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A UNIFIED PRESENTATION OF COMPETITION ANALYSIS IN TWO-SIDED MARKETS

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Abstract. The goal of this paper is to present quantitative tools to manage competition policy analysis in two-sided platforms, based on a common framework for transaction and non-transaction platforms. We explore tools for relevant market definition [Critical Loss Analysis and a small but significant non-transitory increase in price (SSNIP) test], unilateral effects indicators [Upward Pricing Pressure (UPP) and Gross Upward Pricing Pressure Index (GUPPI)] and tests for exclusionary practices. We review dispersed results in the literature and fill the gaps where appropriate. We highlight the required changes from the usual one-sided market framework and tools. While discussions of antitrust tools can be found in specialized forums devoted to advances in competition policy analysis, we organize the material in an integrated framework.

Keywords. Competition analysis; Multi-sided platforms; Quantitative tools

1. Introduction

Multi-sided platforms (MSPs) are ubiquitous in many sectors, particularly in digital markets, taking advantage of internet communications and information power. Google, eBay, Uber, Booking.com and credit cards are just a few examples. These multi-sided (often two-sided) platforms provide an opportunity for users of both sides to interact and solve, in many cases, informational problems that hinder transactions. The key characteristic of a multi-sided market is the presence of network externalities across sides of the platforms in the market. In other words, the attractiveness of doing business through the platform on one side depends on the number of users on the other side and vice versa. Cross-side externalities are the basis for the MSP business model, which has been analysed by many scholars starting from the pioneering work of Rochet and Tirole (2003).

The economics of MSPs is still evolving. However, many findings are already commonly accepted in the literature (e.g. Rochet and Tirole, 2006; Evans and Schmalensee, 2015). For instance, it is agreed that there are different types of platforms, depending on the observability of transactions and the nature of the cross-side network effects. It is shown that the structure of MSP prices, in addition to the total price level, becomes an important determinant of the platform sales. In case cross-side externalities are positive (as they are in majority of the cases), it is proven that reaching some minimal effective size

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is a necessary condition for an MSP to survive; and after that, direct and indirect externalities lead the platform to growth. Thus, mergers and consolidation, as well as abuse of dominance control, are a likely path for MSP.

The characteristics of an MSP generate the need to adapt the tools for a competition policy analysis at all stages of investigation. Cross-side network effects influence demand and pricing, requiring practitioners to adapt relevant market delineation and inference on market power. This field of study has attracted the attention of researchers. However, studies are mostly focused on a particular type of MSP or a particular tool for competition analysis. We find it useful to review dispersed results in the literature. The present study highlights the required changes from the usual one-sided market frameworks and tools, focusing on the quantitative tools used in these tasks, namely, delimiting markets, the potential price effects from mergers (price pressure indicators) and the tests for exclusionary practices. While discussions of antitrust tools can be found in important forums (e.g. CRESSE Meetings), we organize the material for both merger analysis and abuse of dominance cases in an integrated framework. We also fill the gaps where appropriate.

In most antitrust investigations, the basic step of the analysis is delimiting relevant markets to determine the competing firms of the business under analysis and the extent of market power. In the case of platforms, central is the issue of delimiting a single multi-sided or two interrelated markets, depending on the type of the platform. Evans and Noel (2008) and Filistrucchi (2008) have developed critical loss tools for transaction and non-transaction audience-providing platforms. We complete their analysis by presenting the tools in a unified fashion and under common and standard assumptions. We also present Critical Loss Analysis (CLA) expressions for non-transaction matching platforms. The key point here is that cross-side network effects are to be taken into consideration when applying critical loss tools. A one-sided analysis that ignores such effects may lead to incorrect market delineation, which is crucial for the conclusions on the market power of a platform and its ability to abuse it. As we shall see below, interestingly, depending on the market, standard tools may point to either too broad or too narrow a market, underestimating or overestimating, respectively, the market shares and dominance of firms under antitrust scrutiny.

After the market is delimited, authorities search for evidence of potential or actual anticompetitive effects from business practices. A number of tests are developed for traditional one-sided markets to fulfil such a task. Most of them are based on price–cost comparisons. Considering that the pricing strategies of MSPs are different from the ones in one-sided businesses, the tests may lead to type I (punishment of the innocent) and type II (acquittal of the offender) legal errors if applied while ignoring cross-side network effects. Multi-sidedness also affects the application of the effect-based approach, which requires assessment of direct anticompetitive effects from the business practice, as well as the efficiencies generated. Here, issues of interrelated markets and single and multi-homing, which are absent from a one-sided analysis, are central.

For merger analysis, the goal is to infer the likelihood of a lessening of competition levels or the consumer welfare losses from the merger. Price pressure indicators are the tools used for assessing the probability of an increase in consumer prices after a merger, which is associated with welfare losses. The key feature of an MSP business strategy is optimization of the price structure, considering that the quantity of services provided from one of its sides affects the quantity of services provided from its other sides. Thus, the incentives of an MSP to increase prices are affected by cross-side network effects, and this should be taken into account by competition authorities. Regarding pricing pressure indicators, Affeldt *et al.* (2013) presented the required modification of the tools for non-transaction audience-providing platforms. We extend their analysis and provide the expressions for transaction and non-transaction matching platforms. In both cases, the issue of simultaneous price increases on both sides of a firm, as argued by Cosnita-Langlais *et al.* (2018) for audience markets is addressed, and the corresponding results are presented for the other markets.

This paper is organized as follows. Section 1 provides the basic dimensions and differences between two-sided platform or MSP firms and markets and one-sided markets for purposes of a competition policy analysis. The taxonomy of MSPs is then used to formulate demand functions in Section 2 and discuss modifications of the Lerner indices for two-sided markets in Section 3. Recognizing the types of two-sided markets and the pricing rules helps clarify how to delimit markets. Next, Section 4 describes the adjustments in the hypothetical monopolist test implementation using CLA as well as other tools for market delineation, given different types of two-sided markets. Section 5 presents the pressure price indices for the different types of MSPs. The last sections (Sections 6 and 7) present suggestions for the abuse of dominance tools, before the concluding comments.

2. A Taxonomy of MSPs

The key distinctive characteristic of an MSP is the existence of cross-side positive/negative externalities related to the number of agents on the other side of the platform, the so-called indirect network effect or cross-side network effect. The effect can be present in the case of any business that acts as an intermediary.

Economists distinguish between *transaction* and *non-transaction* multi-sided markets (see Filistrucchi, 2018, and papers therein). The classification is very important for understanding the economic effects of multi-sidedness and market delineation in the case of MSPs. In particular, one should address if in a two-sided platform one should delimit one relevant market with consumers from both sides, or two interrelated markets, one on each side of the platform.

Transaction markets are those wherein transactions between different (usually, two) groups of platform users are observable. A ride-hailing app is a good example. The product offered by a platform is the transaction that occurs through it. Different groups of users can be charged a per-transaction fee for using it (although a two-part pricing method with a membership or joining fee is not ruled out). For example, Uber charges per ride, not by membership. An earlier study (see Evans and Schmalensee, 2015) denoted transaction markets as usage externalities markets.

An important additional characteristic of the role of two sides in altering the analysis from the usual market analysis is whether the platform is able to control the relative prices charged on the two sides. If the sides of the platform can interact and negotiate the incidence of the fees of the platform on one side, the two-sided nature of the platform is lost, as a complete pass-through is possible. As Rochet and Tirole (2006) point out, when parties can negotiate directly and pass through changes in relative prices, an equivalent situation to the Coase theorem will be at work, where efficiency can be achieved whatever the imposed price structure is (only the price level matters). From this viewpoint, the market's multi-sidedness gives no special tools to a platform that desires to affect side A's demand for its services by manipulating prices for side B users. With pass-through, this manipulation is not possible, and the market can be analysed as a single, one-sided market, where the price structure is not relevant for attracting customers on either side to the platform´s benefit. With pass-through, the sides internalize their externalities and the cross-side network effect is not influenced by the price structure.

Moreover, services provided by a platform to its users on different sides are perfect complements, as a 'transaction' means that the service to A-type user can be provided only in case some B-type user consumes its service at the same time.

Taking all this into consideration, in the case of two-sided transaction markets, one should define only one market – the market of transaction services. Economic agents may use and pay for the services of one of the competing platforms (if any) or transact without an intermediary. Unless the platform is able to restrict economic agents in their ability to choose how to transact with each other, the price should reflect the value of the platform services (i.e. quick search of the counteragent, better matching and others) for the users.

Non-transaction markets are those wherein different groups of platform users do not transact directly, or the transactions are not observable. These markets were known as membership externalities markets in an earlier study (Evans and Schmalensee, 2015). They can be of different types (Wismer and Rasek, 2018). The most well-known example is media, such as newspapers, and also 'audience-providing' or 'advertising' platforms, which provide one user group (advertisers) with the audience or attention of another user group (readers). In case of audience markets, the cross-side network externality is positive for just one side and might be negative or negligible for the other. It is agreed that in this case, two 'interrelated' markets are to be defined, as the products offered to each side are different.

