respective utilities, i.e. $n_1 = \phi_1(u_1)$ and $n_2 = \phi_2(u_2)$. The platform's profit is $\pi = n_1(p_1 - f_1) + n_2(p_2 - f_2)$, with f_1 and f_2 representing per-agent costs of serving respectively group 1 and group 2.

[33] M. Armstrong (2006) – *"Competition in two-sided markets"*.

[34] In production and project management, a **bottleneck** is one process in a chain of processes arranged in such a way that, if it has limited capacity, it reduces the capacity of the whole chain. The result of bottlenecks are stalls in production, supply overstock, pressure from customers and low employee morale. Here it is used to exemplify what happens when one side of the market multi-homes and the other does not. In this case if a member of the multi-homing side wants to interact with a member of the single-homing one, he is obliged to participate in the same platform as the single-homing agent he wants to reach.

Considering the platform to be offering utilities $\{u_1, u_2\}$ rather than prices $\{p_1, p_2\}$ the implicit price for group 1 would be $p_1 = \alpha_1 n_2 - u_1$ and similarly for group 2.
Expressed in terms of utilities, the platform's profit becomes:

$$\pi(u_1, u_2) = \phi_1(u_1)[\alpha_1 \phi_2(u_2) - u_1 - f_1] + \phi_2(u_2)[\alpha_2 \phi_1(u_1) - u_2 - f_2] \tag{2.2}$$

From (2.1), the expression for socially optimal prices must satisfy

$$p_1 = f_1 - \alpha_2 n_2 \text{ and } p_2 = f_2 - \alpha_1 n_1.$$

This implies that the optimal price for both groups equals the cost of serving that group's type, adjusted downward by the external benefit that group exerts on the other. A similar expression for optimal prices derives from the maximization of (2.2):

$$p_1 = f_1 - \alpha_2 n_2 + \frac{\phi_1(u_1)}{\phi_1'(u_1)} \text{ and } p_2 = f_2 - \alpha_1 n_1 + \frac{\phi_2(u_2)}{\phi_2'(u_2)}$$

Thus, the profit-maximizing prices equal the cost of providing the service to the specific group, adjusted downward by the external benefit that group exerts on the other and adjusted upward by a factor related to the elasticity of the group's demand.
The analysis above yields substantial results with respect to cross-group externalities.
First, as already pointed out by Rochet and Tirole, if a specific group exerts a large positive externality on the other, then the first is targeted more aggressively by the platform. Furthermore, unless they generate a tipping to monopoly dynamic, positive cross-group externalities and the subsequent need of courting one side, act to intensify competition and reduce platform profits. More specifically, in case of intense and positive cross-side effects, there is a downward pressure on the prices offered to both groups of agents with respect to a situation with no externalities at all. This implies that platforms may have some incentives to mitigate network effects, which are responsible for this mechanism.
The above conclusion serves as starting point for Armstrong to investigate platform's pricing strategies aimed to soften cross-group externalities.

The author compares two different charging bases, fixed fees and per-transaction charges. The first pricing scheme qualifies as a lump-sum charge, independent on how the platform performs on the other side. The second form of payment is an explicit function of the platform's success on the other side. An example of the latter scheme occurs when advertisers are charged an increasing function of the audience or readership of a media platform: the prices of commercials broadcasted before *YouTube*'s videos are function of the number of viewers; the sponsorship costs for *Facebook* pages depend on the desired exposure.

Armstrong claims that the latter pricing strategy is able to weaken cross-group externalities since a fraction of the benefit from the interaction of an extra agent on the other side is eroded by the extra payment incurred. Therefore, platform's profits are likely to be higher when per-transaction charges are applied.

Finally, the author analyzes the effects of multi-homing comparing a situation where both sides of the market single-home to one in which one side multi-homes and the other does not.

The latter configuration is termed "competitive bottleneck", in order to express the limitation imposed to multi-homers. More specifically, should an agent on the multi-homing side be willing to interact with another agent on the single-homing side, he would be obliged to join the platform chosen by the single-homing agent. Thus, towards multi-homing customers, platforms practically have monopoly power over providing access to their single-homing users.

This monopoly power leads to higher prices on the multi-homing side, lowering that group of agents to a sub-optimal level from a social perspective.

On the other hand, platforms have to fiercely compete on the single-homing side. Therefore, most of the high profits generated from multi-homers are passed on the single-homers in the form of low prices and subsidies.

To conclude the literature review, we find interesting to describe the pricing analysis made by **Belleflamme and Peitz** in their paper[35] from **2016**.

After the study of monopoly pricing in two-sided markets, with similar results to the ones mentioned above, Belleflamme and Peitz present a section on pricing under platform competition when markets tip, meaning when all agents end up interacting on the unique platform that survives at equilibrium.

The conditions they identify for observing market tipping are: positive and strong cross-group effects, closely substitutable platforms and single-homing.

[35] P. Belleflamme, M. Peitz (2016) – *"Platforms and network effects"*.

In the model they develop, adapted from **Caillaud and Jullien (2003)**[36], two platforms, 1 and 2, compete in the market and two distinct groups of agents are active: sellers (group S) and buyers (group B). Both groups are assumed to consist of a continuum of mass 1.

Offering exactly the same features, the platforms are seen as perfectly substitutes by agents, which use platforms' matching services in order to find their unique trading partner in the other group. Therefore, the probability to find the right partner on a specific platform increases with the number of agents of the other group registering with that platform. In particular, the probability for a buyer to find his match on platform i is equal to λn_B^i with λ being the probability that two matching partners that registered with the same platform find each other.

Similarly, the probability for a seller to find his match on platform i is equal to λn_S^i, with n_B^i and n_S^i the number of buyers and sellers that registered with platform i, $i = \{1,2\}$.

Gains from trade are normalized to one and supposed to be equally shared among the matching agents. Therefore, the gross gain from a successful match is equal to $1/2$ for each agent. The net gain is then $1/2\ (1 - p_i)$, with p_i being the transaction fee charged by the platform. The platform is assumed to charge also membership fees to both sides, m_B^i to buyers and m_S^i to sellers.

Then, the expected utilities for a sellers and a buyers registering with platform i are the following:

$$U_S^i = \lambda n_B^i \frac{1}{2}(1 - p_i) - m_S^i \text{ and } U_B^i = \lambda n_S^i \frac{1}{2}(1 - p_i) - m_B^i$$

At this point, the authors develop a sequential game. In the first stage the platform chooses the triple $\left(m_S^i, m_B^i, p_i\right)$ to maximize its profits

$$\Pi^i = n_S^i\left(m_S^i - c_S\right) + n_B^i\left(m_B^i - c_B\right) + \lambda n_S^i n_B^i p_i$$

with c_S and c_B being the costs the platform incurs in serving agents of each group. It is assumed that $c_S + c_B < \lambda$, in order to have that total gains from trade are larger than total costs.

In the second stage agents choose a platform to register with. Single-homing is assumed on both sides and all agents' outside options are normalized to zero.

The analysis of the resulting Bertrand competition reveals that platforms exploit cross-group effects applying a "divide-and-conquer" strategy. The "dividing" consists in price discriminating

[36] B. Caillaud, B. Jullien (2003) – *"Chicken & egg: competition among intermediation service providers"*.

between the two sides, subsidizing the one exerting larger externalities on the other. The "conquering" consists in using the subsidized side as valuable asset to attract the other one.

To be sure it will successfully attract the first group's participation, say the buyers' one, platform i should offer a better deal with respect to platform j, even in case of pessimistic beliefs on the buyers' side with respect to the number of sellers they will find on platform i.

More specifically, if the equation $-m_B^i > \lambda\frac{1}{2}(1-p^j) - m_B^j$ is satisfied, then all buyers will join platform i with sellers following them shortly. This scenario would generate the maximal aggregate surplus of $\lambda - c_S - c_B$ which is captured by the platform by setting the transaction fee at its maximal level, i.e. $p^i = 1$.

However, given that also platform j may engage in the "divide-and-conquer" strategy, this type of competition will gradually drive profits to zero. Moreover, only one platform will be able to remain active in the end. At equilibrium, the unique platform subsidizes full participation, charges the maximal transaction fee and makes zero profits. Furthermore, due to the presence of significant cross-side effects, making efficient for agents to be all registered with the same platform, the outcome is socially desirable. The same result can be applied to a situation in which one platform (the incumbent) is able to play before the other (the entrant). In this case the same equilibrium would prevail, with the incumbent deterring entry with low membership fees but foregoing all its profit.

Belleflamme and Peitz result is very interesting, especially within the debate on welfare implications related to a situation in which there is only one platform serving all agents, which is becoming increasingly common in digital markets.

Theoretical analysis of two-sided markets: two simple settings

As extensively discussed above, one of the most investigated feature of two-sided markets is the violation of a fundamental economic rule: the one for which, to make profits, a firm should charge a price above its marginal cost.

It can be shown that a two-sided firm not only finds most profitable to charge $p < MC$ (even $p = 0$) to one side and $p > MC$ to the other, but that this asymmetric pattern may have a positive impact on total welfare, despite the increasingly uneven distribution of costs among the two sides.

We know attempt to model the concepts above through a simple illustration.
Suppose only one platform serves the market and there are two types of potential customers of the platform, type A and B, that can be interpreted respectively as advertisers and users, developers and gamers and so on.
The goal of the firm is to charge prices such that both groups of customers are attracted on board.
Customers A and B differ in their valuation of joining the platform. In particular, customers A care about the number of customers B in the platform, while customers B simply judge the standalone benefit of being part of the platform.
Customers B can be of two types: *high value customers* with valuation v_B^H and *low value customers* with valuation v_B^L. The overall number of customers B that join the platform is N_B which is the sum of high value and low value customers (i.e. $N_B = N_B^H + N_B^L$).
The total number of customers A that join the platform is N_A and they all have the same valuation of the platform which is linearly dependent on the number of customers B that joined: $v_A = \alpha N_B$, with $\alpha > 1$. α represents the importance customers A attribute to the presence of customers B on the platform. Marginal cost of serving customers A and B are respectively MC_A and MC_B. We assume for now that $MC_A = MC_B$.
If the platform charges prices equal to the marginal costs (i.e. $p_A = MC_A$ and $p_B = MC_B$) the resulting price p is equal for both groups of customers:

$$MC_A = MC_B \Rightarrow p_A = p_B = p.$$

In this case all customers A would join the platform if and only if $v_A > MC_A \Rightarrow \alpha N_B > MC_A = p$.
This happens for a value of α such that $\alpha > \frac{MC_A}{N_B} = \frac{p}{N_B}$.
Knowing that $\alpha > 1$ the above equation is verified as soon as $\frac{p}{N_B} \leq 1 \Rightarrow\ p \leq N_B$. This latter condition implies that, once the unitary price payed by advertisers to get on board becomes lower than the number of "eyeballs" in the platform, all advertisers N_A will have an incentive to join the platform. This can be assumed to happen soon enough along the dynamic.
Customers B will join the platform if and only if $v_B > MC_B$. But customers B can be of two types and the platform does not know their valuation in advance.
If $v_B^H > p > v_B^L$ only the high valuation customers will join the platform and platform's profits would be:

$$\Pi = p(N_A + N_B^H) = pN_A + p(N_B - N_B^L).$$

(2.3)

The participation of low valuation customers B is therefore lost, meaning that platform's profits are diminished by N_B^L with respect to a full coverage situation.

