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Digital Platforms, Multi-Sided Markets, and the Anticommon Problem

Abstract

In this article we analyzed some of the most relevant contributions of the economic literature on competition among platforms and among firms selling their products within or across platforms. We focused on the impact that such new business models produce on prices, firm profits, and welfare, with particular attention paid to small and medium enterprises (SMEs). In the new Internet of Things, platforms compose “multi-sided ecosystems” where they can either be substitutes—competing to attract the most successful independent complementors—or complementary to one another “by necessity” because of technical or legal reasons. We studied both cases “transversally” and focused on the role of complementarity in shaping price and quantity competition in imperfectly competitive markets. Thus, we will be able to verify whether the standard results on the so-called “tragedy of the anticommons,” which dates to Cournot (1838), can be extended to multi-sided markets.

Key Words: Multi-sided Markets, Platforms Competition, Complementarity, SMEs, Licensing, Tragedy of the Anticommons.

1. Introduction

At a time when the internet and digital technologies are transforming our world, creating a Digital Single Market (DSM) is one of the European Commission's political priorities. Its aim is to empower people and firms with a new generation of technologies. There is, however, a growing concern about the ability of small and medium enterprises (SMEs) to thrive as independent players in the DSM economy (Hänninen et al., 2017). Their incumbent business models are indeed challenged by new competition and evolving consumer expectations because their trades have increasingly moved online, which requires their managers to understand and react to the changing landscape at a fast pace.

One example of such a business model innovation is multi-sided digital platforms. Platforms are all those firms, or the services of firms, that connect market participants and allow them to interact or transact. Platforms are prevalent in many markets. Health insurance companies, for example, mediate between consumers and care providers, and cable television companies mediate between content providers and viewers. It's their rise on the internet, however, that has especially changed the way vast parts of the economy are organized. This has led scholars to an intense re-examination of the nature of market power, competition policy, and regulation (Jullien et al., 2021).

This study analyzes some of economic literature's most relevant contributions on competition among platforms and among firms selling their products within or across platforms. It focuses on the impact that such new forms of competition have on prices, firm profits, and welfare. One typical feature of such contributions is that both the platform and the profit of each firm selling its products within it depends on the prices of all other market players via their effects on the relative attractiveness of each platform.

One implication of such a feature is that platforms often appear as substitutes to one another for consumers and will then fiercely compete to attract the most important and successful independent complementors (retailers, movie distributors, game developers, software programmers) present in the market. There are, however, circumstances under which platforms look complementary to one other by necessity due to technical or legal reasons. One goal of this review is to analyze both cases by adopting a transversal approach that focuses on what seems to be one of their most relevant common features: complementarity (either among the products offered by each platform or among the platforms themselves). In fact, thanks to such a transversal perspective, we will be able to consider the span of results obtained by the law and economic literature on the so-called "tragedy of the anticommons," which dates to Cournot (1838) and analyzes the role of complementarity in shaping the welfare effects of price and quantity competition in imperfectly competitive markets.

More specifically, Section 2 briefly illustrates how economists model platform competition as two-sided markets, considering both direct and indirect network effects. Section 3 introduces the "tragedy of the anticommons," focusing on its impact on oligopolistic markets. Section 4 studies those modern network industries that feature both complementarity and two-sidedness and, thus, focuses on the competition among substitute platforms selling complementary products. Finally, Section 5 presents the more recent economic literature on complementary platforms by analyzing, among other things, whether the standard results of the "tragedy" can be extended to two- and multi-sided markets. We will first verify if an extreme fragmentation of property rights induces monopoly outcomes in the presence of complementary platforms. Second, we determine the impact of mergers among them.

2. Two-sided markets and Platforms

Platform economics is central to understanding a wide variety of recent policy debates, such as net neutrality, financial market reforms, and antitrust policy, as well as related topics such as

privacy, consumer protection, and media diversity. Moreover, platform economics provides a useful framework to analyze the impact of online platforms on SMEs, whose ability to develop internal digital infrastructures that can benefit from digitalization is limited by a lack of financial resources and/or skills (OECD, 2019).

