# Upward Pricing Pressure in Two-Sided Markets: Incorporating Rebalancing Effects*

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**Abstract**

In two-sided markets it is important to consider rebalancing effects following a merger, *i.e.* the impact of a change in margin on one side of the market, either due to a price change or to efficiency gains, on the pricing incentives on the other side. We propose modified versions for the indices of pricing pressure (UPP and GUPPI) that take this into account. We show that in two-sided markets where the cross-group externalities are positive the upward pricing pressure will typically be overstated if the rebalancing effect is ignored. Our approach explains why competition agencies should look at both sides of the market when assessing platform mergers.

Keywords: merger assessment, two-sided markets, Upward Pricing Pressure.
JEL codes: L13, L40, L82.

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This paper deals with horizontal mergers on two-sided markets.

We propose modified versions for the indices of pricing pressure adapted to two-sided markets.

The purpose is to account for how a margin change on one side affects the price change on the other.

With positive cross-group externalities, ignoring this effect overstates the upward pricing pressure.

Our results suggest competition agencies should examine both sides when assessing platform mergers.

 

# 1 Introduction

Merger assessment has undergone substantial changes since the 90s, from an approach based on market definition, market shares and concentration index, to the application of methods that can directly indicate the potential price increase. Merger simulation has started being used as a modeling tool for predicting the unilateral anticompetitive effect (see Werden and Froeb 1994, for instance), but the quality of the prediction is known to be sensitive to the various specifications that need to be made (the demand curvature and the pass-on rate being crucial assumptions). Implementing the merger simulation is also prone to practical difficulties, which is why it is useful to resort to less expensive, quick but still reliable alternative merger screening tools. Simplified approaches that focus instead on the *mere* post-merger pricing incentives of the insiders have thus been proposed.

For instance, the approaches of Werden (1996) and Shapiro (1996) only require data on markups (obtainable from the insiders) and diversion ratios (empirically measurable and relatively easily available). In order to circumvent the problem of demand curvature and efficiencies pass-through, Werden (1996) focused on the marginal cost reductions necessary to offset the post-merger price increase, evaluated at the pre-merger prices.[1] In contrast, Shapiro (1996) computed the post-merger price increase assuming linear or constant elasticity of demand to obtain the indicative price increase (IPR). The latter has been further developed by Farrell and Shapiro (2010) into the Upward Pricing Pressure (UPP) approach by focusing on the pre-merger prices.[2] Importantly, UPP calculations appear to be a good substitute for full merger simulations.[3] Since 2005 various antitrust

[1]See also Goppelsroeder et al. (2008) and Werden and Froeb (2011) for further discussions of the Compensating Marginal Cost Reduction method with Bertrand competition and product differentiation. Similarly, Farrell and Shapiro (1990) considered instead Cournot competition in order to derive the condition for how large the reduction in marginal cost should be to counterveil any upward pricing pressure.

[2]Subsequently Moresi (2010) introduced the gross upward pricing pressure index (GUPPI) to compute the upward pricing pressure absent any efficiencies. The approach was later generalized by Jaffe and Weyl (2013) to include a demand pass-through matrix, which makes the UPP computation more theoretically accurate. The first-order approach of Jaffe and Weyl (2013) also applies to multi-product firms and is independent of particular functional forms for demand or costs. Willig (2011) examines the UPP for mergers with product quality changes for the insiders, while Moresi and Salop (2013) study unilateral pricing incentives for vertical mergers with cost efficiencies both upstream and downstream.

[3]Cheung (2016) compares the performance of UPP as a merger screening tool against standard structural merger simulation in the case of hypothetical mergers in the US airline industry, and finds favorable results when full information is available. Miller et al. (2017) do the same for a variety of economic environments and with different specifications (mis-observed demand elasticity, wrong functional form of demand and pass-through), and find that UPP is accurate with standard log-concave demand and

authorities have applied this simplified approach in many cases, and it has become a standard method referred to in merger guidelines.[4] It is often used as a filtering device for separating unproblematic deals from those that require a more in-depth review, but also as an important input for the analysis of the competitive harm when banning mergers or solving them with remedies.[5]

Mergers on digital markets are attracting growing attention and increased antitrust scrutiny.[6] It is now quite generally acknowledged that insights from traditional merger analysis may not directly apply to platforms (see e.g. Wright 2004, or Evans and Noel 2008). Using tools developed for one-sided markets may lead to wrong decisions, such as clearing anti-competitive mergers or banning pro-competitive ones, because the type and magnitude of indirect network externalities are likely to affect firm behavior on two-sided markets.