We can proxy overall social welfare as the sum of the net benefit from joining the platform enjoyed by both sides, weighted for the number of customers joining per-side:

$$\begin{aligned} W &= N_A(v_A - p) + N_B^H(v_B^H - p) \\ &= N_A(\alpha N_B - p) + N_B^H(v_B^H - p) \\ &= N_B(\alpha N_A + v_B^H) - p(N_A + N_B - N_B^L) \end{aligned}$$

(2.4)

From the expression for profits (2.3) it is clear that the lower the fraction of left out consumers, which are customers B with low valuation v_B^L, the higher the platform's profits. Seeking to attract a larger share of customers B, the platform may decide to charge a price below the marginal cost to group B, thus subsidizing the side with more elastic demand. At the same time the platform would keep on charging a price above the marginal cost to group A, the one with more rigid demand. We therefore give up the assumption for which $MC_A = MC_B$ and allow the platform to price discriminate between the two sides. We assume that $p_B < p < p_A$, with $p = MC_A = MC_B$. Platform's profits would become:

$$\widetilde{\Pi} = p_A N_A + p_B N_B$$

(2.5)

Notice that the platform can raise p_A by virtually any amount, without fearing the loss of customers A. Indeed, the increase in p_A will not affect customers A participation provided that $p_A < v_A \Rightarrow p_A < \alpha N_B$ which becomes increasingly easy to be satisfied as the number of customers B joining the platform increases along the dynamic.

In addition, to further attract customers B, the platform can lower p_B up to the point $p_B = v_B^L - \varepsilon$, or even down to 0, which is the lower limit bound for p_B, for a v_B^L small enough.

In case of price discrimination between the two sides, the formula for welfare would become the following:

$$\begin{aligned}\widetilde{W} &= N_A(v_A - p_A) + N_B\,(v_B - p_B)\\ &= N_A(\alpha N_B - p_A) + N_B\,(v_B - p_B)\\ &= N_B(\alpha N_A + v_B - p_B) - p_A N_A.\end{aligned} \tag{2.6}$$

with v_B defined as the average valuation among customers B, (i.e. $v_B = \frac{v_B^H + v_B^L}{2}$).

If we compare the profits resulting from the two scenarios we can say that, with a fraction of left out consumers N_B^L high enough, meaning a significant expansion opportunity on side B, the profits with price discrimination $\widetilde{\Pi}$ are higher than Π, the ones deriving from the charge of a unique price equal to marginal cost. Formally:

$$\widetilde{\Pi} > \Pi \Leftrightarrow \frac{N_B^L}{N_B} = \frac{p - p_B}{p}$$

Recalling that $N_B = N_B^H + N_B^L$ we know that $N_B^L \leq N_B$. The above equation implies that, in order to attain a gain through price discrimination, the margin of further expansion on side B should equate the margin of price decrease on that side. We can apply the limit case of charging zero prices to customers B to the above condition. If the platform sets $p_B = 0$ all customers B have virtually the same valuation $N_B^L = N_B^H = N_B \Leftrightarrow \frac{N_B^L}{N_B} = 1$. If we assume that $v_B^H > v_B^L > 0$, everyone on side B would join the platform.

We now look at welfare formulas and attempt to assess the relationship between $\widetilde{W}$ and W.

$$W = N_A(\alpha N_B - p) + N_B^H(v_B^H - p) \text{ and } \widetilde{W} = N_A(\alpha N_B - p_A) + N_B\,(v_B - p_B)$$

Since $p_A > p$ the first term of W is higher than the first one of $\widetilde{W}$, meaning that the fraction of welfare generated in favor of customers A is lower if the platform price discriminates, due to the fact that customers A are now paying a higher price with respect to the one paid within the previous setting.

On the other hand, the second term, which is the fraction of welfare generated in favor of customers B, is greater in case of price discrimination (since $N_B \geq N_B^H$, $p > p_B$ and $v_B \geq v_B^H$).

Indeed, this strategy may benefit the elastic side of the market but it is less advantageous for the rigid one. Moreover, the asymmetry is increasing as the gap between p_B and p_A, relatively to the perfect competition price p, increases.

We now study when is it that $\widetilde{W}$ is higher than W.

$$\widetilde{W} > W \Leftrightarrow N_B v_B - N_B^H v_B^H + N_B^H p - N_B p_B > N_A(p_A - p)$$

with $N_B v_B - N_B^H v_B^H$ representing the fraction of new customers that price discrimination is allowing the platform to attract, $N_B^H p$ the cost for customers B without price discrimination (that in a sense is recovered in this second scenario) and $N_B p_B$ the cost that customers B actually pay in the second scenario. $N_A(p_A - p)$ captures the margin of price increase that the platform is exploiting while price discriminating on side A.

It is interesting to notice that while p_B can be diminished until the lower bound 0, p_A does not have any upper bound constraint, or rather, its upper bound αN_B is constantly moving up.

We can observe that the condition above crucially depends on the difference between p_B and p_A and on the number of new customers B that the price discrimination strategy is attracting on the platform. If the snowball effect on side B is greater than the utility loss on side A we can reasonably expect an increase on total welfare, despite the uneven distribution.

Indeed, the utility loss on side A, which derives from the raise in price p_A, is at least partially compensated by the increase of customers B, which exert a positive externality on customers A's valuation.

This asymmetric scheme and its potential detriment to welfare in terms of "fairness of allocation", constitute the main drivers of the attentive scrutiny of two-sided markets by competition authorities and of their numerous interventions to seek some kind of rebalancing.

We now try to depict a possible evolution for the dynamics of both sides of the market. In particular, we analyze the evolution of the two sides of a media platform, a search service for instance, respectively represented by advertisers and users.

In order to do so we use a pair of first-order, nonlinear, differential equations, deriving from a modified version of the famous **Lotka – Volterra equations**, also known as the **predator – prey equations**[37].

In this modified version of the model we assume that the number of users joining the platform increases in the amount of content provided by the platform itself and decreases in the number of advertisers present in the platform. This implies that the presence of advertising is bothersome to users. On the other side of the market, we assume that the number of advertisers linearly increases in the number of users that joined the platform, but decreases in the number of advertisers that are already there, due to the fact that they compete for a limited amount of advertising space. The following system of equations exemplifies the above dynamics, the first is the users' equation while the second is the advertisers' one.

$$\begin{aligned} x'(t) &= x(t)\big(\alpha M - p_x x(t)\big) - \beta x(t)y(t) \\ y'(t) &= -p_y y(t) + \alpha x(t)y(t) \end{aligned} \tag{2.7}$$

with $\alpha > 1, \beta \in (0,1), M > 0, p_x > 0, p_y > 0.$

$x(t)$ and $y(t)$ are the amounts of users and advertisers respectively that joined the platform up to time t; p_x and p_y are the prices charged to users and advertisers; M is the overall amount of content provided by the platform to users, meaning the total set of information that users are allowed to search through; α is the multiplicative factor associated with the quality of the search service algorithm; β is a parameter capturing users' dislike of advertising.

In order to illustrate the fact that users are bothered by the presence of advertisers interrupting their searching experience, the interaction term in the dynamic of users $\beta x(t)y(t)$ is negative. At the same time, the interaction term on advertisers' side $\alpha x(t)y(t)$ is positive.

In addition, the factor α not only multiplies M, capturing the fact that a good algorithm quality increases the search service ability to exploit the content provided, but also the interaction term on advertisers' dynamic. This latter formulation entails the fact that the better is the search service algorithm, the better are the matches it can get to advertisers. Therefore, α has a

[37] The **Lotka – Volterra model is** frequently used to describe the dynamics of biological systems in which two species interact, one as predator and the other as prey. The evolution of the two populations is closely liked: predators increase in the number of preys which represent their feeding and preys decrease in the number of predators. However, given the crucial role of preys in predators' survival, an overexploitation of preys by predators would cause the end of both species.

multiplicative effect both on the content management put into practice by the platform and on the positive impact that users exert on advertisers.

We first look for equilibria of the above system, which are the zeros of the equations' right-hand sides:

$$\begin{cases} x(\alpha M - p_x x) - \beta xy = 0 \\ -p_y y + \alpha xy = 0 \end{cases}$$

The above system has three distinct solutions, which correspond to three different equilibria for the model:

$$\boldsymbol{x^1} = (0,0)$$

$$\boldsymbol{x^2} = \left(\frac{\alpha M}{p_x}, 0\right)$$

$$\boldsymbol{x^3} = \left(\frac{p_y}{\alpha}, \frac{1}{\beta}\left(\alpha M - \frac{p_x p_y}{\alpha}\right)\right)$$

After carrying out a stability analysis[38] for the three points we identify some conditions for which they are stable or unstable. The Jacobian matrix associated to the system is the following:

$$D(x,y) = \begin{pmatrix} \alpha M - 2xp_x - \beta y & -\beta x \\ \alpha y & -p_y + \alpha x \end{pmatrix}$$

When evaluated in the first equilibrium point, the Jacobian $D(0,0)$ has two distinct eigenvalues: αM and $-p_y$. Given that α, M and p_y are all positive by assumption, the eigenvalues of $D(0,0)$ are of opposite sign. This implies that the first equilibrium point, where both sides of the market are zero, is always unstable.

[38] The stability analysis is carried out following the **Hartman – Grobman theorem** about the local behavior of dynamical systems in the neighborhood of equilibrium points. It asserts that a linear simplification of the system is effective in predicting a qualitative pattern of its behavior. It requires the application of spectral decomposition to the system's Jacobian matrix. In particular, for an equilibrium point to be stable, the eigenvalues of the Jacobian matrix associated to the system and evaluated in that equilibrium point should be lower than zero.