On one hand, online platforms offer SMEs some obvious benefits. They provide access to new markets, sourcing channels, and a multitude of digital networks. They also provide a range of efficiencies that can determine economies of scale and, in turn, boost competitiveness and productivity. Finally, digital technologies can substantially lower many costs: such as search, replication, distribution, tracking, and verification costs (Goldfarb and Tucker, 2019).

On the other hand, SMEs face challenges in adoption and adapting. There are direct and indirect costs involved in capitalizing on online platforms. They range from the fee structure proposed by platforms to the need to share sensitive business data, and the implicit acceptance to be subjected to “matching algorithms” on which SMEs have little influence. Moreover, many offline business models have been disrupted by online platforms, which creates the need for SMEs to adapt to the changing scenario (OECD, 2021).

The role of direct and indirect network effects is a central aspect of platform economics. These effects apply when the value of a product depends on the extent to which other market participants adopt or use the same product. Specifically, direct network effects are observed when the value of a product increases as it diffuses into the market and drives further adoption. For our purposes, however, indirect network effects are even more relevant, and they emerge when the adoption and use of a product leads to increased provision of complementary products and services. The value of adopting the original product increases with the provision of such complementary goods. In other words, indirect network effects lead to a feedback loop as more participants on each side of the platform (sellers and final consumers) find it more valuable to adopt and use the platform when they expect the other side to attract more users and products.¹

In this respect, such effects lead to consideration of the various interdependencies between the two sides of the market. This phenomenon might lead to increased market efficiency (because more market participants can interact with each other), but it may also lead to a greater degree of market power in some circumstances, as network effects can protect platform owners from entry. Indeed, in markets with low marginal costs, which is the case for many digital markets, platforms with strong network effects can grow to be enormous and eventually dominate the market (Jullien et al., 2021).

For instance, in the early 2000s, Sony and Toshiba released a new generation of technologically differentiated, non-compatible DVD formats:² Blu-ray and HD-DVD. The market eventually determined a victory for Sony (Carrillo and Tan, 2021). According to some industry experts, a major reason for Blu-ray’s success stemmed from the ability of the Sony group to secure the exclusive participation of a large fraction of complementary suppliers (complementors) such as movie studios and major retail distributors. Firm alliances and network effects were at least as decisive as consumer preferences and technological differentiation between the respective platforms.

¹ One example of indirect network effects would be upselling/cross-selling on software tools (e.g., Microsoft 365, G Suite), as the positive benefits emerge later on from a different product, after an upgrade, or from the collaboration between the tools.

² These formats can indeed be interpreted as platforms connecting movie producers to consumers.

The economic literature that studies these interdependencies is often termed the study of two-sided markets. This literature traditionally describes information and communication channels as platforms connecting two distinct sides of a market. On one side, there is a group of consumers who want information. They may consult a website to learn about their field of interest and, thus, become the “target group” to producers located on the other side of the market. This side of the market wants to get its information across and does so by buying advertising space. In such a setting, the platform (in this example, the internet browser and/or the website) is the tool that connects the “receivers” (consumers) and the “senders” (advertisers), respectively. Its value for one side of the market often increases with the number of players adhering from the other side of the platform. [For instance, see Rochet and Tirole (2006, 2011), Caillaud and Jullien (2003), Armstrong (2006), Hagiu (2006), Armstrong and Wright (2007), Choi (2010), Weyl (2010), Jullien (2011), Jullien and Pavan (2019), and Tan and Zhou (2021) for theoretical analyses, and Lee (2013), Chao and Dardenger (2013) for empirical studies.]

In such an economic perspective, price is the most obvious tool that a platform has available to manage and expand its use. However, the issue with pricing decisions in the face of positive externalities generated by indirect network effects is that most of the time they are complex: raising the price on one side of the market affects demand not only on that side but also on the other (and might involve cross-subsidization, as well). Also, such decisions depend significantly on the specific shape platforms might take and on the impact they might have on firms selling their products through them, especially SMEs (Hänninen et al., 2017).

For instance, retailing platforms might consist of either multi-sided networks that do not have their own inventory (one for all, the Alibaba Group) or hybrids like Amazon.com that complete their own inventory by opening the platform to independent suppliers (e.g., Hagiu and Wright, 2015).³ On the other hand, in the new Information Technology (IT), we observe competition between both vertically and horizontally differentiated platforms that sell digital products—movie streaming sites (Netflix, Amazon Prime), music streaming sites (Spotify, Apple Music), computer operating systems (Windows, macOS, and Linux), smartphone operating systems (Android and iOS)—and such platforms can either be compatible or incompatible with one another.