This paper belongs to a recent strand of the literature addressing the way in which antitrust analyses, in particular the UPP approach, should be adapted for two-sided markets.[7] More precisely, we focus on the UPP index derived by Affeldt et al. (2013) for horizontal mergers in two-sided markets. Instead of having two firms producing one product each, Affeldt et al. (2013) consider two merging firms that serve two different groups of users, such as advertisers and readers. To derive the two-sided version of an

only slightly underestates the price effect with greater convexity demands. Moreover, they show that predicted errors with UPP are not larger than those of merger simulations with misspecified models or imprecise demand elasticities. See also Valletti and Zenger (2020) for a recent comparative analysis of UPP/GUPPIs vs IPR vs merger simulations.

[4]The method was first applied in a merger case in the grocery sector in the UK in 2005 (Somerfield/Morrison, 02.09.2005). Although many national competition authorities in Europe applied the UPP method from 2005 and onwards, the European Commission first used it in a phase-II assessment for the Hutchison 3G Austria/Orange Austria merger in 2012. The US Federal Trade Commission (FTC) and Department of Justice (DoJ) has applied the method in several cases, see for example Electrolux/GE Appliance and Dollar Tree/Family Dollar. FTC and DoJ endorsed the UPP methodology in the August 2010 Horizontal Merger Guidelines. The UK competition authorities (Office of Fair Trading and Competition Commission) did the same in their Merger Assessment Guidelines in September 2010, and the French Comeptition Authority in its 2013 Merger Guidelines/*Lignes Directrices*.

[5]See Valletti and Zenger (2020) for examples of both cases in the recent practice of the EC and several National Competition Agencies. Baltzopoulos et al. (2015) provide such examples for Sweden, and the 2020 *Lignes directrices de l'Autorité de la concurrence relatives au contrôle des concentrations* list examples of UPP application by the French Autorité de la Concurrence.

[6]The Google/DoubleClick, Facebook/WhatsApp or Deutsche Börse/NYSE Euronext are some examples of front-page cases. Stepstone/Evenbase and Ticketmaster/Seatwave are two merger cases in the UK. For more examples of mergers in two-sided markets, see Filistruchi et al. (2014), Foros et al. (2015) and Wismer et al. (2016).

[7]See also Evans and Schmalensee (2013), Alexandrov et al. (2011) and Alexandrov and Spulber (2017).

UPP for each of the products sold by one of the insiders, Affeldt et al. (2013) assume that the prices of *all* other products are fixed, including that of the same firm on the other side of the market. In so doing, they build on the simpler UPP promoted by Farrell and Shapiro (2010), for which it is also assumed that the merged firm's other price is unchanged. Farrell and Shapiro (2010) acknowledge that it would be more accurate to take into account the merged firm's incentives to change *both* its prices. However, they also note that there is only a relatively small loss in accuracy when instead using the simplified, any-other-price-kept-constant version of the UPP index, because this test is always more conservative compared to the more accurate measures proposed by e.g. Werden (1996), hence still appropriate to flag mergers in need of further scrutiny.

In this paper we argue that this may not be the case in two-sided markets. Implicitly assuming that the platform makes enough cost savings on one product/side to write off its incentive to change the price of that product can scale down but also up the UPP for its other product/side, depending on the cross-group externality. We refine the UPP indices of Affeldt et al. (2013) by no longer assuming that the insider's price on one side is constant when looking at its incentive to raise its price on the other side. We show as a result that in response to a price increase on one side, the insider's other price may either increase or decrease, feeding back into the price on the side that the UPP is supposed to analyze.

This is explained by the fact that there are actually three effects to be considered when assessing the incentives for a price raise on one side of the platform: an effect on demand from users on the same side, a second effect from demand of users on the opposite side, and finally a third one from the price on the opposite side. The first effect is negative, because demand will fall on the side where the price increases. The second effect is also negative as long as the cross-group externality is positive, because then demand on the opposite side will fall as well. The third effect is that, given positive cross-user externality, the firm has incentives to set a lower price on the opposite side, which increases demand on that side and thereby also increase demand on the initial side. The reason for the price drop on the opposite side is that increasing the margin (by a price increase) on the initial side increases the incentive to raise participation on the opposite side, since this extra participation attracts more high-margin sales on the initial side. Hence, when the cross-platform network externality is positive, this third effect is likely to work against the first and second effects. Overlooking this third effect may therefore overstate the incentives to raise price on the initial side.