Another type of non-transaction markets is called a 'matching market' when different groups of users get an opportunity to find a match using the MSP service. A good example is recruitment application. The platform provides access to the database for employers and potential employees, thereby decreasing the transaction costs related to the search for matching for both sides. In general, prices charged to different types of users are different, while the product (the opportunity to find a match) is the same. In this case, only one two-sided market is to be defined.

In non-transaction markets, pass-through is not possible, and the platform has control over the relative prices charged to different sides. The control becomes a source of extra benefits for the platform, as it internalizes the cross-side network externalities. The intensity of cross-side externalities determines if the multi-sided nature of the market should be taken into consideration in an antitrust investigation. In case the externalities are weak, and there are no reasons to believe that they are taken into account in the price-setting strategies of the platform, the analysis should proceed as usual, delimiting two different markets for each side that act mostly independently, with no feedback effects. Otherwise, cross-side network effects should be taken into consideration. When delimiting markets, the demand elasticities are influenced by the cross-side demand elasticities.

3. Demand Functions for Two-Sided Markets

As mentioned, understanding which firms impose competitive constraints on each other is central in any antitrust investigation. This starts with delimiting the relevant market. From the list of actual competitors for purposes of the antitrust investigation, market power is inferred from market shares and/or the concentration indices of that relevant market. The paradigm for delimiting a relevant market is the hypothetical monopolist test, which is described in horizontal merger guidelines in almost all jurisdictions. A known quantitative tool for delimiting a relevant market is the CLA. Other quantitative tools are available, as we shall see below.

In addition to market shares, particularly since the 2010 US Horizontal Merger Guidelines, there has been a trend of inferring the abuse of market power from a merger by using price pressure indices and other diversion-ratio–based indicators, such as Gross Upward Pricing Pressure Index (GUPPI) (Salop and Moresi, 2009; Farrell and Shapiro, 2010).

In delimiting markets or in inferring market power, demand estimates (jointly with assumptions on competitive behaviour) are central. Demand elasticities are used in a critical-loss–type analysis or in measuring diversion ratios for GUPPI-type indicators.

Demand estimation for markets with two-sided characteristics must take into account the cross-platform externalities across platform sides. From the two canonical models of market analysis for two-sided markets, as described in Rochet and Tirole (2006) and Evans and Schmalensee (2015), cross-side network externalities may take the form of an interaction effect in the actual output or the form of an explicit complementarity across sides on the demand function.

In the first case, associated with transaction (usage externality) markets, the actual demand for transactions (Q) would be modelled as:

$$Q = D_A\left(P_A\right) D_B\left(P_B\right),$$

where $D_i(P_i)$, $i = A, B$ represent the demand functions for each side of the platform. Here, each demand depends on the price charged on each side. Even if zero prices are charged on one of the sides, the demand function should account for network effects. We consider (for exposition) a monopolist, so that a single price is relevant for the demand on each side. In markets where there are many producers, the demand function for each side of the platform should consider a vector of prices. In this model, there are cross-side network effects on the number of transactions, although the price demand function on each side does not incorporate the price (or quantity) on the other side.

In the second case, associated with two-sided non-transaction (membership externalities) markets, the demand function for each side would be characterized as follows:

$$Q_A = D_A(P_A, Q_B) \quad \text{and} \quad Q_B = D_B(P_B, Q_A),$$

where cross-side externalities (cross-quantity effects) $\partial Q_i/\partial Q_j$, $i \neq j$, can be positive or negative.

Again, we consider a single firm price as relevant for each side for expositional purposes. This demand function system can be written in a 'reduced form' in terms of prices, as follows:

$$Q_A = D_A(P_A, P_B) \quad \text{and} \quad Q_B = D_B(P_B, P_A),$$

where $\partial Q_i/\partial P_j < 0$, $i \neq j$, in the case of a positive cross-quantity effect; and $\partial Q_i/\partial P_j > 0$, $i \neq j$, in the case of a negative cross-quantity effect.

Actual estimation of these demand functions face additional challenges compared with the usual demand estimation requirements for identification (such as the use of instrumental variables). Compatible data (e.g. in units, data sources, time periods) from both sides of the platform are needed. Dealing with zero prices also implies adjustments in the demand estimation for the zero-price side (where other competitive dimensions might be relevant; e.g. Jeziorski, 2014).

There are few examples of demand estimation in the literature for the abovementioned demand functions. Most, if not all, deal with audience markets, such as printed media readership and advertising (e.g. newspapers in Italy in Argentesti and Filistrucchi, 2007; newspapers in the Netherlands in Filistrucchi *et al.*, 2012a, 2010, 2012b; newspapers in Belgium in Van Cayseele and Vanormelingen, 2019; and TV magazines in Germany in Song, 2013).

Both Argentesti and Filistrucchi (2007) and Song (2013) estimate demand models for each side of the market using the well-known (Nested) logit demand functional form, expanded to include a quantity measure from the other side. They estimate structural models of the $Q_A = D_A(P_A, Q_B)$ type. In Argentesti and Filistrucchi (2007), cross-side network effects are present on the advertising side only. In Filistrucchi *et al.* (2012a), indirect network effects are present on both sides. For example, the readership logit model in the latter is given by:

$$log\left(s_{jt}^r\right) - log\left(s_{0t}^r\right) = \alpha_r P_{jt}^r + \beta_r Q_{jt}^a + \varepsilon_{jt}^r,$$

where s_{jt}^r is the readership (circulation) share of newspaper *j* in period *t*; s_{0t}^r is the share of the outside good in period *t*; P_{jt}^r is the unit price of newspaper *j* in period *t*; and Q_{jt}^a is the volume of advertising (in the printed pages area) in newspaper *j* in period *t*.

4. Modified Lerner Indices for Two-Sided Markets

4.1 *Transaction Markets*

As seen in the previous section, in a transaction market, following Rochet and Tirole (2003) and Evans and Schmalensee (2015), the actual demand for transactions (*Q*) would be modelled as follows:

$$Q = D_A(P_A)\, D_B(P_B),$$

where $D_i(P_i)$, $i = A, B$ are the demand functions on each side of the platform. As above, we consider (for exposition) a monopolist, so that only the firm's own price is relevant for the demand on each side.

The firm maximizes profits from margins on both sides, where the number of transactions is given by Q as follows:

$$Max_{P_A,P_B}\left[(P_A - C_A)\,Q + (P_B - C_B)\,Q\right]$$

or

$$Max_{P_\mathrm{A},P_\mathrm{B}}\left[(P_\mathrm{A} - C_\mathrm{A}) + (P_\mathrm{B} - C_\mathrm{B})\right] D_\mathrm{A}(P_\mathrm{A})\,D_\mathrm{B}(P_\mathrm{B})\,.$$

From the first-order conditions the following results emerge:

$$\frac{P_i - \left(C_i - \left(P_j - C_j\right)\right)}{P_i} = \frac{1}{\varepsilon_i},\ i \neq j, i, j = A, B. \tag{1}$$

$$\frac{(P - C)}{P} = \frac{1}{\mu} \tag{2}$$

and $P_A/P_B = \varepsilon_A/\varepsilon_B$, where $P = P_A + P_B$ denotes the 'total' price; $C = C_A + C_B$ is the 'total' marginal cost; and $\mu = \varepsilon_1 + \varepsilon_2$ is the 'total' elasticity that includes both sides.

As Rochet and Tirole point out, the markup of the platform is inversely proportional, as usual, to the platform's 'total' elasticity, where both elasticities are taken into account. This is the pricing rule for the so-called *price level* defined as (2). The *price structure* (the actual values of each price P_i) may be very different from the price level, as the markup on each price depends not only on the marginal cost of that side but also on that of the other side as shown in equation (1). Note that the expression allows for one of the prices to be (close to) zero. In such a case, the costs of that side are covered by revenues from the other side. Note that the above pricing rules are for a monopolist, which has no interest in pricing below the marginal cost for exclusionary reasons. Such a pricing below marginal cost arises naturally from profit maximization, as one side exerts influence on the other side. Consider the same marginal cost for both sides. If one side is relatively more price elastic than the other, the more elastic side will have a higher relative price. Then, the side with lower elasticity can set its price below the marginal cost. The restriction is that this cannot happen on both sides, as the total markup (2) has to be positive.

When inferring market power from the price elasticity of the transaction market, the need to account for cross-side network effects is visible. Given the price elasticity, the markup without incorporating the unit margin on the other side of the platform will overestimate (underestimate) the markup and market power on a given side of the platform if the other side's price is above (below) that side marginal cost, as highlighted in the literature (e.g. Wright, 2004).