There is, however, a common ground under which price decisions might be studied for both retailing and IT sales through platforms. First, each platform’s profit and each product’s profit depend on the prices of all the market players via their effects on the relative attractiveness of each platform. Second, platforms themselves provide only a limited utility to consumers. In fact, a platform is essentially a means to enjoy some complementary products, making the availability of complementors an essential component in the consumers’ purchase decision.

One implication of such common characteristics is that consumers typically perceive platforms as substitutes to one another.⁴ There are, however, circumstances under which platforms

³ Moreover, as indicated by Hänninen et al. (2017), when platforms link consumers with the independent supplier base, they transform the nature of exchanges for retailers. That is, they change the marketplace itself (e.g., Haucap and Heimeshoff, 2014; Van Alstyne et al., 2016). Now, a retailer intermediates the transactions between buyers and sellers (thus shifting the inventory risk from itself to the supplier), while the platform owners orchestrate their retail of suppliers and consumers (Evans, 2003) differently from other types of online retail business models, where retailers sell their own inventory (Spiller and Lohse, 1997).

⁴ Section 3 will indeed analyze in more detail how substitute platforms fiercely compete through prices (and/or quantities) to attract the most appealing complementors in the market. Of course, in

do not share these characteristics and appear as complementary to one another by necessity because of technical or legal reasons. Think about clearing houses for patents that match technology suppliers with potential users. They can either have a very general approach and provide a marketplace for a variety of technologies, digital ones included, or they can be specialized, actively searching for potential licensees while providing an array of supporting services to innovators (Van Cayseele and Raynaerts, 2007). As a result of these activities, they collect payments from both sides of the market and, hence, can be modeled as platforms.

Whether platforms are substitutes or complementary, it should be stressed that no matter the differences in approaching price decisions, it is still possible to analyze them transversally by considering complementarity (either among the products offered by each platform or among the platforms themselves). This transversal perspective seems very promising, especially when thinking about the large amount of results the economics literature has available on the role of complementarity in shaping the welfare effects of price and quantity competition in imperfectly competitive markets. These results date back to Cournot (1838) and were later summarized in law and economics literature by the term the “tragedy of the anticommons” (Michelman, 1982) and are briefly reviewed in Section 3.

3. The tragedy of the Anticommons

Cournot (1838) was the first to investigate a market structure in which two producers have a monopoly on goods that are complements in the production of a third composite good. The striking conclusion of Cournot’s complementary monopoly theory is that welfare in this industry decreases with the number of individual producers, a result also known as the “tragedy of the anticommons.”⁵ Whereas the more well-known “problem of the commons” stems from inadequately defined property rights,⁶ the problem of the anticommons is the exact opposite. The negative externality results from too many individual owners, who do not consider the impact of their independent pricing decisions on total demand (see Heller, 1998, Buchanan and Yoon, 2000, and Parisi et al., 2005).

The literature on this market distortion argues that social welfare might be better served by integration policies. In fact, when complementary goods are sold by different firms, prices are higher than those set by a monopoly selling all the complementary goods. A merger would then yield a higher consumer surplus. While the resulting social welfare may fall short of the perfectly competitive one, a merger might thus represent a second-best solution (see also Ellet, 1839; Gaudet and Salant, 1992; Feinberg and Kamien, 2001).

Strictly speaking, such literature is applicable only to situations in which the markets for all complementary goods are monopolies. However, there are few real-world examples with these characteristics. Each complement is usually produced in an oligopoly. Consider, for instance, software markets where each component of a system is produced by many competing firms, such as Microsoft, Apple, and Linux operating systems; Microsoft, Google, and Apple for internet browsers, and so on. In fact, the possible trade-off between the tragedy of the anticommons and the lack of competition has been emphasized by some important antitrust cases. For instance, in United

such case platform providers are also likely to produce some of these complementary products directly, as well (Sky original TV series, Netflix documentaries. etc.)