Applying the same procedure to the second equilibrium point we can say that $\boldsymbol{x^2} = \left(\frac{\alpha M}{p_x}, 0\right)$ is stable, meaning that the eigenvalues of the Jacobian matrix evaluated in $\boldsymbol{x^2}$ are negative, if and only if the following equations are both verified:

$$-\alpha M < 0$$

$$-p_y + \frac{\alpha^2 M}{p_x} < 0 \Leftrightarrow M < \frac{p_x p_y}{\alpha^2}$$

The first condition is always verified, since both α and M are positive. The second implies that, with a sufficiently small amount of content M, an equilibrium with zero advertisers and a positive population of users is stable. As mentioned above in the characterization of two-sided markets, such equilibrium does not entail a full-regime functioning of the search service platform, that should get both groups of customers on board in order to gain full profits.

From the analysis of the Jacobian matrix evaluated in $\boldsymbol{x^3} = \left(\frac{p_y}{\alpha}, \frac{1}{\beta}\left(\alpha M - \frac{p_x p_y}{\alpha}\right)\right)$ we similarly conclude that the third equilibrium point is stable if and only if both equations below are verified:

$$-\frac{p_x p_y}{\alpha} < 0$$

$$\frac{p_y}{\alpha}\left(\alpha^2 M - p_x p_y\right) > 0 \Leftrightarrow M > \frac{p_x p_y}{\alpha^2}$$

The first condition is always satisfied since p_x, p_y and α are all greater than zero. The second implies that, for an amount of content served to users which is large enough, an equilibrium with both populations positive is stable.

Summing up, the model predicts that up to the point where $M < \frac{p_x p_y}{\alpha^2}$ the equilibrium with no advertisers at all on the platform is locally stable. However, as soon as M becomes larger than $\frac{p_x p_y}{\alpha^2}$, the previous equilibrium is replaced by another with both sides participating in the platform. Therefore, it seems to exist a critical amount of content M that the platform needs to provide in order to attract a substantial mass of users, that in turn would effectively trigger advertisers' participation. Moreover, the model underlines the importance of the search algorithm quality in reaching a full-functioning equilibrium. As the platform increases its investments in algorithm quality it is gradually easier that the condition $M > \frac{p_x p_y}{\alpha^2}$ is satisfied, even with a constant provision of content M. This implies that the way the content is searched for, proxied by the algorithm quality α, is crucial in determining the evolution of a search service, in addition to the mere amount of content at the platform's disposal.

Chapter III

Google business

Google is a multinational technology company headquartered in Mountain View, California, with a wide and sophisticated business, ranging across Internet search, online advertising, cloud computing and software/hardware development.

The American Internet Giant was founded in 1996 by Larry Page and Sergey Brin, both PhD students at Stanford University back then. When presenting their project, Brin and Page clearly state Google's mission: *"to organize the world's information and make it universally accessible and useful"*[39].

In their **1998 paper** Google[40] is described as a *"prototype of a large-scale search engine which makes a heavy use of the structure present in the hypertext."*

In other words, Google's data model is designed to crawl the whole Web efficiently in search for information, then to index the findings storing them in a database and finally to rank them based on their relevance as results for a specific query. We call this procedure *page ranking*.

Exploiting its own ability to "read" the hypertext, the engine provides results simply based on the occurrence of the searched keywords throughout the content (*citation counting*).

By 2000, Google was able to deliver the largest index available on the World Wide Web, comprising more than 1.3 billion indexed web pages and supported by an infrastructure of more than 6000 Linux-based computer servers in multiple data centers[41].

Since the content was provided to users for free, very soon Brit and Page had to elaborate a way to monetize the engine. That same year Google launches *AdWords*, an advertising program that will shortly become its main driver of revenues. AdWords works as an auction system: advertisers bid for specific keywords in correlation to which, in case of winning, their ads will be displayed prominently. Advertisers are able to purchase keywords selectively, in order to target potential customers by serving them ads that match their search queries.

At its early stages AdWords was not exploiting any user's personal information to provide specialized search or targeted advertising results. The search was anonymous and the

[39] S. Brin, L. Page (1998) – "*The Anatomy of a Large-Scale Hypertextual Web Search Engine".*

[40] The site has been named after "googol", which is the mathematical definition for the number 1 followed by 100 zeros, found in the book "Mathematics and the Imagination" by Edward Kasner and James Newman. The founders chose this particular name in order to represents the huge amount of information that a search engine is generally able to manage and classify.

[41] www.google.com, Google's official website.

advertisement was served based exclusively on the website content and the user's geographical location. Typing the same keyword, everyone living on the same street would get the same ads and organic results.

In 2009 Google introduces the *Personalized Search*, a fundamental search model innovation enabling the algorithm to store data on user's historical searches and utilize them as a refining tool for future ones. As every user search history grows, his personalized results gradually improve, making the engine more and more proficient in returning relevant and tailored answers, both in terms of organic links and advertising content.

For the sake of making the search experience user-specific, in 2007 Google had already announced the introduction of the Universal Search box, a comprehensive bundle of results containing all Google's relevant properties.

In case of searching for a restaurant in a specific part of a city through the Universal Search box, Google would return an all-inclusive summary box containing Google maps of the area, a preview list of the present restaurants and direct links to Google Reviews. The box, aimed to provide quick and exhaustive answers to queries, was placed prominently above Google's organic links, one of the reasons why some of its features will be the core of the antitrust investigation recently faced by Google.

For the purpose of the later antitrust discussion, we consider appropriate to focus more specifically on some of the most relevant Google's businesses, namely *Google Shopping*, *Google AdWords/AdSense* and *Android OS*.[42]

Google Shopping is a Google service that allows users to search for products on online shopping websites and compare their prices between different vendors.

At first, Google was acting as a mere intermediary between potential buyers and merchants, which were required to enter private deals with the platform in order to submit products prices. In May 2012, the service switched to a "pay-to-play" model, where merchants would pay Google in order to gain a slot in the Google Shopping Box. This is a shopping unit displaying prices and commercial information placed above the organic links and next to traditional ads. The slot allocation is influenced by the merchants' relevance for the query and by the bid amount they paid. The original version of Google Shopping, called Froogle, dates back to December 2002. It simply crawled and indexed product data directly from vendors websites.

Through **AdSense**, first launched in 2003 as *content targeting advertising*, Google is no longer

[42] The following information on Google's businesses and offered products and features can be found in Google's official website: www.google.com.

limited to the advertisement provided directly on its own search websites.

The program allows to create and place advertising banners on third party websites or blogs and to receive a commission whenever a customer searching on the website's search box clicks on the ads displayed by Google. The advertising content is usually relevant to the specific website content, not to interfere too intrusively with users' search experience. While serving ads contextually related to a website content may result in less purchases with respect to ads related to search results, AdSense can be particularly effective for delivering advertising revenue to small websites that lack the resources for developing advertising sales programs themselves. All AdSense income comes from the **AdWords** program, a complex pricing model based on a Vickrey second price auction. Advertisers submit a sealed bid and, for any click received, pay one bid increment above the second-highest bid.

Android, originally developed by Android Inc, is a mobile operating system based on the Linux kernel and primarily designed for touchscreen devices such as smartphones and tablets. After acquiring Android Inc in 2005, Google released its new version of Android in 2007, officially entering the mobile OS space. Android's interface is extensively based on direct manipulation: users can swipe, tap and pinch to manage on-screen objects and input text through a virtual touch keyboard. Over the years, Google expanded Android's scope releasing Android TV for televisions, Android Auto for cars, and Android Wear for wrist watches. Although most Android devices are provided with a combination of open source and proprietary software, usually required to access Google services, Google realized Android's source code under an open source license policy. Being an open source OS, Android allows many developers and technology enthusiasts "to modify, update and insert features to a ready-made, low-cost and customizable foundation."[43]

Google's digital media store, Play Store, serves as official app store for the Android OS, allowing users to browse and download applications compatible with Android devices. With its massive installed base of consumers Android is particularly dominant in the smartphones segment. For this reason, many developers primarily dedicate themselves to write apps suitable for Android devices. As of July 2013, the Google Play store had over one million Android applications published and over 50 billion applications downloaded.[44]

[43] www.google.com, Google's official website.
[44] www.google.com, Google's official website.

Chronology of Google case

In **November 2010,** the European Commission opened an investigation on the Internet giant from Mountain View, aimed to verify whether Google was abusing of its dominance in the market for online search, through its search engine Google Chrome, *"by according preferential placement to the results of its own vertical search services in order to shut out competing services."* [45]

With the term vertical search services the EC refers to websites specialized in providing users with information on specific topics such as products price comparisons, travel tips and restaurants reviews. Google Chrome may be leveraging its dominant position as horizontal search service, in order to favor its own vertical services.

According to the investigation, Google may also be imposing exclusive obligations on its advertising partners, limiting their interaction with other advertising space providers and the portability of their advertising campaign data. In addition, Google's exclusive obligations may be binding hardware and software vendors too, for the purpose of shutting out competing search tools.

In **2012** the EC released a speech by the competition policy Commissioner Joaquin Almunia who strengthened the preferential treatment thesis and integrated the investigation with an additional concern according to which Google would copy original material from competing websites and serve it, unauthorized, on its own channels. This procedure, called *scraping*, is brought to the authority attention due to the potential disincentive for competitors to create original content and the consequent harm to innovation.

That same year also the Federal Trade Commission is assessing whether Google is preferring its vertical properties to the competitors' ones by leveraging its dominance in the horizontal search (this behavior is called *search bias*). One year after, the FTC issued a decision paper[46] presenting the unanimous conclusion to close this portion of the market investigation, claiming that *"Google's primary goal was to quickly answer, and better satisfy, its users' search queries by providing directly relevant information"*.

All these early antitrust issues are mainly related to Google's introduction of the *Universal Search* box which displays prominently Google's proprietary contents with the collateral effect of

[45] Press Release Database of the European Commission, 30 November 2010, http://europa.eu/rapid/press-release_IP-10-1624_en.htm

[46] Statement of the Federal Trade Commission Regarding Google's Search Practices in the Matter of Google Inc., 3 January 2013.

pushing farther down on the results page the traditional “ten blue links” of organic results. Regarding the supposed scraping behavior and the alleged restrictions on advertisers, the FTC dismisses its concerns, as long as Google commits “to *refrain from this conduct in the future.”* Although there are indications of some sort of pressure towards FTC to file this case, the American commission based its dismissal on the sensible evolution that the Universal Search box imposed to the search world. For the first time in history of Internet search, users were able to get directly the temperature in their geographical location when typing "weather" or straight some restaurant suggestions if wondering where to eat nearby.

While the US decided to refrain from intervention, Europe took further steps against the Internet giant. In **April 2013**, after a negotiation process that failed to deliver satisfactory remedies in the view of the EC, Google received a first *Statement of Objections*, which constitutes the formal procedural step for the opening of an antitrust case.

The document alleged that Google *"abused its dominant position in the markets for general internet search services in the European Economic Area (with a market shares above 90% in most EEA countries) by systematically favoring its own comparison shopping product in its general search results pages”*[47], through a biased application of the system of penalties.