4.2 *Non-Transaction Two-Sided Markets*

In the second case, associated with two-sided non-transaction (audience externalities) markets, the demand function on each side would be characterized as follows:

$$Q_A = D_A(P_A, Q_B) \quad \text{and} \quad Q_B = D_B(P_B, Q_A)\,,$$

or in a reduced form, parallel to transaction markets:

$$Q_A = D_A(P_A, P_B) \quad \text{and} \quad Q_B = D_B(P_B, P_A)\,.$$

The unit of observation is the number of users on each side. The first-order conditions are a set of equations as follows:

$$M_i - \varepsilon_{ii}^{-1} + M_j D_{ij}\left(P_j/P_i\right) = 0, \quad i \neq j, i, j = A, B, \tag{3}$$

where $M_i = (P_i - C_i)/P_i$ is the side i margin; $\varepsilon_{ii} = -(\partial D_i/\partial P_i)(P_i/Q_i)$ is the own price elasticity (in absolute value) on side i, measured at the reduced form demand model; and $D_{ij} = (\partial D_j/\partial P_i)/(\partial D_i/\partial P_i)$ is the diversion ratio of sales change on side j, expressed as a proportion on sales lost on side i from the side i price increase. Note that in case of matching markets when both cross-side network effects are positive, this diversion ratio is positive with no normalization required, as the goods are complementary in the reduced form of the demand function. In the case of audience markets, the diversion ratio might be negative for one of the sides (as readers possibly prefer to have less advertising).

While it is traditional in the literature to denote D_{ij} as a diversion ratio (e.g. Affeldt *et al.*, 2013), a more informative name is possibly 'side complementarity ratio' or 'cross-side relative demand effect'. It measures how one additional unit from side i generates additional D_{ij} units on side j.

Each first-order condition can be reorganized so that prices simultaneously verify the more familiar form:

$$\frac{P_i - \left(C_i - \left(P_j - C_j\right) D_{ij}\right)}{P_i} = \frac{1}{\epsilon_{ii}}, \quad i \neq j; i, j = A, B. \tag{4}$$

Note that this expression resembles the markup expression for transaction platforms in so far as the marginal 'cost' in the numerator incorporates the cross-side network effect. In the transaction platform case, the quantity depends on both sides on a one-to-one basis, such that $D_{ij} = 1$, and expressions (4) and (1) are equivalent.

In Rochet and Tirole (2006) or Evans and Schmalensee (2015), this expression is presented as: $(P_i - (C_i - \theta_{ij}))/P_i = 1/\varepsilon_{ii}$. For our setting, the cross-side network effect is expressed as $\theta_{ij} = (P_j - C_j)D_{ij}$, while the original model is derived for linear demand only.

When the cross-side network effect is positive, this reduces the firm's perceived cost on a given side. Prices set by the platform internalize this effect, compared with two independent firms operating on each side of the market. If, in addition, consumer preferences change, such that D_{ij} increases, prices on the side of the platform would tend to decrease.

Rewriting the two conditions (4) for the two sides A and B, so as to isolate the one side markup, we have:

$$\frac{(P_i - C_i)}{P_i} = \left(\frac{1}{\epsilon_{ii}} - \frac{D_{ij} P_j/P_i}{\epsilon_{jj}}\right)\left(\frac{1}{1 - D_{ij} D_{ji}}\right). \tag{5}$$

Let us pay some attention to expression (5). Two opposite effects influence the one side markup of a non-transaction platform when cross-side network effects are present. The second term in the first parenthesis reduces (increases) the markup when the sides experience a positive (negative) cross-side network effect. Meanwhile, the second parenthesis increases the markup as it incorporates the feedback effects of joint pricing by the platform, internalizing the externalities generated by the cross-side network effects. In a special case, one can sign the difference between the markups with and without network effects. Assume $D_{ij} \neq 0$, and $D_{ji} = 0$, that is, the cross-side network effect works asymmetrically from one side to the other, but not vice versa. Then, the feedback-pricing effect cancels, and the margin on the side that induces the cross-side network effect is lower than the usual one-sided markup.

In this sense, when inferring markups from price elasticities without taking into account cross-side network effects, one overestimates margins, and thus market power, in the asymmetric case if cross-side network effects are positive. Following the same logic, one can prove that market power can be underestimated if cross-side network effects are negative, as in transaction markets.

5. Critical Loss Analysis

The most rigorous tool used for market delineation is the so-called 'small but significant non-transitory increase in price' (SSNIP) test. It defines the smallest set of substitute products, such that a substantial (usually 5%–10%) and non-transitory (usually one year) price increase would be profitable for a hypothetical monopolist. If it is not profitable, then at least one close-enough substitute to the product is expected to exist. The price increase is an SSNIP, and is denoted by X below.

The SSNIP test is often performed in a CLA, as mentioned by Davies and Garcés (2010). The idea is to compare a ‘critical loss’ in sales, CL (the percentage loss in the quantity of a product sold by a hypothetical monopolist that is enough to make an X percent price increase unprofitable) and the ‘actual loss’ in sales, AL (the predicted percentage loss in quantity that the monopolist would suffer in case of a price increase by X percent).

For regular one-sided markets, the most often used formulae are:

$$CL = X/(X+M) \quad \text{and} \quad AL = X\varepsilon^{HM},$$

where M is the percentage markup, and ε^{HM} is the price elasticity of the hypothetical monopolist (collection of firms in the candidate market), respectively.

The model assumes that firms within the market do not optimize the price increase and that the criteria is whether the X price increase (i.e. the SSNIP) is profitable or not (breakeven condition).

A relevant market is determined when $CL \geq AL$. If $CL < AL$, the SSNIP is not profitable, suggesting that there are close enough substitutes outside the hypothetical group of firms, or group of products (in the case of multiproduct firm) within the relevant market. The market should be expanded to include these substitutes.

The formulae can be rewritten in terms of ‘critical elasticity’ and ‘actual elasticity’, dividing both sides of the percentage quantity decrease by a percentage price increase, that is, the SSNIP:

$$\text{Critical elasticity}: \ \varepsilon^{HM*} = 1/(X+M).$$

If the (absolute value) of the actual hypothetical market price elasticity is larger than the (absolute value) of the critical elasticity, the candidate market should be enlarged.

In the case of an MSP, the formulae need to be corrected due to the existence of cross-side network externalities. We present the results for the three market types as discussed above. For the case of transaction markets, Emch and Thompson (2006) argue for a regular SSNIP test using total price and total cost but do not develop the expressions. We confirm their intuition. For the case of non-transaction markets, where two different markets are delimited, one on each side, Evans and Noel (2008) and Filistrucchi (2008) deduce formulae for delimiting markets using an SSNIP test. For the case of non-transaction markets with a matching objective, where one market is delimited, we introduce the CL formulae.

The studies differ in the assumptions about (i) the price changes regarding whether simultaneous price increases occur on both sides of the platform and (ii) regarding the re-optimization of prices from feedback effects across platforms.

We take a simpler approach, in line with the basic CL exercise. We assume that each firm/platform that is a part of the candidate market imposes the same price increase in the goods in the relevant market under study. On a transaction market this may be natural, as the SSNIP price increase applies to the total price, not each price. Regarding non-transaction markets, on whether one should specify one or two markets, the assumption is parallel to the standard one-sided relevant market SSNIP test assumption on the hypothetical monopolist exercise that firms and products outside the market do not react to the SSNIP. Interestingly, as we shall see below, even under the assumption of no price realignment within the platform from an SSNIP on one side of the platform, the indirect network effects play a very important role in the calculation of the CL. Last but not least, we take the simple benchmark method for CL calculation. The CL is obtained by evaluating whether the SSNIP is profitable.

5.1 *Transaction Markets*

Using the abovementioned setup for modelling transaction markets, consider a hypothetical monopolist that operates on two sides of a platform. We assume that within relevant market, competitors operate on both sides of the market. The profit of the hypothetical monopolist will be:

$$\Pi = (P_A - C_A)\,Q + (P_B - C_B)\,Q.$$

The breakeven criteria for CL asks whether a price increase of X, the SSNIP, is profitable. Let $P'_A = P_A(1 + X_A)$. The SSNIP is the same for both prices. Equal SSNIPs for both prices is used ($X_A = X_B = X$). This is based on the assumption of constant elasticity and that the relative price result $P_A/P_B = \varepsilon_A/\varepsilon_B$ as obtained above. In other words, the SSNIP does not alter the price structure (see also Emch and Thompson, 2006). The new prices entail new quantity ($Q' = D_A(P'_A)D_B(P'_B)$) and profit (Π'). The condition for the smallest $\Delta Q/Q = (Q' - Q)/Q$ decrease that still makes the SSNIP profitable is:

$$\Pi' - \Pi = \left(P'_A - C_A\right) Q' + \left(P'_B - C_B\right) Q' - [(P_A - C_A)\,Q + (P_B - C_B)\,Q] > 0, ,$$

where C_i, $i = A, B$ represent the marginal costs for sides A and B, respectively.