Note that the pricing of complements in a standard one-sided model shares a relationship with the problem of how a platform should set prices on each side of a two-sided market.[8] An important difference between the two-sided framework and the one-sided complements model is that generally for platforms the cross-group externality between sides can also be negative - while obviously indirect externalities cannot *both* be negative. As a result, on two-sided markets the feedback from the other product's price into the price increase on the first product may go both ways, enhance it but also mitigate it.[9]

To calculate the adjusted pricing pressure indices that take into account the impact of a platform's price change on one side, we propose to use the very intuition behind the more accurate version of Farrell and Shapiro's (2010) UPP index, the one which incorporates Werden's (1996) compensating marginal cost approach. This does not require more data than that used by Affeldt et al. (2013) for their UPP measures. By using the compensating marginal cost approach we are able to show that a merger leading to upward pricing pressure on one side of the market may lead to a downward pricing pressure on the other side of the market, even if there are no efficiencies and margins on both sides are non-negative. This price effect on the other side of the market is not taken into account by the UPP index of Affeldt et al. (2013). We show that using their version of the UPP measure in some situations may overstate the upward pricing pressure on both sides of the market, and hence it may predict an upward pricing pressure when in reality there may be a downward pricing pressure. On one-sided markets the simpler indices (that ignore the firms' incentives concerning prices on other products) are conservative, so screening mergers based on them may *only* lead to false negatives. The point we make in this paper is that this conclusion may not hold for mergers on two-sided markets, for which using the simpler version of the UPP may also lead to false positives. In such cases, the use of the simpler, any-other-price-kept-constant UPP measure (either as a screening device or as part of the in-depth analysis of mergers) loses some of its value, because we can no longer be certain of which way the error goes. This also suggests that an approach where the competition agency only focuses on one side, which we have seen some examples of, can

[8]For instance, manufacturers of printers and their compatible ink cartridges typically subsidize the former product to maximize their overall profit from the sale of the latter. Should the price of ink increase, the manufacturer will drop that of printers, in order to further drive sales of ink, because they are now generating larger margins.

[9]Another crucial difference is of course the fact that a platform needs to serve both sides while many businesses sell only one complement but not another - see Evans and Schmalensee (2018, footnote 13).

lead to an erroneous decision.[10] Hence our analysis indicates that competition agency's decision may depend on whether they consider each side of the market separately or both sides in total,[11] and as such fuels the long-lasting academic and policy debate on how to properly assess competitive harm on platform markets. The recent AmEx decision in the U.S.[12] partially settled this debate by making clear that *all*, i.e. two-sided, incentives on parties' pricing and output decisions must be taken into account in both defining a market and assessing the harm in that market for transaction platforms. This integrated approach is nonetheless recommended by recent academic contributions for all platforms as far as the competitive assessment goes,[13] and our analysis of the UPP measure on two-sided markets supports this: in order to properly assess the incentives for a price increase on one side, we argue it is necessary to account for the two-sided impact of that price raise.

In what follows we first examine the difference between the simpler and the more accurate versions of the UPP for one-sided markets, to remind that both yield similar conclusions for the screening of mergers. We then turn to the two-sided UPP measure, and propose a modified (and in many cases more conservative) version of the measure proposed by Affeldt et al. (2013). We also provide a comparison of the two approaches based on the data used by Affeldt et al. (2013), and discuss our results before concluding on their implications for the practice of competition agencies.

[10] Wismer *et al.* (2016) provides an overview of recent merger cases for two-sided markets, and they report that in some of the cases each side of the market is defined separately. See also the *Archant/Independent News* and *Media* merger in the UK in 2004, which involved two local newspapers. In that case the competition agency only considered one side of the two-sided market (the advertising side).

[11] In Europe for instance, the General Court and the European Court of Justice made clear that the market's two-sides should be examined and considered separately as far as the welfare analysis goes - see the MasterCard decision (Case T-111/08).

[12] Ohio v American Express Co, No. 16-1454 (25 June 2018)

[13] Wright and Yun (2019) argue that, regardless of the approach retained for market definition, an integrated effects analysis based on output changes across the two sides is the most consistent, including for non-transactional platforms.

# 2 UPP in one-sided markets

## 2.1 The basic version

The Upward Pricing Pressure (UPP) concept proposed by Farrell and Shapiro (2010) captures the net post-merger pricing incentives of the insiders, which result from the trade-off between an upward pressure due to loss of competition between them and a downward pressure through possible marginal cost reductions.