As evidence of a favorable treatment the EC mentions the poor performance of Froogle, Google’s first comparison shopping service, that presumably did not benefit from the same preferring mechanism as all the subsequent comparison shopping services (Google Product Search and Google Shopping).

In the same document the EC formally opens a separate antitrust investigation on Android, Google’s mobile OS. The analysis is aimed to investigate the agreements into which manufacturers that use Android OS enter in order to install Google’s applications on their devices and whether Google leveraged its dominance in the mobile OS segment to hinder rivals. The EC is concerned that Google would require or incentivize smartphone and tablet manufacturers to exclusively pre-install Google’s own applications and services, preventing them from developing and marketing modified (and competing) versions of Android: the so-called “Android forks”.

Moreover, Google is accused to tie some of its services together. Indeed, if they want to provide customers with access to Google Play Store, device manufacturers are required to place Google Search and Chrome on the primary home screen of their Android devices.

Beside the official (and confidential) responses to the EC *requests for information*, Google

[47] Press Release Database of the European Commission, 20 April 2015, http://europa.eu/rapid/press-release_IP-16-1492_en.htm.

defended itself with a series of public articles on its own blog, published by company's key figures.

The first, titled "The Search for Harm"[48] and published by Amit Singhal, starts recalling that Google's acquisition of ITA, a flight search provider that would have enabled the company to show flight options directly on its first result page. The article underlines that the acquisition resulted in no harm to the online travel companies that were fighting the deal (Expedia, Kayak, and Travelocity), all still fiercely competing in the market for flight information.

Google's coverage with respect to some specific vertical services such Google Travel and Google Shopping is then presented for several European countries, revealing that, despite Google's dominance in the search space, other players dominate the vertical segments. German, French and British shopping online services for instance, are clearly dominated by Amazon and eBay, with Google Shopping being 7th in Germany, 10th in France and 5th in UK.

The article further highlights the role of Amazon and eBay as largest players among the online shopping providers and points out the high degree of innovation and turnover of companies within this space, quoting the quick success the famous German shopping website Zalando.

In another blog post[49] by Kent Walker, Google strengthens its defense claiming that "the Statement of Objections' preliminary conclusions are wrong as a matter of fact, law, and economics". Google defend its choice to go beyond the "10 blue links" through the Universal Search Box's format, that was aimed to better serve both advertisers. On the one hand, allowing a more efficient and user-friendly organization of product information and on the other hand, increasing the likelihood of a successful connection between the two sides.

In addition, Google firmly criticizes the proposed remedy requiring the company to share its advertising space and show ads sourced and ranked by other companies. Walker claims that such an obligation would be only justified should the company control an essential input or facility, with respect to which, under the essential facility doctrine, it would have duty to supply.[50]

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[48] Amit Singhal, *"The Search for Harm*", 15 April 2015, https://googleblog.blogspot.it/2015/04/the-search-for-harm.html.

[49] Kent Walker, *"Improving quality isn't anti-competitive*", 27 August 2015, https://europe.googleblog.com/2015/08/improving-quality-isnt-anti-competitive.html.

[50] The **essential facility doctrine** is a legal doctrine in the field of competition law which describes a particular type of claim of monopolization. It refers to a type of anti-competitive behavior in which an incumbent firm with significant market power controls an indispensable input or facility and refuses other firms to access it. The incumbent's denial works as a so-called *bottleneck*, meaning an obstacle (usually in production or logistics) that limits the other firms' ability to compete.

In **July 2016**[51] the Commission takes further steps in the investigation reinforcing its preliminary conclusions on abuse of dominance and restrictive agreements. Additional evidence is added to support the allegation that Google's conduct weakened or even marginalized competitors in the market for comparison shopping services, which is not considered the same relevant market where Amazon and eBay are active, contrary to Google's view.

Google most recent response to the EC consists in 2 different blog articles, which analyze jointly the Shopping and Advertising case and the Android case separately.

In "Improving Quality isn't anti-competitive, part II"[52], Google defends its targeted ads, aimed to offer customers immediate access to products that are likely relevant for them.

The author claims that nowadays consumers look for products not only via general search, but also directly visiting price comparison sites, specialist search services, original merchant platforms, social-media sites. Moreover, given the significant share of mobile Internet traffic in Europe, also dedicated apps compete in online shopping.

In response to the authority claim that Amazon cannot be considered in the scope of comparison shopping market, Google underlines that not only Amazon provides tools to compare products, but also the immediate possibility to buy and have them delivered the next day. From Google's perspective, this makes Amazon an even stronger competitor, likely the one to which complaining comparison shopping aggregators lost many of their clicks.

Another article, again by Kent Walker, titled "Android: Choice at every turn"[53], starts enumerating all the alleged benefits of the Android ecosystem, that "carefully balances the interests of users, developers, hardware makers, and mobile network operators providing high quality, wide distribution and accessibility for an affordable price". The article disagrees with the EC choice of not considering Apple's iOS as an Android's competitor only due to its vertically integrated business model, pointing out that consumers do compare these two systems while choosing which smartphone to buy.

Walker then justifies Google's agreements with the hardware makers underlying the necessity to safeguard Android from fragmentation and ensure the establishment of a minimum level of compatibility, due to developers' crucial dependence on a stable working framework.

[51] Press Release Database of the European Commission, 14 July 2016, http://europa.eu/rapid/press-release_IP-16-2532_en.htm

[52] Kent Walker, *"Improving quality isn't anti-competitive Part II*", 3 November 2016, https://blog.google/topics/google-europe/improving-quality-isnt-anti-competitive-part-ii/.

[53] Kent Walker, *"Android: choice at every turn*", 10 November 2010, https://www.blog.google/topics/google-europe/android-choice-competition-response-europe/.

The final part of the article is devoted to address the Commission concern with respect the integrated offering of Google apps on Android. Google claims to offer to manufacturers the opportunity to acquire a default package of apps, aimed to serve as familiar set of basic services right after the purchase. However, this opportunity is not an obligation for hardware makers. Walker further adds that on Android OS, Google's proprietary apps typically account for less than one-third of the preloaded total. Given that the average Android user in Europe is estimated to download (and replace) 50 additional apps over the lifetime of his device, Google does not see signs of foreclosure. Finally, rapid innovation, wide choice, and falling prices in the smartphones space are presented by Walker as evidences of "robust competition" in the market.

To this day, the triparty antitrust case carried out by the European Commission against Google is still on going and no definitive conclusion or settlement agreement, regarding the firm's alleged anti-competitive conduct, has been reached between the authority and the Internet giant.

Google key drivers of success

If we define a market for digital platforms in general, this is clearly dominated by five so-called *Internet giants*: Amazon, Apple, Facebook, Microsoft and Google.

Despite their core competences, respectively retailing for Amazon, devices for Apple, social network for Facebook, office tools for Microsoft and Internet search for Google, these multinational companies compete across the board in a large number of *adjacent markets*.

Apple, Amazon, Google and Microsoft overlap for instance in the operating system space, in the market for browsers and in the one for smartphones and tablets. Moreover, if we look at the market for specialized search and targeted advertising, we find Amazon, Facebook, Google and Microsoft as bordering competitors. Also in the social networks segment, there is an minor overlap between Google Plus and Facebook.

The fact that all these multinational platforms do not compete just in their vertical field, but fiercely interact in many adjoining markets, each one with a peculiar business model, makes very difficult to assess what is exactly their "relevant market", which is essential to formulate a correct competitive assessment.

During a conference[54] hosted in Brussels by the European think tank Bruegel, Hal Varian, Google's

[54] Bruegel, *"Big data, digital platforms and market competition"*, 3 October 2016, http://bruegel.org/events/big-data-digital-platforms-and-market-competition/

chief economist, described the market for digital platforms as highly competitive and contestable due to the flexibility of technology and its ease to allow re-purposes.

To compete in the web technology field, firms need production factors that are easily replicated and purchased in the market, such as “data centers, a network, a software and some engineers”, Varian says. Producers can quickly switch among different businesses, easily entering new ones. The frequent new launches of similar competing products by digital platforms gives large evidence of these recurring dynamics.

Not only producers can promptly reconvert and shift their production, also consumers seem to be able to easily switch between different products. Given the gradual tendency towards standardization of interfaces, consumers do not bear significant switching cost in terms of learning how to use a new product. This is proven by the fact that multi-homing is very common among digital users. According to Varian, a share between 35 and 55% of search engine users multi-homes during a month and 64% of developers declares to multi-home among different OS, writing apps for both Android and Apple for instance.

If we assess the relevance of switching costs focusing on the possibility to switch rather than on the actual share of consumers that effectively switch, we can agree, to some extent, with Google’s famous motto for which “competition is only a free click away”.

In this market, we indeed observe low prices, high quality, rapid innovation and a significant turnover of firms that, despite dominance at some point in time, may fall behind very quickly. Few years ago, MySpace was a leader in social networking, Yahoo was very well placed in the search engine space and Nokia, Motorola and Blackberry had significant shares in the market for mobile phones. As reported by Varian, around 4000 new technology companies entered in the European market since 2010, and 32.5 billion of venture capitalist funds were devoted to investments in this space.

Not just for big firms, also for small ones, production factors are very cheaply and readily available. Nowadays, a small firm is not required to build its own data center, being able to buy one’s capacity and compute capabilities there using easily portable tools and open source software such Linux, Apache, MySQL or Phyton.

Given the ease of purchasing the expertise and the high potential rewards of a global market, Varian calls the small firms arising in this world “micro multinationals”, meaning firms that are born global due to their potential coverage, irrespective of their actual size.

Varian’s *Shumpeterian* view of disruptive innovation may be able to explain, to a sizeable extent, digital markets’ dynamics. However, it is still fundamental to investigate the additional drivers of the active players' most distinctive features, extraordinary size and success, and the actual possibility for competing firms to replicate them.

The main reason for these platforms' great proportion and performance are usually direct or indirect network effects, generating large demand-side economies of scale that are able to amplify success as much as failure.

Looking at Facebook, the outstanding size of the platform is evidently driven by *direct network effects*, meaning that the value of joining the social network perceived by user increases directly with other users' participation. Within the OS market, we can identify instead *indirect network effects* coming from the chain that links product quality, users and developers.

In relation to Google, the source of the "snowball effect" is not as clear as in the previous examples. If we disentangle Google's business focusing exclusively on its search engine-related activities, we can model it as a simple two-sided market. On one side there are the end users, to which both content and advertisement is served for free, while on the other side there are advertisers, bidding and paying for their ads to be displayed.