After performing some algebra steps and rearranging terms, we have:

$$CL = \frac{(\Delta P_A + \Delta P_B)}{[(\Delta P_A + \Delta P_B) + (P_A - C_A + P_B - C_B)]}. \quad (6)$$

Note the total price as the important price dimension seen in the markup analysis of the previous section. Interestingly, there is a total price representation for the critical elasticity if we write the total price increase SSNIP, that is, $(\Delta P_A + \Delta P_B)/(P_A + P_B) = X$. If the formula is divided by $(P_A + P_B)$, the second term in the denominator in equation (6) becomes a weighted average of the margins on each side $[(P_A + P_B) - (C_A + C_B)]/(P_A + P_B) = w_A(P_A - C_A)/P_A + w_B(P_B - C_B)/P_B = M$, where $w_i = P_i/(P_A + P_B)$. The CL formula reduces to $X/(X + M)$, as in the non-platform case. The use of total price and total margin for an SSNIP test was suggested by Emch and Thompson (2006) and Evans and Noel (2008).

The cross-side network effects alter the CL formula significantly, such that the total price and total margins are relevant for calculating it. Using only the price and margin from the hypothetical platform on one side of the business could lead to too narrow or too large a market, depending on the relative margins. Suppose we use side *A*'s price and margin only. The resulting CL will be lower than the correct CL if $M_A > M_B$ (the same expression is obtained by Evans and Noel, 2008). Using the high-margin side information only to calculate the CL would lead to too broad a market, as the calculated CL is too small, leading to higher likelihood of an unprofitable SSNIP. Symmetrically, using the low-margin side's information only to calculate the CL would lead to narrow relevant markets and an upward bias in the calculated market shares.

If the market's usual business practice is to have a zero price on one of the sides of the platform, the CL formula above would be based on an SSNIP for the non-zero price side only and include costs related to both sides.

5.2 *Non-Transaction Two-Sided Markets*

In *non-transaction* markets, one or two relevant market(s) should be specified for matching and audience markets, respectively, both taking into account cross-side network externalities.

In the case of a single market (*matching market*) the same price increase X is imposed on both sides ($X_A = X_B = X$). The relevant market would be correctly specified if the SSNIP is profitable, that is, if the following condition is met:

$$\Pi' - \Pi = \left(P'_A - C_A\right) Q'_A + \left(P'_B - C_B\right) Q'_B - \left[(P_A - C_A)\, Q_A + (P_B - C_B)\, Q_B\right] > 0.$$

Notice that the demand function, as seen in the previous section, depends on both sides' prices. After some rearranging, parallel to the derivation of (6) above, the profitable SSNIP condition may be written as follows:

$$\frac{X + M_A}{X} \left|AL_A\right| s_A + \frac{X + M_B}{X} \left|AL_B\right| s_B < 1$$

or

$$\frac{|AL_A|}{CL_A} s_A + \frac{|AL_B|}{CL_B} s_B < 1, \tag{7}$$

where $|AL_i|$, $i = A, B$ is the actual loss after the SSNIP (i.e. $AL_A = D_A(P'_A, P'_B)/D_A(P_A, P_B) - 1$); s_j is the *revenue* share of side j; and $CL_j = X/(X + M_j)$ is a 'critical loss' criteria based on each side's markup. Recall that the usual expression for a single one-sided market may be written as $|AL|(X + M)/X < 1$ or $|AL|/CL < 1$. As such, the analysis here is a weighted average (with revenue weights) of the critical to the actual loss on each side. The cross-side network effects appear in the estimation of the actual loss. Interestingly, the expression is remarkably similar to the multiproduct, one-sided market SSNIP test by Dajlord (2009).

Failing to acknowledge the two-sided nature of the market could lead to too narrow or too broad a market definition. It may happen that $AL_A > CL_A$, even if condition (7) is met, depending on the values of s_i and the 'critical loss' condition on side B. It is not possible to point the direction of the bias, except in the case of a zero price on one of the sides. Suppose $P_B = 0$. Then, $s_A = 1$; $s_B = 0$; and the condition of a profitable SSNIP (a not broader market) reduces to the standard $AL_A < CL_A$. A cross-side positive network effect would increase AL_A, compared with the situation where the demand for side A is miss-specified and omits the reduction in D_B as induced by the increase in P_A. Thus, a one-sided analysis generates the risk associated with too narrow a market.

In the case of *audience markets*, it makes sense to delimit two different but related markets, as discussed above. In this case, a price increase X is imposed only on the market we are delimiting. The breakeven criteria are:

$$\Pi' - \Pi = \left(P'_A - C_A\right) Q'_A + \left(P'_B - C_B\right) Q'_B - \left[(P_A - C_A)\, Q_A + (P_B - C_B)\, Q_B\right] > 0.$$

Note that the quantity on side B changes with P_A. We assume that prices outside the candidate market do not react to the SSNIP, as in a standard CLA. This implies that the hypothetical monopolist does not optimize the other side's price given side A's price increase.

Under these assumptions, the CL formula for delimiting the side A market is given by:

$$CL_A = \frac{X_A}{[X_A + M_A]} + \frac{M_B\, R_B X_A \varepsilon_{AB}}{[X_A + M_A]\, R_A}$$

or

$$CL_A = \frac{X_A}{[X_A + M_A]} \left(1 + \varepsilon_{AB} \frac{M_B R_B}{R_A}\right), \tag{8}$$

where $M_i = (P_i - C_i)/P_i$; $i = A, B$; $R_i = P_i Q_i$; and $\varepsilon_{AB} = (\Delta Q_B/Q_B)/(\Delta P_A/P_A)$ is the cross price elasticity of demand across sides of the platform. The same expression would apply for the other market when reversing indices A and B. Interestingly, equation (8) is a special case of Filistrucchi (2008). Note that the author claims it is also present in Evans and Noel (2008; equation 5 in that text), but the expression is actually different.

Equation (8) reflects the result in the cited papers, specifically, that if the cross-side network externality is positive (so that the sides are complements, $\varepsilon_{AB} < 0$), the cross-side network effect reduces the CL, as long as the margin on side B is positive. If the analyst does not take the cross-side network effect into consideration, the CL will be overestimated (an incorrect CL estimation would find the price increase profitable), leading to defining too narrow a (relevant) market.

In many two-sided non-transaction markets, one side has a zero price. While this case has not been explored in the papers cited, we can use the above expression to evaluate CL for the side of the platform (A in our example) that charges a non-zero price, while the other side carries a zero price, that is, $P_B = 0$.

$$CL_A = \frac{\Delta P_A/P_A}{[\Delta P_A/P_A + (P_A - C_A)/P_A]} - \frac{C_B Q_B X_A \varepsilon_{AB}}{[\Delta P_A/P_A + (P_A - C_A)/P_A]\, R_A};$$

or in the previous notation,

$$CL_A = \frac{X_A}{[X_A + M_A]} \left(1 - \varepsilon_{AB} \frac{C_B Q_B}{R_A}\right). \tag{9}$$

The additional term is positive if the cross-side network effect is positive, so that the cross-price elasticity is negative, as if the sides were complements. The correct CL would be larger than the one calculated with a miss-specified demand model with no cross-side network effects. The miss-specified model would delimit too broad a market.

Interestingly, the same expression applies in matching markets, where only one market is delimited. The relevant market is defined using revenue data from one side and costs from both sides.

Regarding data requirements, cost and margin measures may be difficult to calculate, as marginal costs are minimal and fixed costs are significant in many information-based markets. As an extreme case, Brekke (2018) argues that under some conditions the firm's average per unit profit (from accounting information) can be used.

Clearly, the challenge in implementing the above expressions lay in calculating the price elasticities (e.g. Evans and Noel, 2008). A full-fledged demand system would be required, with additional cost information from all firms in the candidate market. In case of transaction markets without pass-through, the 'standard' (for regular one-sided markets) CLA is to be used where the quantities would be transactions and the price would be the sum of prices charged on the two sides of the platform. In cases where transaction markets use two-part tariffs (a membership and a per unit fee), additional care is required. If one of the sides has a zero price, demand estimation is relevant only for the other side. Note that since the number of transactions is the quantity variable, the fact that one price is zero does not alter the estimation significantly.

For non-transaction markets the challenge is in measuring prices and quantities in terms of comparable units. For audience markets, while two separate markets are estimated, units of measurement and quantities must be compatible for each side. The business practice should be used; for example, Argentesti and Filistrucchi (2007) use cover price per newspaper (abstracting from the fact that across the week the number of pages and prices vary) for the readership side and the number of advertising slots and the price per slot in Italy. Filistrucchi *et al.* (2012a) use advertising price per column millimetre and advertising area purchased for the Dutch market.

A common practice in delimiting markets is to use a residual demand approach for the hypothetical monopolist. If all the firms in the candidate market have a similar business model that allows comparability of prices and quantities, this can be replicated. However, when the relevant market includes different business models (e.g. a platform that uses only membership fees in its transaction market, and others that use a per transaction fee) econometric exercises are not feasible.

Difficulties in obtaining quantity and prices may hinder a full-fledged demand estimation exercise. Filistrucchi (2018) and Wismer and Rasek (2018) point to alternatives such as customer surveys. For between platform diversion ratios, customer churning or natural experiments of supply interruption or entry effects could be used. Brekke (2018) provides an example from the Norwegian Competition Authority regarding a newspaper merger. A survey was sent out to users on each side of the platforms (readers and advertisers) asking what would be the second option if their current newspaper was not available. This was used to calculate same-side, between-firms diversion ratios. The survey was carried out by phone (readers) or letter (businesses), given the relative number of each side's users. The author points out that the survey could have been used to infer about diversion ratios across platform sides.