⁵ Cournot’s findings with respect to the pricing of complementary goods by monopolists each providing a component are dual to the results on the quantity decisions taken by oligopolists in the presence of a Walrasian auctioneer, as shown by Sonnenschein (1968).

⁶ See Gordon (1954) and Hardin (1968) for the original contributions on the commons problem.

States v. Microsoft Corp. (2000), Microsoft was required to divest branches of its business other than operating systems, which created a new company dedicated to application development. The breakup plan (later abandoned) would have created two firms selling complementary goods, possibly generating a tragedy of the anticommons. According to Judge Jackson, however, such effect, far from being socially undesirable, would have reduced the possibility for Microsoft to engage in limit pricing. This would have increased competition and improved allocative efficiency.⁷ In other decisions (General Electric–Honeywell, 2001), the European Commission acknowledged that the merger between the two firms would generate lower prices, thus pointing to the existence of an anticommons problem. Interestingly, however, the merger was prohibited because, according to the Commission, post-merger prices would be so low as to injure other firms, thus reducing competition.⁸ Antitrust authorities seem to believe that they are facing a trade-off between the tragedy of the anticommons and the lack of competition. They therefore reason that they should allow integration only when the former becomes a more serious problem than the latter.⁹

In the economic literature, Dari-Mattiacci and Parisi (2006) have already demonstrated that the nature of the anticommons problem changes when there are multiple sellers providing perfectly substitutable complementary goods. Specifically, under Bertrand competition, two perfect substitutes for all but one complement are sufficient to eliminate the tragedy. In that case, competing independent firms set prices whose sum equals the price chosen by a monopolist selling all components. Thus, when the goods are perfect substitutes, the tragedy of the anticommons is not an issue in oligopolistic markets. Integration has no impact on social welfare, and the prescription for antitrust authorities would be inactivity (i.e., maintaining the existing market configuration, be that integrated or separated firms).

Alvisi and Carbonara (2013) proved instead that these conclusions change significantly when the assumption of perfect substitutability is relaxed, and the components are produced in an oligopolistic setting with product differentiation. They studied a case of a composite good consisting of two perfectly complementary components. If one component is still produced by a monopolist, introducing competition in the other market may reduce welfare, unless competitors differ in the quality they supply. Solving the problem of complementary oligopoly involves introducing competition in each sector, and the number of competing firms must be sufficiently high.

Alvisi et al. (2011) further explored this issue by introducing vertical (or quality) differentiation. They showed that the presence of a quality leader (i.e., a firm manufacturing a superior version of both components) may change the nature of the “complementary oligopoly” problem. In terms of consumer surplus, this may render competition for the perfectly complementary goods in the markets always preferable to a situation in which both components are produced by a monopolist.¹⁰

⁷ United States v. Microsoft Corp., 97 F. Supp. 2d. 59 (D.D.C. 2000).

⁸ European Commission Decision of 03/07/2001, declaring a concentration to be incompatible with the common market and the EEA Agreement Case, No. COMP/M.2220—General Electric/Honeywell.

⁹ The “efficiency offense” argument used by the EC in the GE–Honeywell case is analyzed by Motta and Vasconcelos (2005).

¹⁰ Alvisi et al. (2011) considered a setting in which two competing integrated firms produce all components of a system (e.g., operating system plus a word processor). With vertical differentiation, when the market is characterized by the presence of a quality leader, either “disintegrating” (i.e., breaking up) a firm producing complementary goods or prohibiting a merger

Finally, Alvisi and Carbonara (2020) analyzed the effects of the introduction by firms or authorities of a composite good consisting of a fixed proportion of two imperfectly substitutable stand-alone goods produced by two oligopolistic firms. First, they found that such a “cocktail” raises the equilibrium prices (as it introduces a certain degree of complementarity) but might decrease the duopolists’ profits. Therefore, it is not obvious that firms themselves would be in favor of new bundles consisting of combinations of existing products. When the cocktail does not provide a substantial quality improvement on the existing stand-alone goods, both profits and consumer surplus decrease. This result indicates that the introduction of the cocktail generates the tragedy again.¹¹