The first feature we notice is the presence of strong inter-side network effects, at least on one side, since advertisers do care about the search engine coverage in reaching eyeballs. The value they assign to the platform increases in the likelihood of matching with buyers that are willing to purchase their products, therefore, they demand advertising space accordingly.

Consumers in turn can influence advertisers doubly. First, with their mere participation to the platform, which directly expands the pool of potential buyers; second, with their personal data contribution. Given the refining mechanism computed by the algorithm, the more users run queries on the platform, the more data are available to the search engine for improving its matching algorithms. Moreover, a better quality of the search results, gradually attracts an increasing number of users.

Indeed, consumers mainly value a search engine relatively to its ability to minimize their searching costs, providing high quality results in terms of accuracy, page load speed and real-time relevance.

For the reasons set above, each search engine's perceived quality is fundamentally connected to the amount of data from previous searches it has been able to collect and efficiently process. Furthermore, given the crucial importance of data accumulation in improving the algorithm predictive power, also consumers critical mass, upon which advertisers' revenues depend, is ultimately determined by the stock of data that the platform has stored to date.

Due to these dynamics, the access to big data by a search engine may be relevant not only in assessing dominance, but also while looking at barriers to entry. A large pool of information and experience in data analytics can definitely help incumbents in protecting their positions against potential entrants.

In a recent Bruegel's article[55] titled "Search engines, big data and network effects" Georgios Petropoulos asserts that the huge stocks of data about users and their preferences, while helping search engines with the offering of better services, practically constitutes an almost insuperable barrier to entry in the market for digital platforms.

According to Petropoulos, experience undeniably matters, but the main impact of learning by doing in digital markets, where it seems to be magnified with respect to traditional ones, is fundamentally data-driven. In particular, a search engine's "learning curve"[56] would in the end coincide with its proprietary stock of data.

Varian agrees that it is not network effects, but a specific type of learning by doing the real propeller spinning Google's success. Past data regarding the historical searches teach the engine about users' preferences enabling it to provide increasingly targeted ads and results.

In Varian's view, the use of data in order to offer better services, possibly at a lower cost, is essentially a supply side phenomenon, not depending on network effects, and more importantly welfare enhancing.

Furthermore, continues Varian, Google's enormous stock of data and its efficient management, is not a side effect of size or a natural result, but requires investment and it is also subject to obsolescence. As a matter of fact, data can depreciate as soon as a superior technology breaks through or simply due to the arising of more timely-relevant data.

In conclusion, to what extent platforms' success is merely driven by the intrinsic superiority of their matching algorithms with respect to competing ones remains unclear.

However, the first mover advantage for the incumbent in gathering data may definitely contribute to the creation of strong and lasting positions such Facebook and Google.

Accepting the idea that Google's robust position depends on data scale effects offers to competition authorities interesting tools for intervention, given data non-rival nature and ease of sharing.

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[55] Georgios Petropoulos, "Search engines, big data and network effects", Bruegel, 22 November 2016, http://bruegel.org/2016/11/search-engines-big-data-and-network-effects/.

[56] A **learning curve** is a graphical representation of the increase of learning with progressive accumulation of experience. The refined concept has been introduced by **Arrow** in 1954 and refers to product unit cost reduction and quality improvement as cumulative experience increases.

This is the exact starting point of the **2012** paper[57] by **Argenton and Prufer**, in which the authors scrutinize the relevance of query log data in assessing the degree of contestability of a search engines market.

A possible remedy: Argenton and Prufer proposal

In their paper from 2012 Argenton and Prufer want to verify, beyond Google's success or dominance, whether competition in the market for search engines is really "only a free click away"[58], as argued by the Financial Times in 2010 and endorsed by Google since then.

The authors start observing the high concentration in the market for Internet search. According to them, assessing the degree of contestability of this market is prior to any debate on Google allegedly abusive behavior or leverage of dominance. If the market can be considered highly contestable, Google's significant market share simply reveals the superiority of its service. If on the other hand the market is poorly contestable, it is its very structure, rather than the conduct of any market participant, calling for antitrust or even regulatory intervention.

Argenton and Prufer claim that the search quality production is characterized by an "intertemporal type of indirect network externalities". This concept refers to the aggregation of users past clicking behavior and the consequent improvement of the algorithm's guess on what users with similar revealed characteristics, such as geographical location or language, are looking for when entering a specific keyword.

They then construct a simple model of search engine competition aimed to explain coherently the past decade evolution of the active players' market shares. Then they point out the strong tendency towards market tipping and concentration and the potential negative consequences on economic welfare.

The authors proxy the perceived quality of a search engine by the expected time a user needs to obtain a satisfactory result to his query. This expected time is further broken down as determined by three main factors: the algorithm quality, the hardware quality and the data quality. Data quality, meaning the amount of potentially relevant data that the algorithm can search through, can be divided in two different components: the public, raw data available online, which virtually

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[57] C. Argenton, J. Prufer (2012) – "Search Engine Competition with Network externalities".

[58] Google Should Be Watched Carefully, Financial Times, 15 July 2010, http://www.ft.com/cms/s/0/a84e8438-9049-11df-ad26-00144feab49a.html#axzz1izSgsNzm.

coincides with all the World Wide Web data, and the context-specific data, generated by previous searches of the same keyword and the subsequent clicking behavior of other users.

Argenton and Prufer assume that the algorithm quality, the hardware quality and the amount of public data are of a peer level across (almost) equally efficient competitors, this implying that the search engine perceived quality and the whole *market tipping process* are mainly driven by the amount of context-specific data already stored by the engine.

Under this scenario, a firm with a leading market share at some point in time can spectacularly increase its advantage, whereas the other firms' market shares tend to gradually decrease.

To remedy this unavoidable concentration, they present the following policy proposal: "*All search engines should be required to share their (anonymized) data on clicking behavior of users following previous search queries.*"[59]

The illustration of the concentration dynamic starts with the analysis of a discrete choice model in a triopoly situation. Search engines compete submitting simultaneous bids x_i, which represents firm i's search quality as perceived by users. Three firms are present in the market, assumed to be fully covered. Firms are indexed by the numbers 1, 2 and 3 and the market share of each one is given by:

$$D_i = \frac{x_i}{\sum_{j=1}^{n} x_j}.$$

Since incomplete information is assumed, meaning that search quality is unknown by users before the search, the model yields an outcome where each firm's market share is monotonically increasing in its perceived average search quality but also where it is possible to retain a positive market share, even with a relatively low perceived search quality. The cost of producing quality $\mathrm{x_i}$ is given by $C(x_i) = \frac{x_i}{N_i}$ where N_i is the amount of previous search queries run on i. This cost equation shows that as the firm collects an increasing amount of data, it finds gradually easier to return satisfactory results to the submitted queries. The authors assume that firm 1 starts already with a competitive advantage, i.e. $N_1 \geq N_2 \geq N_3 \equiv 1$, and that each firm bears a fixed cost F. The profit function each firm is called to maximize over the offered quality x_i is then:

$$\pi_i = \frac{x_i}{x_1 + x_2 + x_3} p - \frac{x_i}{N_i} - F.$$

[59] C. Argenton, J. Prufer (2012) – "Search Engine Competition with Network externalities".

where p is the exogenously given advertising revenue associated with one consumer.
Analyzing the triopoly case and solving for equilibria, the authors show that if one firm enjoys a data-related first mover advantage, the resulting gap in quality levels and consequently profits increases over time, forcing the "weakest" firm to exit the market at some point. Equilibrium profits of the three firms are given by:

$$\pi_1 = \frac{(N_2 - N_1(1 + N_2))^2}{(N_2 + N_1(1 + N_2))^2} p - F,$$

$$\pi_2 = \frac{(N_2 + N_1(N_2 - 1))^2}{(N_2 + N_1(1 + N_2))^2} p - F,$$

$$\pi_3 = \frac{(N_2 + N_1(1 - N_2))^2}{(N_2 + N_1(1 + N_2))^2} p - F.$$

It can be noticed that the profits of the firm with the smallest installed base of context-specific data (firm 3) are negatively correlated with the amount of data detained by the other two firms. Furthermore, in the long run, firm 1 would keep on expanding its competitive advantage while firm 3 would inevitably end up exiting the market in order to avoid negative profits.
Figure 7, **Figure 8** and **Figure 9** below display the equilibrium profits, quality levels and market shares as a function of N_1, the amount of context-specific data to be searched by firm 1.

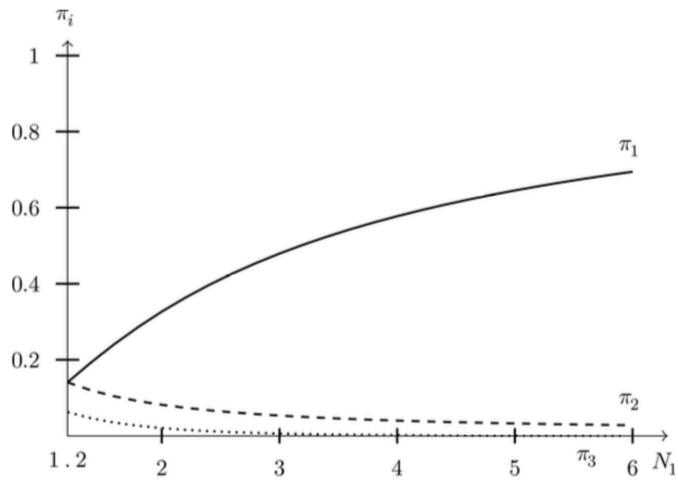

Figure 7 – Equilibrium profits as a function of N_1– Numerical example for $p = 1, F = 0, N_2 = 1.2, N_1 \in [1.2,6]$
Source: *"Search Engine Competition with Network externalities"* – C. Argenton, J. Prufer (2012)

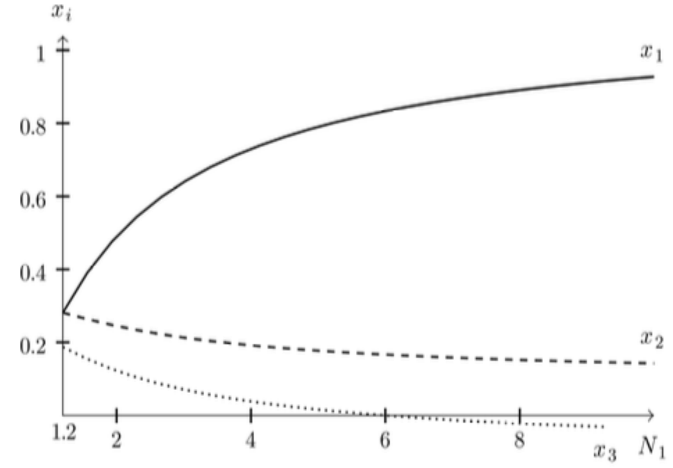

Figure 8 – Equilibrium quality levels as a function of $\mathbf{N_1}$ – Numerical example for $p = 1, N_2 = 1.2$.
Source: *"Search Engine Competition with Network externalities"* – C. Argenton, J. Prufer (2012).