Brekke (2018) argues that capturing cross-side deviations is more complex. Consumers might not be able to evaluate whether an increase in the volume of, say, advertising, would lead them to switch to another platform. While this could suggest that one of the cross-side network effects is null, it may just reflect difficulties in recognizing this situation.

In all cases, usual care on survey design is recommended to avoid steering respondents (framing bias), recollection bias and others. For example, the questions should not create certain abstract situations, such that members on each side of the platform would not be able to provide realistic answers.

6. Using Modified Price Pressure Indices for Unilateral Effects Assessment

A central issue when evaluating the economic effects of a merger is the possible change in consumer prices. Such price increases are associated with welfare losses and are subject to antitrust scrutiny. Based on a competition model for the relevant market under study (generally a Bertrand model for differentiated products), it is possible to simulate the price effects of a merger (e.g. Davies and Garcés, 2010). Price, quantity, and cost data of the merging parties, as well as those of relevant market firms, are necessary to estimate a demand model. The estimated demand model parameters are then used in the simulation model. The simulation model is used also to estimate marginal costs and model-consistent margins. Yet, the simulation-based analysis has been criticized as its results can be very sensitive to the assumed hypothesis about demand functions (Crooke *et al.*, 1999). In addition, a simulation-based merger evaluation would require modelling the interaction of all firms in the relevant market (Farrel and Shapiro, 2010).

As an alternative, under data restrictions and concerns about the sensitivity of the simulation results, practitioners and antitrust authorities have looked for price increase indicators. These price pressure indicators can inform on the size of the merger-price effects, or provide a lower bound on such effects, without claiming to provide a precise or robust answer.

The Upward Pricing Pressure (UPP) concept was proposed by Farrell and Shapiro in 2010. The idea can be traced back to Salop and O´Brien (2000) and Willig (1991). Instead of comparing prices before and after a merger in a fully simulated model of relevant market firm behaviour, UPP compares a merging firm's first-order condition differences before and after a merger. In other words, it evaluates the increase in prices after a merger, keeping other firms' prices constant. In a Bertrand model, as other firm prices increase given a competitor price increase, this in turn would push merging firms' prices further up. UPP would give a conservative or a possible lower bound on price increases after a merger. This idea was incorporated in the US Federal Trade Comission (FTC)'s 2010 Horizontal Merger Guidelines.

UPP is the difference between two pricing incentives of a merger: an upward pressure on prices due to the loss of competitive pressure from the merging party and a downward pressure on prices due to merger-related rise in production efficiency (marginal cost decrease). The formula is given by:

$$UPP_1 = (P_2 - C_2)\,D_{12} - E_1 C_1,$$

where 1 and 2 are differentiated products supplied by the corresponding merging companies; D_{12} is the diversion ratio from product/firm 1 to product/firm 2; P_2 is the price of product 2; C_1 and C_2 are the marginal costs of products 1 and 2, respectively; E_1 is the measure of a possible merger-related cost decrease in producing product 1; and UPP_1 is the UPP for the price of product 1. As long as $UPP_1 \geq 0$

the merging firms will have incentives to increase the price of product 1. The UPP gives a lower bound on the possible price increases (in monetary units) after a merger. A similar indicator may be calculated for the other firm's price using $UPP_2 = (P_1 - C_1)D_{21} - E_2C_2$.

The diversion ratio measures the proportion of sales lost by firm 1 after a price increase that is recaptured by the merged entity through increased sales of firm 2. Its expression is $D_{12} = -(\partial D_2/\partial P_1)/(\partial D_1/\partial P_1)$. Using a firm's price and cross-price elasticities, it may be written as $D_{12} = (\varepsilon_{12}/|\varepsilon_{11}|)(Q_1/Q_2)$. A characteristic of the UPP indicator is that it allows merger efficiencies to reduce the expected merging firm's price increase.

Alternatively, the GUPPI proposed by Salop and Moresi (2009) does not grant an efficiency credit and presents the information as a percentage price increase for firm 1 as follows:

$$GUPPI_1 = \frac{P_2 - C_2}{P_2} D_{12} \frac{P_2}{P_1} = M_2 D_{12} \frac{P_2}{P_1}.$$

The formula takes into consideration the upward pressure on prices only. The GUPPI will always be positive if the merging parties' products are substitutes. A practical use of this tool for merger screening requires some threshold level to be specified by the competition authority, as suggested by the authors. Farrell and Shapiro suggest up to 5%, as this is the likely level of efficiencies in many mergers.

Applying the UPP/GUPPI methods requires data on prices and economic margins of the merging firms. Economic margins are often proxied by operational margins. It also requires an estimate of the diversion ratio. Careful estimation of diversion ratios are based on the specification of a full market demand model, with data on merging and non-merging parties. Simplified models can be used (under independence of irrelevant alternatives assumptions), such as the logit models described in Section 4 above. If data restrictions do not allow the estimation of a demand model, the diversion ratio could be estimated using surveys or other methods described at the end of Section 4. Given the use of many simplifications for UPP calculation, one may argue that the indicator may provide misleading information on the direction and the lower bound of the post-merger price increase. Miller *et al.* (2017) provide an extensive analysis of the UPP/GUPPI indicators, compared with a full-fledged simulation. In realistic situations there may be misspecification of the demand function estimation or uncertainty about margins. Their simulation shows that in these cases, the prediction errors of predicted and actual price increases from UPP do not differ much from a miss-specified simulation. This suggests that UPP/GUPPI is a valid and useful tool for informing about the possible price effects of a merger.

The literature considers *non-transaction audience-providing platforms* only. We start the presentation from the literature and later consider transaction platforms when we introduce the corresponding expressions for UPP/GUPPI indicators. Affeldt *et al.* (2013) extend UPP and GUPPI for the case of merging non-transaction platforms when two markets are delimited. Price changes in multi-sided markets involve both direct demand effects across firms, as in one-sided markets, and also network effects across sides, as seen above. The merger affects both sides, A and B. The authors consider the newspaper business, consisting of the advertising (A) market and the readership (B) market. The demand functions for each side and each firm depend on all prices. For example, $Q_1^A = D_1(P_1^A, P_2^A, P_1^B, P_2^B)$. If positive cross-side network effects are present, the effect of P_2^B on Q_1^A is positive, as firms' products are substitutes and platform sides are complements.

The authors show that in case of a merger between firms 1 and 2, the UPP expression for non-transaction audience-providing platforms ($AUPP$) for firm 1 in the B market (readership) is given by:

$$AUPP_1^B = \left(P_2^B - C_2^B\right) D_{12}^{BB} - E_1^B C_1^B + \left(P_2^A - C_2^A\right) D_{12}^{BA} - E_1^A C_1^A D_{11}^{BA}, \quad (10)$$

where $D_{12}^{BB} = -(\partial Q_2^B/\partial P_1^B)/(\partial Q_1^B/\partial P_1^B)$ is the diversion ratio between firms 1 and 2 for the platform's side B output; $D_{12}^{BA} = -(\partial Q_2^A/\partial P_1^B)/(\partial Q_1^B/\partial P_1^B)$ denotes the diversion ratio from side B in firm 1 to firm 2's side A; and $D_{11}^{BA} = (\partial Q_1^A/\partial P_1^B)/(\partial Q_1^B/\partial P_1^B)$ denotes the diversion ratio between sides A and

B of the same firm 1. Note that same-firm diversion ratios are not normalized to positive, as cross-side effects may be negative (sides as 'complements') or positive.

The first two terms are the standard UPP measure for one-sided markets, as seen above. The additional two terms appear due to the cross-side network effect. D_{12}^{BA} measures the increase in the sales in firm 2's A side (advertising) business from a price increase in firm 1's B side (readership, i.e. newspaper cover) price. This is likely to be positive in the case of newspapers, but generally D_{12}^{BA} can take any sign depending on the nature of the network externality. The last term is of particular interest: it measures the efficiency gains on the other side (in this case, A) of the platform, multiplied by the sales volume's relative change, as induced by an increase in side B's (newspaper cover) price D_{11}^{BA}. This term is likely to be negative in this example: a price increase in newspaper cover price reduces readership, making it less attractive to advertisers. The total effect of the cost savings on the advertising side may be to increase readership prices.

The GUPPI measure for non-transaction audience-providing platforms (*AGUPPI*), also presented by Affeldt *et al.* (2013), which ignores efficiency gains, for a price increase on side B, by firm 1 can be written as follows:

$$AGUPPI_1^B = M_2^B D_{12}^{BB} \frac{P_2^B}{P_1^B} + M_2^A D_{12}^{BA} \frac{P_2^A}{P_1^B}, \tag{11}$$

where M_2^B and M_2^A are the profit margins (as a percentage of price) of firm 2 in markets B and A, respectively. Again, it is not difficult to see that considering only side B (one-sided logic for a two-sided market analysis) would underestimate the price pressure indicator, if sides have positive cross-side network externalities ($D_{12}^{BA} > 0$) and margins are positive. Interestingly, if the B (audience) side has below-cost pricing, the GUPPI/UPP formulae will suggest a possibly negative price change after the merger, as reducing the readership mitigates losses across platforms, as Affeldt *et al.* (2013) indicate. This, of course, would be compensated from the cross-side margin, that is, $M_2^A > 0$.