4. Substitute platforms with complementary products

A significant research question in the economic literature on two-sided markets addresses agents’ single- and multi-homing patterns, where the term “home” refers to a single platform.¹² When platforms are substitutes, one side of the market typically single-homes because of preferences or tastes, and hence the other side must consider multi-homing. This would also explain why competing platforms are sometimes used simultaneously. In early contributions, the possibility of multi-homing was found to hurt the side that could multi-home, while benefiting the single side (Rochet and Tirole, 2003). In fact, consider an initial setting where we have two competing platforms and where both sides of each platform single-home, so that each platform provides users on one side exclusive access to its users on the other side. Now, if one side multi-homes, platforms compete on the single-homing side and exert monopoly power on the multi-homing side. More

leads to lower prices, lower profits, and higher consumer surplus. On the contrary, if a market is characterized by shared quality leadership, integration may be welfare superior for consumers as disintegrating (or not allowing mergers) could create an anticommons problem. In other words, while the negative effects of lack of competition always overcome the anticommons problem in the presence of a quality leader, the tragedy might prevail in case of shared quality leadership. Similarly, Economides and Salop (1992) analyze the different effects of competition and integration on the equilibrium prices of complementary components by examining several alternative market configurations. They prove that such prices are always lower with integration. In their model, however, there is no quality differentiation. Consequently, their results are characterized by traditional cross-price effects among same firm components and disintegration always involves an anticommons problem. In other words, their contribution represents a generalized version of the Cournot complementary monopoly.

¹¹ Alvisi and Carbonara (2020) emphasized that this result is especially important in pharmaceutical markets: when a cocktail of substitute drugs does not significantly improve the efficacy of the stand-alone products, approving it increases prices and unambiguously decreases consumer surplus. The authors also stressed that cocktails create incentives to discriminate in terms of prices, so that single components may be sold at a discount or at a premium (depending on their degree of substitutability) when they are used as part of the composite good. Consumer welfare increases under price discrimination when producers coordinate on price decisions because of complementarity.

¹² Doganoglu and Wright (2006) analyzed the influence of consumer multihoming on compatibility decisions by firms. At the heart of their analysis lies the observation that although compatibility between firms increases consumers’ network benefits, the same benefits can be obtained when consumers choose to multihome, should firms decide to remain incompatible with other firms. However, the “homes” are standard firms and not platforms.

recently, however, Belleflamme and Peitz (2019) challenged this conventional wisdom and found that this was not always true. Sometimes the multi-homing side or even both sides may benefit from the possibility for multi-homing.¹³

The most interesting models of this well-established literature for our purposes are the ones that study those modern network industries featuring both complementarity and two-sidedness. These models thus focus on the competition among substitute platforms selling complementary products.¹⁴ In such models there are typically three types of players: 1. two or more platforms that offer vertically and/or horizontally differentiated products; 2. a set of complementors that produces goods for either platform; and 3. a set of consumers with different preferences over platforms and complementary products. Consumers enjoy both the platform and the complementary goods associated with the platform. However, platforms are essential in the sense that complementary goods can only be enjoyed through them. Also, competition is typically characterized by a multi-party pricing structure: each platform charges positive or negative per-unit fees (royalties or subsidies) to the complementors in its group, and both platforms and all the complementors set prices simultaneously and noncooperatively to consumers. Finally, platforms may or may not own some complementors.

For example, Carrillo and Tan (2006) first analyzed consumers' single- or multi-homing decisions in a setting where third parties offer goods and services that are complementary to the ones provided by two competing horizontally differentiated platforms. They found that the platforms' pricing structure depends on the degree of horizontal differentiation and on the number of complementors.

More recently Carrillo and Tan (2021) build up a more complex framework where platforms are both horizontally and vertically differentiated, complementors themselves compete in oligopolistic markets and players at both ends can make direct payments between them. The fraction of players on the complementors' side that adheres to each platform is exogenously fixed but is not necessarily the same, so that one group (platform + complementors) would typically be dominant. In such new setting they don't simply determine the prices set by the complementors and the platforms to consumers but also investigate the platforms' incentives to form strategic alliances through technological compatibility or exclusive contracts, and the consequences of these business arrangements for the welfare of consumers. And a crucial role in such decisions is again played by indirect network externalities, since a platform becomes more attractive to consumers as the number of its complementors increases. In this way, platform competition results in a complex structure of interactions: the number of complementors in each platform affects the prices and profits of both platforms and all complementors, and it also affects the equilibrium utility of consumers.