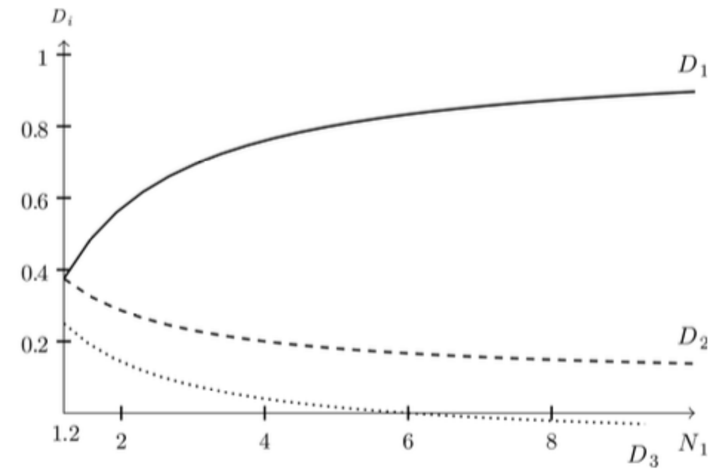

Figure 9 – Market shares as a function of $\mathbf{N_1}$ – Numerical example for $p = 1, N_2 = 1.2$.
Source: *"Search Engine Competition with Network externalities"* – C. Argenton, J. Prufer (2012).

This is shown to be detrimental for total welfare, which is computed as the sum of producers' surplus and consumers' one. Producers' surplus is simply given adding the three firms' profits together (i.e. $\sum_{i=1}^{3} \pi_i$) while consumers' surplus is proxied by the equilibrium quality levels, derived from each firm's profit maximization, weighted with their market shares:

$$CS = D_1 x_1^* + D_2 x_2^* + D_3 x_3^* = \frac{2N_1 N_2 (3N_2^2 - 2N_1 N_2 (1 + N_2) + N_1^2)))}{(N_2 + N_1 (1 + N_2))^3} p.$$

Total welfare is then given by the following formula:

$$W = \frac{(N_2 + N_1(3N_2 + 1))(3N_2^2 - 2N_1N_2(1 + N_2) + N_1^2)(3 + N_2(3N_2 - 2))}{(N_2 + N_1(1 + N_2))^3} p - 3F.$$

Figure 10 below display the evolution of total welfare, consumers' and producers' surplus as functions of N_1.

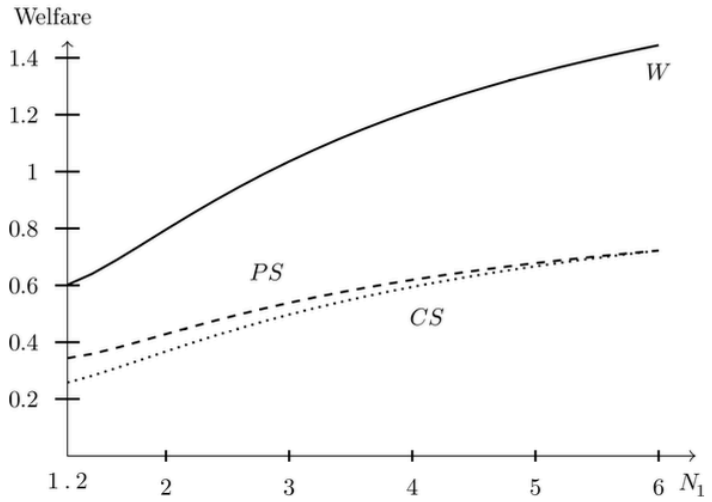

Figure 10 – Welfare as a function of N_1– Numerical example for $p = 1, F = 0, N_2 = 1.2, N_1 \in [1.2,6]$
Source: *"Search Engine Competition with Network externalities"* – C. Argenton, J. Prufer (2012).

Repeating the same procedure for the resulting duopoly the authors show that the gradual increase of the leader's installed base causes the exit of firm 2 as well, driving naturally the market to monopoly. Two variants of the monopoly case are analyzed: (i) a *pure monopoly* (or uncontested monopoly) where the incumbent does not fear any competition and therefore sets search quality at the minimum level and (ii) a *contestable monopoly*, where the incumbent puts in place an appropriate limit strategy in order to deter potential entry. Both cases are showed to be stable market structures with poorer quality and welfare with respect to the triopoly and duopoly cases.

In the last section of the paper Argenton and Prufer implement their policy proposal, meaning the request of a mandatory sharing of the context-specific data among the three firms. This is simply modeled assuming $N = N_1 = N_2 = N_3$.

The fact that the three firms share a unique installed base of data is shown to be able to turn a

monopoly situation in a “competitive oligopoly”. In this case, each of the three firms maximizes its profits as before, but with equal installed base $N_1 = N_2 = N_3 = N$.
The resulting Nash equilibrium in quality levels is

$$x_1^* = x_2^* = x_3^* = \frac{2}{9}Np = x^{comp},$$

which leads to an equally divided market in terms of shares and profits:

$$\pi_1 = \pi_2 = \pi_3 = \frac{p}{9} - F;. \qquad PS^{comp} = \frac{p}{3} - 3F; \qquad CS^{comp} = \frac{2}{9}Np;.$$

$$W^{comp} = \frac{p}{9}(3 + 2N) - 3F.$$

Even with the duplication of fixed costs for producing qualitative investments, the competitive oligopoly would generate consistent incentives to innovate for search engines due to constant competition. Moreover, the implementation of the policy proposal raises consumers’ surplus, due to users’ continuous benefit from high quality results. Argenton and Prufer conclude that such intervention of mandatory data sharing can spur innovation, search quality, consumer surplus, and total welfare.
Despite the model’s ability to fit enough realistically the developments of this market since early 2000, capturing its tendency towards concentration, in our view, the rationale behind the structure and especially the policy proposal presents some drawbacks.
First of all, the assumption of fixed algorithm quality is obviously unrealistic. The algorithm does not just influence search quality exogenously, but can significantly alter the magnitude of the variable N_i in affecting the model’s dynamics. A superior algorithm is crucial for an efficient and timely relevant management of the available data, exerting a major effect on search quality. Moreover, in the long run, it is reasonable to assume that, in order to sustain a relatively high level of profits, it will be *how* the data is searched through to be decisive, rather than *how much* of it is at the platform’s disposal.
It would be interesting to analyze how the equilibrium results would change if we modeled search quality as a function not only of the data available but also of a firm-specific parameter, representing the algorithm’s quality (i.e. $x_i = x_i(\alpha_i, N_i)$). Moreover, one could assume that the

algorithm quality parameter exerts a multiplicative effect on the data variable, both in producing a certain level of search quality and in reducing the cost associated with it.

The same point can be made relatively to the fact that the authors assume that the leader has an advantageous position exclusively due to the amount of data it has been able to store in the past. However, following the caveat above, this could be incorrect. The leading firm could simply have owned a better algorithm from the beginning, allowing it to return better results to queries, even possessing the same amount of context-specific data as the other firms.

We also believe that a mandatory sharing would be too strong as a measure, especially in view of the potential detriment on investment in quality by the leading engine.

Argenton and Prufer themselves admit that "every better targeted advertising is an important margin of innovation and competition in the industry", therefore, we cannot really say what would happen whether one firm decided to engage in a massive investment in algorithm quality. Around 2009 Microsoft's Bing for instance was able to exploit a re-branding (the transition from its previous search service MSN) to experience some growth, after years of falling profits.

Coordination of users away from one platform to join another one is not very easy as a dynamic to occur. However, it is certainly plausible, highly amplified by the extent of network effects and difficult to reverse once propels. Therefore, one could argue that in multi-sided platforms markets with high enough network externalities, potential competition exercises on the incumbent firm a level of pressure that is comparable to the one exerted by actual competition.

It is also important to underline that the possibility of multi-homing makes this market virtually unbounded, allowing for complete overlaps between the active engines. Due to this possibility, Argenton and Prufer specification of the firms' market shares and consequently of the advertising revenues, gives a partial figure of the actual functioning of search engines markets.

The non-rival nature of context-specific data, essentially provided by users during their queries, and the presence of multi-homing, meaning the fact that users can supply the same data to more than one search engine on a daily basis, may alter significantly the paper's analysis.

A final point can be made noticing that, despite the static nature of the game, the authors interpret N_i in a dynamic way, without a precise specification of its evolution law over time.

It would be interesting to transform the model dynamically, speculating the plausible evolution of N_i and consequently deriving its role in determining dominance over time.

Competition policy analysis and scope of the regulation

The criticism we advanced above against Argenton and Prufer paper has also a qualitative side. From a competition law perspective, a mandatory sharing of data would be justified only in the presence of an essential facility. The stock of data collected by Google however, qualifies more as the fruit of its success in the market, rather than constituting an essential input that is primarily necessary to start competing.

In addition, the authors' proposal is contradictory to the concept of *"competition on the merits"*, which generally implies that a dominant firm, dominant due to its merits, may lawfully engage in some conducts, even if the related consequence is that rivals are forced to exit the market or their entry or expansion are discouraged.

To some extent, this idea may be assimilated to the US approach to this area of competition law following which it is not dominance to be persecuted by the authority (attitude that may seem closer to the EU competition law approach instead), but simply the abuse of it.

We firmly agree that it is not dominance in itself that should be punished, but manipulation.

Etro and **Tarantino** tackle the theme of manipulation in platforms competition in two interesting papers respectively from **2012**[60] and **2011**[61].

Etro carries an in-depth analysis of the role of leadership in the market of search advertising. He shows that, in the presence of barriers to entry and significant network effects, a leading platform has strategic incentives to exploit scale in search and manipulate search results in order to divert traffic from competing platforms, limit multi-homing and become the monopolist.

Tarantino on the other hand focuses on the distinct incentives to a monopolistic search engine to bias organic and commercial results. He finds out that the engine has stronger incentives to manipulate the organic results rather than the commercial ones, due to the fact that it internalizes the profits deriving from the latter.

A careful reading of similar literature is sufficient to reveal that manipulation is undeniably not easy to investigate, let alone to formally demonstrate.

There is no sharp perimeter that accurately envelops the concept of abuse and the exact classification of what behavior should fall under the scope of "competition on the merits" is unclear and arduous to define.

[60] F. Etro (2012) – "Advertising and search engines. A model of leadership in search advertising".
[61] E. Tarantino (2011) – "A simple model of vertical search engines foreclosure".