Now, consider *non-transaction matching platforms*. When only one two-sided market is delimited, it would make sense to consider simultaneous price increases in both prices, as in the SSNIP analysis of the previous section. This entails an optimization of both price increases by the firm, still taking, in standard price indicator fashion, other firm prices' constant at the pre-merger level.

The GUPPI expression derived here is more complex than (11), as feedback effects from one side's price increase to the other side's price increase must be taken into account. The price increase on, say, side B, affects the 'opportunity cost' on the other side, side A, as seen in the markup rules. This influences the incentives for the price increase on side A. It can be shown that the GUPPI measure for non-transaction matching platforms (MGUPPI) for a price increase on side B, by firm 1 could be written as follows:

$$MGUPPI_1^B = AGUPPI_1^B - K_{11}^B AGUPPI_1^A D_{11}^{AB}, \tag{12}$$

where $K_{11}^B = (1 - 1/|\varepsilon_{1B}|)^{-1}$ is the pass-through rate from costs to prices if cross-price effects were not present, and $\varepsilon_{1B} = (\partial Q_{1B}/\partial P_1^B)/(P_1^B/Q_{1B})$ is the firm's price elasticity for firm 1 and side B. Note that as cross-side network effects are positive, D_{11}^{AB} is not normalized to an absolute value; thus, it is positive when sides are complements, as mentioned above. The MGUPPI is lower than the AGUPPI (equation 11 above). A price increase on side A reduces the demand on that side. Given a positive cross-side network effect, this reduces the demand on side B of the platform. Thus, the GUPPI with optimized prices on both sides is lower than the two-sided GUPPI when the other side's price is held constant.

Using a one-side logic (e.g. considering only side B's prices and costs and ignoring cross-side network effects) would lead to opposing effects on the MGUPPI estimation. As it is shown above for the case of audience markets, when cross-side effects are positive, the first term ($AGUPPI_1^B$) would be underestimated in the one-sided analysis. At the same time, wrongly considering the zero cross-side effect, ($D_{11}^{AB} = 0$), would eliminate the negative effect of the internalization of the other side's 'opportunity cost' (the second term on the right side of equation (12)), increasing the one-sided logic GUPPI. Which effect would prevail is a case-by-case analysis.

For *transaction platforms*, we also introduce the UPP/GUPPI formulae (TGUPPI). Starting with the GUPPI, the expression is as follows:

$$TGUPPI_1^B = \frac{\left[\left(P_2^B - C_2^B\right) + \left(P_2^A - C_2^A\right)\right] \; D_{12}^{BB}}{P_1^B}$$

or

$$TGUPPI_1^B = M_2 D_{12}^{BB} \frac{P_2}{P_1^B}, \tag{13}$$

where firm 2's total margin is $M_2 = [M_2^B s_2^B + M_2^A s_2^A]$, and s_2^A is the *price* share of side A for firm 2's total price; $D_{12}^{BB} = (\partial D_2/\partial P_1^B)/(\partial D_1/\partial P_1^B)$, and $P_2 = P_2^A + P_2^B$ is the 'total' price of firm 2. Recall that the demand function is $Q_i^A = D_i^A(P_i^A, P_j^A) D_i^B(P_i^B, P_j^B)$ for firms $i, j = 1, 2$. As in the usual GUPPI formula, the margin of the other firm and the diversion ratio across firms are central. In a transaction market the relevant margin is the total margin, or the price on one side of the platform minus the adjusted 'opportunity cost' in the words of Rochet and Tirole (2006) $C_2^B - (P_2^A - C_2^A)$. The diversion ratio refers to diversion across firms, as in the simple one-sided market GUPPI. Compared with the non-transaction audience-providing platform's formulae (equation (9)), here, there is no cross-side diversion ratio as in this model transactions that require one-to-one diversion between each side. In other words, $D_{12}^{BB} = (\partial D_2/\partial P_1^B)/(\partial D_1/\partial P_1^B) = D_{12}^{BA}$ as P_1^B influences the demand for transactions through platform 2 via the effect on side B only. In case of transaction platforms, for GUPPI, as for the CLA formulae in the previous section, the total margin matters.

For firm 1, its side B's UPP expression for transaction platforms (TUPP), allowing for efficiencies in both sides of both firms, is as follows:

$$TUPP_1^B = \left[\left(P_2^B - C_2^B\right) + \left(P_2^A - C_2^A\right)\right] D_{12}^{BB} - \left(E_1^B C_1^B + E_1^A C_1^A\right) + \left(E_2^B C_2^B + E_2^A C_2^A\right) D_{12}^{BB}. \tag{14}$$

Note that the efficiency effects across firms are intermediated by the diversion ratio between firms. The transaction demand models imply a one-to-one diversion between sides; thus, a firm's efficiency effects on the other side (A) are not multiplied by a diversion ratio.

Compared with the one-sided analysis, where the formula would be $UPP_1^B = (P_2^B - C_2^B) D_{12}^{BB} - E_1^B C_1^B$, the main issue would be the incorrect use of a one-sided price–cost difference. Consider that for firm 2, side B has $P_2^A - C_2^A > 0$. The standard analysis would underestimate the price incentive increase as the cross-side network effect would amplify the benefits of diverting sales to firm 2.

Before closing the section, we note a discussion in the literature regarding the GUPPI indicator for non-transaction audience-providing platforms. Using the above notation, $AGUPPI_1^B$ assumes that firm 1 does not adjust side A's price when evaluating the incentive to increase price on side B. This has been criticized by Cosnita-Langlais *et al.* (2018), who argue that the firm would consider the optimal rate of the prices on both sides, even if it does consider the prices of the other merged firm to be constant. The criticism is not new and is similar to the usual criticism of GUPPI-like indicators, where full feedback effects across prices should be taken into account when estimating price increases, as in a full simulation (e.g. Hausman *et al.*, 2011). As expected, including cross-side feedback effects when adjusting both sides' prices would change the GUPPI. The modified $AGUPPI_1^B$ for linear demand, as proposed by Cosnita-Langlais *et al.* (2018), is $AGUPPI_1^B - D_{11}^{BA} \frac{AGUPPI_1^A}{2}$. The intuition, following the original interpretation of UPP by Farrell and Shapiro (2010) is that a price increase on side A generates an opportunity cost for side B that alters the incentives for price increases on side B. The opportunity cost in a linear demand has pass-through of one-half and is mediated by the diversion ratio between sides B and A. However, note that since $D_{11}^{BA} > 0$ (when the sides are complements), the Affeldt *et al.* (2013) AGUPPI would overestimate the price increase effects.

This adjusted GUPPI is very similar to the formulae obtained above for matching platforms. Under linear demand, the pass-through from prices to cost is equal to one-half. The formulae should be similar as the main assumption when deriving the formulae for the GUPPI for matching platforms is that both prices of the firm increase, as in Cosnita-Langlais *et al.* (2018).

To complete the analysis, we develop the transaction platforms' GUPPI (*TGUPPI*) when the price on both sides (*A* and *B*) of firm 1 are adjusted after the merger, keeping merged firm 2's prices constant as follows:

$$TGUPPI_1^{B**} = TGUPPI_1^{B} - K_1^{B} TGUPPI_1^{A}.$$

The expression follows the opportunity cost and pass-through intuition of MGUPPI indicator (12) when the prices of both sides change. When evaluating side B's price pressure increase for firm 1 after a merger, allowing the same firm's side *A* price to adjust as well would reduce the GUPPI indicator, in the case of positive cross-side network effects. An increase in side *A*'s price would reduce the demand for side *B* and generate a loss to the firm.

7. Tests for Exclusionary Abuses in MSP

Competition authorities have two main areas of activity; one is merger control, where the tools such as GUPPI are relevant. The other is the control of abusive practices by dominant companies and groups of companies that reduce competition levels in an economy. However, it is necessary to note that the list of enforcement targets of competition authorities in the majority of countries is wider and may include state aid, industry regulation issues, consumer protection and others (Avdasheva *et al.*, 2019).

In the case of an MSP, we can follow the same classification of types of abusive conducts used for traditional markets, such as exploitative abuses and exclusionary abuses.

Exploitative abuses (e.g. excessive/unfair price and price discrimination) are the most complex and controversial subjects of competition law. After more than 50 years of effort, no criteria that is reliable enough for a threshold that distinguishes 'fair' and 'unfair' prices of a dominant company has been developed. In the case of MSPs, the matter is not more transparent. That is why below we discuss exclusionary abuses only. However, it is worth mentioning that all comments given below for specific technical problems related to the identification of predatory pricing (all types of price–cost tests) are relevant in the case of excessive (unfair) price investigations.