More specifically, even in the absence of payments between platforms and complementors the presence itself of a second and smaller group can affect the price and profits of the firms in the dominant group. Also, all firms in a group benefit from an increase in the quality of the platform in such group and in the number of complementors that adhere to it. At the same time, they suffer

¹³ Also, one should not forget the so-called "competitive bottlenecks" approach, where platforms have a local monopoly over the single-homing agents they serve, and where cross-market agents have to multi-home to realize network externalities (Armstrong and Wright, 2007). In such setting, multi-homing agents need to reach a specific (or single) agent on the other side of the market and accordingly only address the platform that agent is tied to.

¹⁴ Indeed, this was the framework of the Sony/Toshiba battle on DVD formats cited in Section 2, but similar battles have been renewed more recently between streaming platforms both in music and television, as well.

from an increase in the platform quality and number of complementors in the rival group. All that happens simply because a platform is more desirable to consumers the greater the number and the quality of the firms in its group relative to those in the other group, so that such platform can charge higher prices while keeping consumers' loyalty.

When instead money transfers between platforms and complementors are allowed prior to the pricing game, results get more interesting. Because a platform is an essential component of a group, it's platforms that choose a royalty or subsidy per unit of output sold by complementors to consumers. From the viewpoint of the complementors, this extra pricing instrument only modifies the marginal cost of production. Instead, from the viewpoint of the platforms, transfers introduce a new trade-off: charging royalties increases direct revenues but providing subsidies decreases the prices that complementors charge to consumers, thereby making the group more attractive. And indeed, at least in the case when the two groups are symmetric, there are conditions on the consumers' demand for complementors under which subsidies arise in equilibrium.

Carrillo and Tan (2021) also analyzed what would happen if a platform owned some or all the complementors in the group. In such case, the platform would have to set prices for both its use and for the consumption of its complementors. Here the optimal pricing scheme is like the one that would be adopted by a monopolist setting a two-part tariff: a platform would price its own complementors at marginal cost to avoid quantity distortions and gain from the sale of the platform at higher prices. It must be noted that this behavior increases the equilibrium market share of the platform, so that it ends up benefiting the independent complementors in the group and hurting all the firms (platform and complementors) in the rival group. Interestingly, consumers are better off if platforms own all complementors than if complementors are independent, consistent with the standard result of the tragedy of the anticommons. Indeed, the decrease in the complementors' price due to the solution of the tragedy more than offsets the possible increase in the platform's price. Moreover, the authors find that a platform that can choose to make its own complementary goods available to the customers of a rival platform (Word for Apple computers or Netflix TV series offered through Sky) faces a trade-off. On one side revenues increase through such sales, but the market share of the platform decreases. As a result, in equilibrium, platforms would always find it optimal to put the complementary goods for sale, but at a price that exceeds the monopoly level!

Finally, as far as the compatibility decision is concerned, Carrillo and Tan (2021) found that on one side each platform gains from making its technology compatible with complementors in the other group, as it expands the attractiveness of the platform to consumers. On the other, each platform gains by signing an exclusive agreement with complementors because it reduces the attractiveness of the rival platform to consumers. The prevailing outcome will depend on the profits of complementors under the different arrangements, the relative bargaining power of firms, and the legal and technological constraints on the feasible set of agreements.

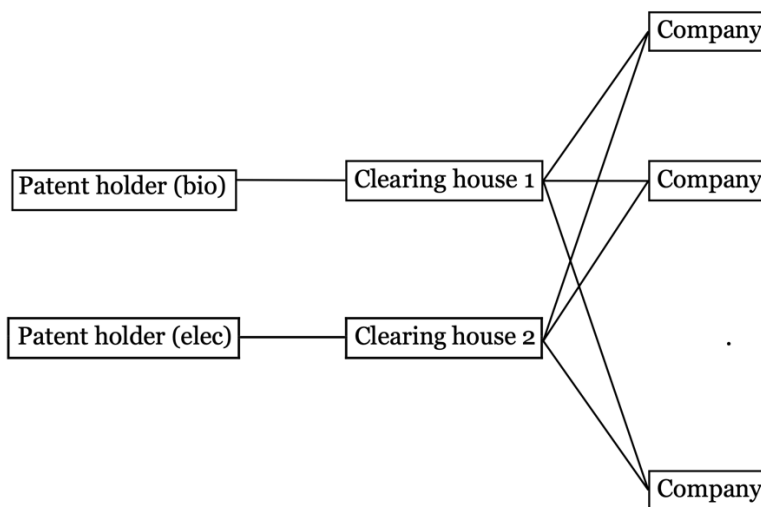
5. Multi-sided markets and complementary platforms