However, from our perspective, this is the field the authority should focus on, especially in platforms' markets where concentration does not univocally coincide with harm to welfare.
If we assume for the sake of speculation that Google is simply the engine equipped with a superior algorithm, we must admit that the possibility to get accurate results to queries definitely enters consumers' surplus. Furthermore, even targeted advertising may be considered welfare enhancing, rather than neutral, due to the significant gains in searching costs it embeds.
If this is the case, there is a side of the market that benefits from the efficiencies of a concentrated pool of information and context-specific data. The potential exploitation of the advertisers' side may be solved through a regulatory intervention directed to the introduction of reasonable caps and tailored limits to the pricing system, leaving the market structure untouched.
We also steadily claim that the search engines' market, together with most of digital markets dominated by the so-called Internet giants, cannot be investigated in isolation with respect to competing firms' adjacent businesses.
The impossibility to define a unique "relevant market" for Google, Microsoft, Apple, Facebook and Amazon, calls into question the traditional competition law framework under which these firms should be scrutinized. Indeed, under the current European framework, the definition of a relevant market is prior to any assessment of the market's competitive dynamics and is fundamental to form a coherent and solid judgement on the firm alleged anti-competitive practices. Some relevant precedents may further suggest that the framework, conceived for *brick and mortar* markets, may be unable to deal with the new challenging implications embedded in the digital ones. In particular, structural remedies, traditionally imposed to correct anti-competitive attitudes, proved more than once their lack of effectiveness while employed against digital businesses.
Over the last two decades, one of the mainly investigated competition issues in network markets has been the famous practice of *tying* and its different application within the digital segment relatively to the physical one. One of the most relevant expositions in recent economic literature of tying in two-sided markets comes from the **2017** paper[62] by **Jay Pil Choi** and **Doh-Shin Jeon**.
Motivated by the increase in antitrust cases involving markets with zero-pricing, the authors develop a leverage theory of tying in two-sided markets. They assume the presence of two markets, one in which two firms compete, the other monopolized by one of the two. Their analysis of this benchmark shows that the two-sidedness of the tied good market constitutes a

[62] Jay Pil Choi, Doh-Shin Jeon (2017) – *"A Leverage Theory of Tying in Two-Sided Markets"*.

robust condition for a tying strategy to become profitable for the monopolist. In particular, both the two-sidedness of the market and the non-negative price constraint make contractual-tying a credible leverage strategy, regardless the relationship between the tied products.
Finally, the authors disentangle the impact of zero-pricing in two different components. On the one hand it creates rents that cannot be competed away, since by tying the monopolist is effectively engaging in charging negative prices, on the other hand the zero-price constraint essentially limits the intensity of the response by the rival firm.
Several early examples of the antitrust investigation regarding the practice of tying, can be found in Microsoft business history.
From 2004 to 2007 the European Commission has been investigating Microsoft focusing on its abuse of dominance by the means of two main anti-competitive practices: (i) tying its OS with other proprietary services and (ii) restricting its licensing policy with respect to interoperability.
After an in-depth investigation, the EC found Microsoft guilty of abuse of dominance by attempting to leverage its coverage in the market for OS to take over the market for video and media content. The anti-competitive practice consisted in the pre-installation of Windows Media Player, Microsoft media library application, on every OS sold to the manufacturers.
Microsoft was obliged to pay a fine and to submit to a structural remedy. The EC imposed to the company the obligation to provide manufacturers with two distinct version of its OS: a classic version containing *Windows Media Player* and a neutral version deprived of it, so that they could choose their preferred option. However, despite the higher price, the sales of the neutral version accounted for less than 1% of the overall sales, determining the practical failure of the remedy.
Behavioral remedies, which are already difficult to monitor in physical markets, where the various stages of the business process (from production to application) are rather tangible, become even more difficult to be successfully applied in digital markets.
During the same investigation, Microsoft was accused to favor its own search engine *Internet Explorer*, by pre-installing it on each basic version of its OS. The EC concluded that this practice was harming competition between web browsers, undermining product innovation and reducing consumers' choice. Microsoft was therefore obliged to display, at every first starting of its proprietary OS on any device, a comprehensive list of the most popular search engines on the market, among which the user would have been free to choose. In 2011 however, Microsoft dropped this feature for 14 months before the Commission was able to detect the violation. Indeed, the remedy was not so easy to be constantly supervised. Following this fault, Microsoft was fined €561 million to deter companies from reneging on settlement promises.

Conclusions

Since technology markets' earliest stages, both scholars and regulators argued about the suitable extent of public intervention within the digital space.

However, the discussion among economists and policy makers on the role of regulation and antitrust in the market for Internet services never reached a decisive conclusion.

As extensively underlined throughout the above presentation, high technology markets possess their own peculiarities and competitive logic and their functioning often diverge considerably from the one of traditional businesses.

The study presented above confirms that, due to the complex scheme of cross-side externalities that users of two-sided markets exert on each other, it is far from trivial to carry out a univocal welfare analysis that would lead to a *Pareto efficient* adjustment.

Whether there are enough grounds to completely regulate technology markets, is still under assessment. Undeniably, when designing anti-fragmentation policies, imposing standards, capping fees or preventing practices in technology markets, public authorities must pay particular attention to the potential short and long-run effects of their interference.

Technology markets' idiosyncratic features of non-linearity, high velocity, systemic interdependencies, frequent shocks and constant innovation, make them an exceptionally critical ground where to intrude. Therefore, regulatory agendas should engage in a close monitoring of emerging markets and technologies using a dynamic approach, not only to shape policy instruments properly, but also to experiment new tools and shelve the ones that failed. Furthermore, policy makers should always maintain a *technology neutral* approach and an open perspective, in order to alter the competitive dynamics as little as possible.

We soundly believe that digital markets are imposing some relevant challenges on competition authorities too. In particular, we call into question the EU competition law framework, conceived for brick and mortar businesses, and its effectiveness in dealing with Internet platforms.

We do long for the European competition authorities to open the existing doctrine to the opportunity of an integration that would take into account the digital markets peculiarities, in order to avoid the stretch of the current rules to fit this new space.

When dealing with two-sided markets, competition authorities should abandon the traditional benchmark of perfect competition, acknowledging that, some of the most targeted issues such market share inequality, strong dominance and high profitability of a leading firm, are natural settings in this type of markets, not necessarily entailing anti-competitive conducts.

In our view, the core of antitrust prosecution should consist in the assessment, and eventual punishment, of abuse and manipulation by an established position, rather than the conviction of dominance itself.

Our last point refers to privacy, an increasingly urgent issue within the digital space, especially due to technology socially crucial role in everyday life.

We believe that subjects such data and privacy protection should be more integrated in the competition authorities' assessments of technology markets, rather than be treated separately.

It is true that a zero price on the end users' side is now a norm in the industry of two-sided markets. However, at a closer look, consumers are paying the platforms with the provision of their personal data. Facebook provides access to an infrastructure that allows people to stay in touch, share information and organize events. At the same time yet, it gets people commercial preferences in return and monetizes them selling targeted advertising space accordingly.

Google Chrome usually provides immediate and accurate results when entering a specific keyword, but it tracks constantly consumers' locations, analyze carefully their previous searches and keeps attentive record of all their interests.

It is our idea that, beyond concentration, privacy protection could be an even more compelling issue in these markets, the implications of which are still relatively unknown to the public of users.

The forthcoming European reform of data protection[63], aimed to *"give citizens back control over their personal data"*, simplify the regulatory environment in the Digital Single Market and to allow users to fully benefit from the digital economy, suggests an increased interest of public authorities with respect to this matter.

In light of this augmented attention, we reasonably expect an imminent growth in the branch of the economic literature regarding the consequences and risks related to privacy issues in digital markets.

[63] The **General Data Protection Regulation** (**GDPR**) is a regulation by which the European Parliament, the Council of the European Union and the European Commission intend to strengthen and unify data protection within EU. The regulation was adopted on April 2016 and will apply from May 2018, replacing the data protection directive from 1995.

References

P. Belleflamme, M. Peitz "*Industrial Organization – Markets and Strategies"*, 2nd edition, July 2015.

N. Economides (1996) – *"The Economics of Networks"*.

Crémer, Rey and Tirole (2000) – "*Connectivity in the Commercial Internet."*

Katz and Shapiro (1985) – "*Network Externalities, Competition and Compatibility*."

S. M. Basen, J. Farrell (1994) – "*Choosing How to Compete: Strategies and Tactics in Standardization".*

P.A. David (1987) – *"Some new Standards for the Economics of Standardization in the Information Age."*

J.C. Rochet, J. Tirole (2003) – *"Platform competition in two-sided markets"*.

M. Armstrong (2006) – *"Competition in two-sided markets"*.

P. Belleflamme, M. Peitz (2016) – *"Platforms and network effects"*.

B. Caillaud, B. Jullien (2003) – *"Chicken & egg: competition among intermediation service providers"*.

S. Brin, L. Page (1998) – "*The Anatomy of a Large-Scale Hypertextual Web Search Engine".*

www.google.com, Google's official website.

Press Release Database of the European Commission, 30 November 2010, http://europa.eu/rapid/press-release_IP-10-1624_en.htm.

Statement of the Federal Trade Commission Regarding Google's Search Practices in the Matter of Google Inc., 3 January 2013.

Press Release Database of the European Commission, 20 April 2015, http://europa.eu/rapid/press-release_IP-16-1492_en.htm.

Amit Singhal, *"The Search for Harm*", 15 April 2015, https://googleblog.blogspot.it/2015/04/the-search-for-harm.html.

Kent Walker, *"Improving quality isn't anti-competitive*", 27 August 2015, https://europe.googleblog.com/2015/08/improving-quality-isnt-anti-competitive.html.

Press Release Database of the European Commission, 14 July 2016, http://europa.eu/rapid/press-release_IP-16-2532_en.htm.

Kent Walker, *"Improving quality isn't anti-competitive Part II*", 3 November 2016, https://blog.google/topics/google-europe/improving-quality-isnt-anti-competitive-part-ii/.

Kent Walker, *"Android: choice at every turn*", 10 November 2010, https://www.blog.google/topics/google-europe/android-choice-competition-response-europe/.

Bruegel, *"Big data, digital platforms and market competition"*, 3 October 2016, http://bruegel.org/events/big-data-digital-platforms-and-market-competition/

Georgios Petropoulos, "Search engines, big data and network effects", Bruegel, 22 November 2016, http://bruegel.org/2016/11/search-engines-big-data-and-network-effects/.

C. Argenton, J. Prufer (2012) – "Search Engine Competition with Network externalities".

Google Should Be Watched Carefully, Financial Times, 15 July 2010, http://www.ft.com/cms/s/0/a84e8438-9049-11df-ad26-00144feab49a.html#axzz1izSgsNzm.