Exclusionary abuses are business practices aimed at driving competitors out of the market and strengthening one's dominant position. Their specific features in the case of MSPs are discussed in Evans and Schmalensee (2015). The main types of exclusionary abuses are as follows.

Exclusive dealing: In the case of MSPs the practice takes the form of single-homing as a necessary condition for dealing with a platform or a condition for getting rebates. Keeping control over the 'bottleneck', an MSP can use its dominant position and spread its market power to the other side of the market and interrelated markets as well.

Tying and bundling: An MSP is often present at many transaction and non-transaction markets and has an opportunity to practice tying and multi-product rebates. The greater the number of products in the bundle, the stronger is the anticompetitive foreclosure. However, from a social welfare perspective, the practice might be beneficial (Rochet and Tirole, 2008; Amelio and Jullien, 2012).

Predatory pricing: As shown above, a one-sided price–cost comparison does not make sense in the case of platforms. Given the cross-side network effects it may be rational for a firm with no exclusionary intent, to set its price below marginal cost, so as to attract more customers to the other, more profitable, side of the platform. Besides, pricing below cost might be the only way for a platform to reach the threshold number of users necessary to make the network attractive to users.

Regarding the anticompetitive effects of MSP practices, these should be evaluated with more care, as cross-side network effects may worsen such anticompetitive effects or actually reflect the pro-competitive effects of these business practices.

A number of tests for sorting out the pro-competitive from anti-competitive exclusionary conduct of a dominant company have been proposed by scholars for traditional (one-side) markets (OECD, 2005). These include:

a) *the profit sacrifice test (the 'but for' test)*, which states that a conduct should be considered unlawful when it involves a profit sacrifice that would be irrational if the conduct did not have a tendency to eliminate or reduce competition;
b) *the no economic sense test (the NES test)*, which states that a conduct should be unlawful if it would make no economic sense without a tendency to eliminate or lessen competition; and
c) *the equally efficient firm test*, which states that a conduct should be unlawful if it would be likely to exclude a rival that is at least as efficient as the dominant firm is.

The above tests are used for non-two-sided markets but are subject to criticism (OECD, 2017). Test (a), the profit sacrifice 'but for' test, is criticized in several ways. First, a short-run profit sacrifice does not always follow an exclusionary conduct. Thus the test is under-inclusive. Second, a profit sacrifice may follow a conduct that formally restricts competition while increasing social/consumer welfare. Thus, the test is over-inclusive as well.

In contrast to the 'but for' test the (b) NES test prohibits the conduct that eliminates competition and provides an economic benefit to the defendant only because of a competition restriction effect, regardless of whether the conduct is costless. Thus the test avoids the criticisms directed at the profit sacrifice test related to the ambiguous relationships between exclusionary conduct and the economic results of a company. At the same time the test is still weak in terms of balancing the positive and negative welfare effects of a conduct.

With regard to test *c)*, the problem of efficiency measurement and comparison when products are differentiated and the business strategies of companies differ is well-known, irrespective of the 'sidedness' of the market. The criticism of the test is related also to the fact that logically, the exclusion of less effective competitors should not be considered harmful for welfare. Many theories of productivity growth require the market selection of more productive firms (e.g. Foster *et al.*, 2008). However, in many cases, a dominant company is more efficient than its smaller competitors, and new entrants need time to reach the level of efficiency comparable with those of existing firms. Results of the test would not treat their exclusion from the market illegal despite their potential ability to compete and improve social welfare.

The above tests implicitly use the pricing results of firms with market power. We should expect firms with market power to set their price above marginal cost, following the Lerner Index. The same approaches could, in principle, be applied to an MSP, taking the abovementioned weaknesses into consideration. However, multi-sidedness adds restrictions on the applicability of the tests because of cross-side network effects. All types of price–cost tests are problematic when applied to an MSP because pricing rules with market power can generate below-cost pricing on one side of the market, with no exclusionary intent. As seen in Section 3, platforms may price one side of the market with a price above the opportunity cost of servicing such a market, including not only the actual direct cost of the service but also the loss in profits from a higher price on the other side of the platform, given cross-side network effects. The Lerner index, as usually measured (using prices and costs on one side of the platform), can possibly overestimate or underestimate the degree or market power. In general, if positive cross-side network effects are present, the Lerner index can be negative when using information from one side of the market only.

The two-sided nature of these markets, with their cross-price elasticities require sharp changes in the tools for analysing the exclusionary practices (as well as excessive pricing), compared with regular analysis. As seen above, following Rochet and Tirole (2006), in transaction platform cases, the price level (the sum of prices on both sides) is the competitive measure that reflects market power, not the price on each side. The relative prices are used to balance the market, in the sense of attracting consumers, in proportion to their relative elasticities, to maximize the number of transactions. Thus, Fletcher (2007) argues that the Areeda/Turner guidance regarding the below-marginal-cost price on a single side of the market does not inform of predatory pricing. One should consider the sum of prices and the joint marginal cost to evaluate whether negative margins are present, that is, if:

$$P_A + P_B < C,$$

where P_A and P_B are prices charged to the two types of users that are involved in a transaction, and C is the total marginal cost associated with a transaction.

For non-transaction two sided markets, Behringer and Filistrucchi (2015) come to a parallel conclusion. Given the cross-side network externalities and the different, possibly unrelated prices, below-marginal-cost pricing is a natural outcome of the internalization of cross-side network externalities, even for a monopoly. The monopoly case is interesting because when there is a single seller, predation does not make sense. The costs and prices on each side have to be taken into account when evaluating below-marginal pricing. The authors present a 'necessary but not sufficient condition for finding predatory pricing' as follows:

$$(P_A - C_A) + (P_B - C_B)\, D_{AB} < 0$$

or/and

$$(P_B - C_B) + (P_A - C_A)\, D_{BA} < 0,$$

where P_i and Q_i are the price and the quantity at i-side, and D_{AB} is the diversion ratio or complementarity ratio between sides A and B, as seen in Section 3. The authors do not deal with the transaction market case, but it can be shown that the 'necessary but not sufficient condition for finding predatory pricing' would be as follows:

$$[(P_A - C_A) + (P_B - C_B)] < 0$$

or

$$[(P_A + P_B) - (C_A + C_B)] < 0.$$

Keeping in mind that a rival should be of the same size, given network effects, it is unlikely that an equally efficient rival would be found in the market. In the absence of an equally efficient competitor, the company's prices and costs are sometimes used and thus, the test becomes similar to the 'but for' one. However, by ignoring the effect of the rival's size, a competition agency may overlook that in many cases, a dominant company is more efficient than its smaller competitors, and new entrants need time to reach the level of efficiency comparable with existing firms. The test conclusion would be not to treat their exclusion from the market as illegal despite the entrants' potential ability to compete and improve social welfare.

In both transaction and non-transaction markets, the differences in prices from costs can be rationalized from the business model of the platform. These business models should recognize the strong cross-side effects of platforms. At the same time, they bring solutions to possible information-asymmetry problems in that market. These solutions often provide the central attractiveness of the platform model. For example, in the case of online taxi applications, such as Uber, the reputation system for both drivers and riders, and the third party's (the platform) price-setting rules, generate great value to all sides. These are market-making businesses that create value and efficiency.

Table 1. Summary of CL and UPP/GUPPI Formulae for Different Platform Markets.

	SSNIP test: CLA	UPP	GUPPI
Transaction platforms (one multi-sided market)	$CL = \frac{(\Delta P_A + \Delta P_B)}{[(\Delta P_A + \Delta P_B) + (P_A - C_A + P_B - C_B)]}$ *Source*: Emch and Thompson (2006)*, Evans and Noel (2008)	$TUPP_1^B = [(P_2^B - C_2^B) + (P_2^A - C_2^A)]D_{12}^{BB} - (E_1^B C_1^B + E_1^A C_1^A)$ *Source*: this paper	$TGUPPI_1^B = \frac{[(P_2^B - C_2^B) + (P_2^A - C_2^A)]\, D_{12}^{BB}}{P_1^B}$ $TGUPPI_1^B = M_2 D_{12}^{BB} \frac{P_2}{P_1^B}$ *Source*: this paper
Non-transaction audience-providing platforms (two markets, one on each side)	$CL_A = \frac{X_A}{[X_A + M_A]}(1 + \varepsilon_{AB} \frac{M_B R_B}{R_A})$ *Source*: Evans and Noel (2008), Filistrucchi (2008)	$UPP_1^B = (P_2^B - C_2^B)D_{12}^{BB} - E_1^B C_1^B + (P_2^A - C_2^A)D_{12}^{BA} - E_1^A C_1^A D_{11}^{BA}$ *Source*: Affeldt *et al.* (2013)	$GUPPI_1^B = M_2^B D_{12}^{BB} \frac{P_2^B}{P_1^B} + M_2^A D_{12}^{BA} \frac{P_2^A}{P_1^B}$ *Source*: Affeldt *et al.* (2013)
Non-transaction matching platforms (one multi-sided market)	$\frac{\lvert AL_A \rvert}{CL_A} s_A + \frac{\lvert AL_B \rvert}{CL_B} s_B < 1$ *Source*: this paper	$MUPP_1^B = UPP_1^B - K_{11}^B UPP_1^A D_{11}^{AB}$ *Source*: this paper	$MGUPPI_1^B = GUPPI_1^B - K_{11}^B GUPPI_1^A D_{11}^{AB}$ *Source*: this paper