Today's innovations build on a variety of patented inventions. The result is that patents are often complements, and the patent holders generate a negative pricing externality upon each other as in the standard "tragedy." The implications of patent complementarity were initially studied in one-sided markets by Shapiro (2001), who showed that within a standard Cournot (complementary monopoly) model a "patent pool" (also known also as a "cross-licensing agreement"), combining

the ownership of the patents involved in the innovations, increases welfare.¹⁵ Interestingly, Smyth and Gray (2011) found that large ag-biotech multinationals increasingly use gene trait cross-licensing agreements with SMEs to foster and maintain their ability to innovate. Apparently, after all the merger and acquisition activity of the 1990s, multinational enterprises realized that outsourcing intellectual property rights turned out to be more valuable than previously thought and that the spillover effects could be increased by having some innovative research that is external to themselves.

As suggested in Section 2, however, patents can also be traded in two-sided markets through complementary platforms. Technological clearing houses specialize in certain technologies (biomedical, electronic, etc.) and a patent-holding innovator will offer his technology to the market over that platform. On the demand side, users may need many complementary inventions managed by different clearing houses that, therefore, become complementary platforms. Thus, with complementarity users cannot choose whether to single- or multi-home (as in the substitute platforms case). They are forced to multi-home instead. Consequently, the other side (here the patent holders) will rationally single-home (Van Cayseele and Raynaerts, 2007). Figure 1 provides a configuration of the economic relationship between patent holders and licensees meeting over a clearing house.

Figure 1: Patent pools and clearing houses (Van Cayseele and Raynaerts, 2007)



Van Cayseele and Reynaerts (2011) made one of the first contributions to the economic literature that explains asymmetric single- and multi-homing patterns across the market, i.e., why one side of the market single-homes and the other side uses multi-homing completely.¹⁵ Also, by investigating the effects of a merger between complementary platforms, they showed for the first time how the tragedy of the anticommons extends to two-sided markets. Specifically, the authors concluded that clearing houses, when allowed to act as a pool, increase both their profits and the surplus of the multi-homers/end-users, who pay a lower license fee (per transaction). However, such a pool is detrimental to the receivers (here, the single-homers/patentees) because they would end up paying a higher fee to the pool. In conclusion, a merger between platforms is welfare enhancing

¹⁵ Subsequent research contributions by Lerner and Tirole (2004) have relaxed the complementary features of patents to allow patents to become substitutes as the license fees for the innovations increase to the level where “dropping” a patent from the bundle becomes a consideration.

as it avoids those allocative inefficiencies arising when individual platforms fail to internalize the negative pricing externality that they exert on the other platforms. It also involves a redistribution of surplus from the receivers to the senders. So, while pools certainly facilitate the dissemination of inventions, their net effect on the patentee's incentive to innovate is ambiguous.

Interestingly, Van Cayseele and Reynaerts (2011) were also able to test whether the results obtained by Dari-Mattiacci and Parisi (2006) indirectly apply to complementary platforms. They found that the bundle price (that is, the sum of the prices of all patents) set by independent complementary platforms does not approach the monopoly price as the number of platforms tends to infinity. Thus, different from Dari-Mattiacci and Parisi (2006), an extreme fragmentation of property rights among platforms does not eliminate the "tragedy." It is indeed the presence of the receiver side that acts as a counterweight and limits the downward pressure on the bundle price.