F. Etro (2011) – "Advertising and search engines. A model of leadership in search advertising"

E. Tarantino (2012) – "A simple model of vertical search engines foreclosure".

Jay Pil Choi, Doh-Shin Jeon (2017) – *"A Leverage Theory of Tying in Two-Sided Markets"*.

Competition in high technology markets: multi-sided platforms and Google antitrust case

Abstract

Over the last few decades, digital markets have been forcing their presence and peculiar features into the traditional economic space of *brick and mortar* businesses.

The dissertation *"Competition in high technology markets: multi-sided platforms and Google antitrust case"* intends to attentively analyze digital markets and their distinctive characteristics, offering a comprehensive overview of their functioning.

Together with an analytical evaluation, the study also qualitatively characterizes some typical welfare and competition policy implications within the technology space.

Nowadays, high technology markets seem to be jointly dominated by few large digital platforms, the so-called *Internet giants*: Amazon, Apple, Facebook, Microsoft and Google. Despite their core competences, these multinational firms compete across the board in a large number of *adjacent markets*, which makes very difficult to precisely categorize their businesses or engage in a straightforward policy assessment.

Chapter I offers a theoretical presentation of markets for network goods and their competitive dynamics. A market for a single network good is used as a starting point to examine the role of *network effects* in affecting users' utilities through the creation of an interconnected scheme of incentives. Differently from most traditional products, while consuming network goods, customers consider not only the intrinsic utility they extract from that specific good, but also the other users' behavior, which determines the size of the network. Due to consumers' lack of coordination and idiosyncratic evaluation of network and standalone benefits, for a given selling price in the industry, multiple equilibria arise, each one relying on self-fulfilling expectations with respect to the network size. After the network reaches a size equilibrium that exceeds its *critical mass*, a self-reinforcing expansion will rapidly generate a larger infrastructure, which Pareto dominates the previous ones.

The implications of compatibility choices in markets for several network goods are then depicted, both from a demand-side and a supply-side perspective, within which various standardization strategies are presented.

Following **Belleflamme and Peitz (2015)** we present a simple sequential model where two incompatible network goods are competitively supplied. The analysis suggests that network competition with incompatibility, meaning competition *for* the market rather than *in* the market, is likely to provoke long-run dominance. Moreover, since the difference in firms' installed bases evolves in a *path dependent* fashion being randomly determined by small and subsequent events, the long-run winner cannot be predicted beforehand.

The described market dynamics might lead to potential inefficiencies. For instance, the good preferred by the majority of users, i.e. the one with the higher long-term payoff, might not be the same that monopolizes the market, ultimately determined by the preferences of early adopters.

Similar market failures are likely to happen in the presence of incomplete information about other users' preferences for the available technologies.

In system markets with sequential moves, we often observe *excess inertia*, meaning that users do not adopt a new technology despite its intrinsic superior quality, or *excess momentum*, that is users adopting a new good even if they would be better off sticking to the old one.

These conditions are enclosed in the famous *chicken and egg phenomenon*. Due to users' uncertainty, as to whether they would be followed in case of switch, no one will take the risk of moving first, giving up the higher benefits of a superior technology.

Regarding the effects of compatibility on equilibrium results, we first show that enhanced compatibility induces a market expansion effect, and consequently a higher consumer surplus. However, it also reduces quality differentiation, being less desirable for a firm that is more efficient or whose brand is better established. Therefore, incentives with respect to compatibility might be misaligned between customers and firms, or even among firms themselves, affecting differently both adoption and provision decisions.

Afterwards, a public policy analysis of network markets is carried out. In particular, the new challenges faced by regulators and antitrust authorities within the digital space are outlined, together with the necessity of an approach that would safeguard competitive dynamics and persistence of innovation incentives.

Chapter II narrows the dissertation's focus on multi-sided platforms and two sided-markets. In this particular framework, it is not enough for a seller or a service provider to convince an isolated group of customers to buy its own goods or join its platform: to attain a full-regime functioning, the firm needs to get both market sides “on board”.

The concept of market intermediation is firstly introduced, and the main roles fulfilled by intermediaries while entering transactions are described with their feasible business models.

Leaving aside potential advantages related to logistics, storage or inventory, Industrial Organization theory shows that intermediated transactions may be able to improve buyers’ and sellers’ matching opportunities. In particular, when specific conditions are met, there is a free spot in the market structure that can be successfully occupied by an intermediary, which would facilitate a more efficient coordination compared to bilateral relationships, regulate transaction costs and safeguard from potential free riding issues.

The determinants of the peculiar pricing structure in two-sided markets are then carefully investigated through the presentation of some relevant literature in this respect.

The **2003** paper[1] by **Rochet and Tirole**, considered one of the earliest and most significant theoretical contributions to the topic, is depicted in its most interesting insights.

The drivers of the pricing asymmetries are shown to be powerful cross-side externalities and differences in demand elasticities among the market’ sides. In order to profitably exploit these features, the platform selects one side to “court” with very low prices, while extracting higher rents from other.

Given their large demand elasticity and the significant externality they exert on advertisers, media platforms’ final users are usually completely subsidized to get to join.

Rochet and Tirole also investigate the relationship between the price structure and the extent to which both sides of the market are served by more than one platform, in economic terms, the extent of *multi-homing*. Price competition is shown to be centered on the side that multi-homes the least, due to the fact that once those consumers are lost to another platform, they are considered locked-in there. Indeed, the platform channels its efforts on the attraction of the side that single-homes, whose presence is perceived as more “rival”.

Similar results from the **2006** paper[2] by **Armstrong** are briefly analyzed. Through a simple platform competition model, it is shown that, in case of intense and positive cross-side effects, there is a consistent downward pressure on both sides’ prices with respect to a setting with no externalities at all. Consequently, platforms may have some incentives to mitigate network effects, through the application of pricing strategies aimed to soften cross-side externalities.

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[1] J.C. Rochet, J. Tirole (2003) – *“Platform competition in two-sided markets”*.

[2] M. Armstrong (2006) – *“Competition in two-sided markets”*.

In this regard, the paper considers two different charging bases, fixed fees and per-transaction payments, and scrutinizes their repercussions on the equilibrium results.

We finally mention **Belleflamme and Peitz** paper[3] from **2016**, focusing on the section on platform pricing under *market tipping*, that is the irreversible development leading to the long-run survival of a unique supplier. At equilibrium, the unique platform subsidizes full participation, charges the maximal transaction fee and makes zero profits. Due to the presence of significant cross-side effects, making efficient for agents to join the same platform, the presented outcome is shown to be socially desirable. This result is extremely interesting, especially within the debate on the welfare implications in markets dominated by a monopoly platform, an increasingly common background for the Internet segment.

At the end of Chapter II, two simple theoretical settings are modeled and discussed. The first starts from the observation that a two-sided firm not only finds most profitable to charge prices below its marginal cost to one side and above to the other, but that this asymmetric pattern may have a positive impact on total welfare, despite the increasingly uneven distribution of costs among the market sides.

The second model, a modified version of the famous Lotka – Volterra system, aims to describe through a pair of nonlinear differential equations, the composition, and possible evolution, of the advertisers' and users' sides in a media platform market.

In the developed system, the users' side increases in the amount of content provided by the platform and decreases with the number of advertisers, i.e. advertising is assumed to enter negatively users' utility function. We further assume that the advertisers' side linearly increases with users joining, but decreases in the number of other advertisers, all competing for a limited amount of commercial space. After the stability analysis of the three possible equilibria, the model predicts that the solution with a positive number of participants on both sides of the market, becomes stable as soon as the content provided to users is large enough. It seems to exist a critical amount of content to attract the adequate mass of users that would trigger advertisers' participation. In addition to content capacity, the model also underlines the crucial importance of the search algorithm quality in determining profitability.

Chapter III consists in a more qualitative representation of two-sided markets and their competition policy implications. The triparty antitrust investigation currently being carried out by the European Commission against Google, is presented in detail and Google alleged anti-competitive practices are submitted, both from the EC perspective, and from the firm's defensive

[3] P. Belleflamme, M. Peitz (2016) – *"Platforms and network effects"*.

one. The Commission concerns refer to Google alleged abuse of dominance in the market for online search, by giving a preferential treatment to its own vertical services in order to shut out competing ones. Google might also be imposing exclusive obligations on its advertising partners, limiting their interaction with other providers and the portability of their advertising campaign data. A third accusation relates to Android's alleged leverage of dominance in the mobile OS segment. The core of the investigation are the agreements into which manufacturers that use Android OS enter in order to install Google's applications on their devices. The EC is concerned that Google might require or incentivize smartphone and tablet manufacturers to exclusively pre-install Google's own applications and services, preventing them from developing competing versions of Android.

To this day, the antitrust case is still on going and no definitive conclusion or settlement agreement has been reached between the authority and the Internet giant.

A second section of Chapter III is devoted to the analysis of present day digital platforms' most distinctive features, extraordinary size and performance, and the actual possibility for competing firms to replicate them. Although the main reason for great proportion and success usually lies in the presence of direct or indirect network effects, for search engines, the role of data accumulation is also crucial in determining a profitable functioning.

The more users run queries on the engine, the more data are available for improving the predictive power of its matching algorithm. This refining mechanism allows a gradually higher quality of the search results, in terms of accuracy, page load speed, real-time relevance and minimized searching costs. Due to the above dynamics, consumers critical mass, upon which advertisers' revenues depend, is ultimately determined by the stock of data the platform has been able stored in the past. Summing up, the access to big data by search engines may be relevant not only in assessing dominance, but also while looking at barriers to entry.

A further analysis of the role of big data in shaping competitive dynamics is offered through the **2012** work[4] of **Argenton and Prufer**. Their policy proposal of a mandatory sharing of data to contrast concentration in search engine markets, is carefully examined and criticized, both from a modeling perspective and from competition law one.

In the final section of the dissertation a competition law assessment of digital platforms is drafted and some considerations with respect to potential regulatory interventions are further run through.

[4] C. Argenton, J. Prufer (2012) – "Search Engine Competition with Network externalities".

Despite both scholars and policy makers long argued about the suitable extent of public intervention in the digital space, the debate on the role of regulation and antitrust in the market for Internet services never reached a decisive conclusion.

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The study presented above confirms that is far from trivial to carry out a univocal welfare analysis that would lead to a *Pareto efficient* adjustment.

Whether there are enough grounds to completely regulate technology markets, is still under assessment. Undeniably, when designing anti-fragmentation policies, imposing standards, capping fees or preventing practices in technology markets, public authorities must pay particular attention to the potential short and long-run effects of their interference.

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