Notes: A, B = platform sides; 1, 2 = firms; total price $P = P_A + P_B$; total marginal cost $C = C_A + C_B$; side A relevance in total revenue $s_A = (P_A Q_A)/(P_A Q_A + P_B Q_B)$; percentage increase in prices (SSNIP) X; side A margin $M_A = (P_A - C_A)/P_A$; actual loss from a SSNIP price increase AL; side A revenues $R_A = P_A Q_A$; diversion ratio between firms 1 and 2 on side B of the platform $D_{12}^{BB} = -(\partial D_2/\partial P_1^B)/(\partial D_1/\partial P_1^B)$; diversion ratio between sides A and B for firm 1 $D_{11}^{BA} = (\partial Q_1^B/\partial P_1^B)/(\partial Q_1^B/\partial P_1^B)$; markup factor on side B product for firm 1, $K_{11}^B = (1 - 1/\lvert\varepsilon_{1B}\rvert)^{-1}$. If cross-side network effects are positive, $\varepsilon_{AB} < 0$ and $D_{11}^{AB} > 0$ as sides as 'complements. UPP with firm 1 efficiency gains only.

*Emch and Thompson do not provide a formal argument for the formula, while suggesting the use of total price, instead of only one of the side´s price.

8. Balancing the Pro- and Anti-Competitive Effects of Business Practices: Efficiency Tests in MSP

Where cross-side network effects are strong, mergers of MSPs might generate efficiencies if they combine separate user bases and increase interoperability. Chandra and Collard-Wexler (2009) argue that a merged platform might better internalize cross-side externalities and thus, set lower prices on both sides of the market, attracting new users and expanding the market. Andreu and Padilla (2018) reason that new technology developments resulting from a platform merger may increase consumer surplus, even while the prices increase, due to the creation of a product of higher quality.

Estimation of the efficiency effects might be demanded in investigations of alleged violations of competition law. When a conduct is not illegal per se some welfare balancing might be applied to test if the negative effects of the conduct on consumer welfare are outweighed by pro-competitive welfare effects (increase in the company's efficiency, new technology development, and others). The criticism of the approach is related to the technical difficulties of identification, estimation, and comparison of the effects.

A number of tools or tests have been proposed with regard to one-sided markets. The *Disproportionality Test* (US Department of Justice, 2008) states that conduct is anticompetitive when it results in harm to competition that is 'disproportionate' to the consumer benefits and to the economic benefits of the defendant. This approach remains open to the questions of how big the 'disproportion' should be and what to do in case they cannot be compared (and even measured, i.e. in case of product quality improvement). The *Elhauge efficiency test* (OECD, 2005) is an attempt to omit the problem of balancing the effects. When an exclusionary effect and an increase in the defendant's dominance are observed, the test asks whether a dominant position is being enhanced or maintained because the defendant is improving its own efficiency (lawful), or because the defendant is impairing the rival's efficiency (unlawful). However, in practice, it is very unlikely that an unambiguous cause-and-effect relationship can be identified. This leaves ample space for appeals and increases the costs of litigation.

In the case of MSPs, balancing the effects becomes even more difficult, as efficiencies generated on different sides of the market should be taken into consideration. Even if some conduct reduces competition in a given market, cross-side network effects may generate compensating benefits in another market.

As far as platforms are able to exploit positive cross-side network effects to compensate for the losses of users on one side via extra revenues from the other side's services, their incentives to undertake exclusionary practices are considered to be greater compared with one-sided businesses (Amelio *et al.*, 2018). In academic literature a special situation when users deal with only one platform to get a certain service (single-homing) attracts a lot of attention from researches. With high probability, the lack of simultaneous use of platforms to do business (multi-homing) might be a result of some exclusionary practice. Theoretical modelling predicts a redistribution of surplus across sides of a platform in favour of the one with a higher elasticity of demand, that is, from single- to a multi-homing side (Armstrong and Wright, 2007). It may also appear in case of mergers (Van Cayseele and Reynaerts, 2011). However, this effect, even though capable of being measured, is helpless for identifying an exclusionary practice, as the result is the same as that of short-run profit maximization. Moreover the exclusionary practice might be welfare-enhancing and competition-preserving when several competing platforms apply single-homing (Calzolari and Denicolò, 2013). This stresses once more the need for, and the non-triviality of, an effect-based approach in the case of platforms.

9. Summary and Conclusions

The growing importance of MSPs as a leading business model in the digital economy urges competition authorities to update and adapt their tools for evaluating possible anticompetitive effects in both merger and abuse of dominance cases. This study presented analytical tools to manage competition policy analysis in MSPs, highlighting the required changes from the usual one-sided market frameworks and tools.

MSPs organize interactions between users, so as to internalize cross-side network externalities. The actual interaction form and the pricing strategy of an MSP influence the analysis. Learning about the business model of the platform (or platforms), within the taxonomy of MSPs from the interaction of and the pricing on the sides of the platform becomes an important starting point. Recognizing whether the MSP under scrutiny is a transaction or non-transaction platform steers the decision as to whether to consider one relevant market or two relevant markets, respectively.

This study provided a unified view of the CL and the GUPPI/UPP indicators for the different types of MSPs, as well as exclusionary practice tests. We collected the results in the literature and filled the gaps. Table 1 summarizes the formulae for CL and GUPPI/UPP, highlighting the contribution of this paper to the literature.

The cross-side network effects are central when evaluating substitution patterns and pricing rules for platforms. We showed that the errors in using 'one-sided logic' to two-sided markets (Wright, 2004) apply to quantitative tools.

Consider the CL analysis for market definition. If cross-side network effects and margins on both sides are positive, a price increase on one side that is profitable under a one-sided analysis might become non-profitable, as the decrease in sales on side A of the platform reduces sales on side B, which feeds back and reduces sales further on side A. Not taking into account the cross-side network effects would lead to too narrow a market definition for audience markets.

Interestingly, if one of the sides has a zero price policy, the result is reversed and the relevant market would be defined as too broad. An important point of the review is that in a general case it may not be possible to point the direction of the decision bias resulting from an incorrect application of a one-sided analysis. The sign of the cross-side network effects and whether margins are positive or negative on either side matter.

After delimiting markets, concentration measures may not be informative of the platform's market power. First, platforms are often innovation-based, disruptive businesses; thus, market shares may change rapidly as in any dynamic, competitive market. Second, MSPs are differentiated products, where markups are weakly associated with concentration measures. Third, pricing formulae in transaction or non-transaction platforms show that the standard Lerner indices are invalid when calculated using costs (or prices) from only one side of the platform. Lerner indices for MSPs must incorporate the cross-side network effects and the balancing need of the platform to increase demand on one side with higher demand on the other side.

Inferences on anticompetitive price effects from mergers can be obtained by expanding the price pressure indices for two-sided platforms. The GUPPI/UPP-like formulae show that the usual one-sided merger formulae omit the cross-side network effects. These effects amplify the price-pressure increase, say, of the price on side A of the merged platform 1, as an increase in demand on side A of the merged platform 2 would boost sales on side B of platform 2. This second effect reinforces the incentives to increase prices on side A of platform 1. Only in the absence of the cross-side network effects the standard formula does not underestimate the price incentive effects. Using one-side margins underestimate price pressure indices in transaction and audience markets if the other side's margin and price are positive. For matching markets, or when one considers simultaneous adjustments of the prices on both sides, the one-sided logic may under- or overestimate the price pressure effect.

As in any other market, exclusionary practices can be observed in MSP. The nature of MSPs requires changes in the usual investigative tools and effects analysis. First, price–cost comparisons in MSPs are not recommended, as optimal pricing formulae with no exclusionary or abusive intent generate below-cost pricing. The requirement that variable costs on both sides be taken into account generates additional difficulties as (i) these costs may be hard to measure, (ii) many digital markets operate basically with zero marginal costs, and (iii) accounting attempts to allocate the fixed costs across platform sides may create statistics that are not relevant for decision-making. Second, the network effects generate 'tipping' points in the demand for a platform. This can both consolidate exclusionary practices and make them more effective. These business dimensions become central in the analysis of exclusionary practices.

Last but not least, a competition policy analysis of MSPs should recognize the dynamic nature of competition in such businesses. MSPs are often innovations that create monopolization; while at the same time, such dominance can be quickly erased by new platforms and business models. Such innovation markets are not unknown to competition authorities. New ways of doing business induce new analytical tools not discussed here. The development of dynamic competition tools for MSPs would help meet the challenges for competition policy analysis.

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