Recently, the growth and proliferation of digital intermediaries has further expanded the scope of the economic analysis of complementary platforms. Indeed, platforms have become real ecosystems, serving not just two but a multitude of sides. As indicated by Jeon et al (2021), one example of such a new framework is the patent licensing for the Internet of Things (IoT). In the past, patent holders licensed two sides of the cellular network (handsets and base stations) and to the extent that handset users valued greater coverage (i.e., more base stations) and carrier investments reflected the size of the user base, licensors faced a two-sided pricing problem. The emergence of IoT—where connected products include not just phones and networks but also cars, watches, appliances, eyeglasses, etc.—converts this into a many-sided pricing problem, where some intermediaries/platforms find themselves in complementary relationships.

When studying such complex ecosystems, Jeon et al. (2021) allowed for an arbitrary number of platforms and devices and a very general specification of the demand-side network externalities among all devices. In such a way, the authors can address several novel issues, beginning with the relationship between each device's position in the ecosystem and its demand on the equilibrium license fees charged by complementary platforms that serve partially or totally overlapping groups of devices.

The study used a monopoly platform for its benchmark (an integrated market structure in anticommons jargon) and found that the license fee for each of the n devices keeps on reflecting the trade-off between internalizing the externalities of the tragedy and extracting value through monopoly power. In fact, the platform subsidizes through a lower fee those devices that generate larger positive externalities on the demand of the other components of the ecosystem. These contrasting forces are captured by a weighted average of all the demand externalities to/from all other devices, where the weight of each device corresponds to its Katz-Bonacich centrality in the overall demand system.¹⁶

¹⁶ In one of his works made in the 1950s, Katz (1953) proposed to model the centrality or the prestige of a node in a network in the following manner: the score associated to a node is based on a discounted sum of the "walks" that initially started from it. Specifically, Katz' centrality computes the relative influence of a node within a network considering both the number of its immediate neighbors (first degree nodes) and the number of all the other nodes in the network that connect to the node under consideration through these immediate neighbors. Connections made with distant neighbors are instead penalized by an attenuation factor α . Each path or connection between any pair of nodes is assigned a weight determined by α^d , where d is the number of links connecting the two nodes. Nowadays, this measure is called the Katz-Bonacich centrality because Bonacich (1987) introduced a similar spectral centrality measure.

When the ecosystem is characterized by m complementary platforms instead, license fees per device will exceed their monopoly level, and suppliers will profit from a coordinated price reduction. However, the platforms' incentives to internalize demand externalities among devices remain, and the authors show that the ecosystem network can be structured in such a way that the incentives to internalize demand-side externalities may be strong enough to completely overturn the anticommons problem, at least for a single device viewed in isolation in the new matrix used to compute centrality. Thus, even if the main feature of the "tragedy" continues to hold (complementary monopolists charge higher prices than an integrated monopolist), surprisingly the sum of the license fees paid by some particular devices in a duopoly can be lower than those set by an integrated platform (can exceed the "Cournot price" charged by a pair of complementary monopolists in the absence of demand externalities).¹⁷

6. Instead, of a conclusion

The European legislature is currently laying the foundations for the governance of platform-based economic sectors. The EU is developing new means of ensuring consumer and SME protection by regulating digital markets. On the other hand, many SMEs are embracing shifts in their business models by focusing more and more on the provision of services rather than on simply selling products. One prominent example is the automotive sector with its increased capability to collect data on people's mobility (through apps, for example, also developed by insurance companies, and event data recorders).¹⁸ This contribution clearly illustrates how much space remains for the analysis of the impact of the tragedy on equilibrium prices and welfare characterized by such digital ecosystems. Indeed, the rise and the evolution of platforms should lead to an intense re-examination of the nature of market power, competition policy, and regulation.

¹⁷ These results are clearly related to the literature on pricing in a network. For instance, Fainmesser and Galeotti (2020), found that firms offer consumers price subsidies for their influence and charge premium prices for their susceptibility. Chen et al. (2018) and Zhang and Chen (2020) study a duopoly market on networks where firm prices depend on consumer network externalities and the level of complementarity among products. We must note that this literature considers network externalities among consumers only and does not focus on network externalities among devices.

¹⁸ The automotive sector seems to be quite promising as a research field, considering how fluid it currently is. Its "digitalization" might lead to a market structure where platforms are substitutes for one another and compete fiercely to attract the most important independent complementors in the market or where platforms end up looking to one other as complements

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