Consider a merger between rival firms 1 and 2, each selling one product only with constant marginal costs. Denote $E_i = \left(C_i - C_i^N\right)/C_i$ the proportionate reduction in marginal cost (from $C_i$ pre merger to $C_i^N$ post merger) for product $i = 1, 2$. Suppose that the price for firm 2, $P_2$, does not change after the merger. As an indication of the merger's possible unilateral adverse effects, Farrell and Shapiro (2010) note that, if the FOC is positive at pre-merger prices, then the merged firm can increase its profits by increasing the price of product 1. The difference between the post- and pre-merger FOCs on product 1 is $\frac{\partial \Pi_{1+2}}{\partial P_1} - \frac{\partial \Pi_1}{\partial P_1} = (P_2 - C_2)\frac{\partial Q_2}{\partial P_1} + E_1 C_1 \frac{\partial Q_1}{\partial P_1} + E_2 C_2 \frac{\partial Q_2}{\partial P_1} \geq 0$. The diversion ratio from firm 1 to firm 2, $D_{12} = [\partial Q_2/\partial P_1] / [-\partial Q_1/\partial P_1]$, becomes apparent by dividing by $-\partial Q_1/\partial P_1$. Hence, given that the price for product 2 remains the same, there are incentives to raise the price for product 1 after the merger as long as

$$(P_2 - C_2) D_{12} + E_2 C_2 D_{12} - E_1 C_1 \geq 0. \tag{1}$$

But Farrell and Shapiro (2010), p.11-12, note that in inequality (1), 'greater default efficiencies for product 2 cause more upward pricing pressure for product 1 (...) While this is technically correct, it has the unattractive property that it seemingly could flag a merger for further scrutiny because of credited efficiencies.' In other words, measuring the upward pricing pressure for product 1 according to (1) would boil down to an efficiency penalty, since efficiencies on product 2 would provide incentives to raise price on product 1 through the higher value of diverted sales. Consequently, Farrell and Shapiro (2010) recommend instead applying a simpler formula which avoids this criticism by ignoring efficiencies on product 2.[14] The UPP measure actually proposed thus becomes

$$UPP_1 = (P_2 - C_2)\, D_{12} - E_1 C_1 \geq 0. \tag{2}$$

Inequality (2) basically states the trade-off between downward pricing pressure from a lower marginal cost $E_1 C_1$, and the upward pricing pressure from the value of diverted sales to the other good $(P_2 - C_2)\, D_{12}$.[15] Inequality (2) captures the essence of all unilateral effects analysis: the greater the diversion ratios between the merging parties, the greater the markups, and the smaller the efficiencies on the product being considered, the more likely the price increase.

In addition, if no efficiency credit is granted for the product considered, another, even simpler measure of the adverse unilateral effect may be derived from (2): the Gross Upward Pricing Pressure Index (GUPPI), proposed by Salop and Moresi (2009). The GUPPI for product 1 is derived by setting $E_1 = 0$, and by using the relative price-cost margin, $\frac{P_2 - C_2}{P_2} = m_2$, it writes[16]

$$GUPPI_1 = m_2 D_{12} \frac{P_2}{P_1}. \tag{3}$$

## 2.2 The more accurate version

In Farrell and Shapiro's (2010) own words (p.12), their 'basic proposal is to flag for closer scrutiny mergers that generate upward pricing pressure'. Hence both UPP and GUPPI formulas above are only indicative, and not predictive of the merger's final price effect, because they are derived under the assumption that prices of all other products on the market are constant. Importantly, this assumption also covers the price of product 2, for

[14] As a result, this formulation of the UPP measure would not capture the full first order effect for a merged firm to increase price.

[15] The upward pricing pressure from the latter effect is explained in US Horizontal Merger Guidelines (2010): 'Adverse unilateral price effects can arise when the merger gives the merged entity an incentive to raise the price of a product previously sold by one merging firm and thereby divert sales to products previously sold by the other merging firm, boosting the profits on the latter products. Taking as given other prices and product offerings, that boost to profits is equal to the value to the merged firm of the sales diverted to those products. The value of sales diverted to a product is equal to the number of units diverted to that product multiplied by the margin between price and incremental cost on that product.' (p. 21)

[16] The GUPPI will always be positive if the insiders' products are substitutes. Thus, to use GUPPI for screening purposes, some threshold must be specified below which the merger does not lead to a substantial adverse unilateral efect.

which the merged firm may nevertheless reap some efficiencies. In particular, inequality (1) indicates that cost savings on product 2 raise the value of diverted sales from product 1 to product 2. Farrell and Shapiro (2010) call this a feedback effect, and note that it can be incorporated into the index of upward pricing pressure by making use of Werden's (1996) compensating marginal cost approach. Explicitly, by calculating the efficiencies for both products that keep simultaneously both prices constant (and thus make plausible the constant-price assumption), one can obtain a more accurate measure of the UPP for each of the products, which takes into account this feedback effect.[17] It can be shown (see the Appendix) that for product 1 this more accurate measure of the upward pricing pressure writes

$$\begin{aligned} \widehat{UPP}_1 &= (P_2 - C_2) D_{12} + (P_1 - C_1) D_{12} D_{21} - E_1 C_1 (1 - D_{12} D_{21}) \\ &= UPP_1 + (P_1 - C_1 (1 - E_1)) D_{12} D_{21} \geq 0 \end{aligned} \tag{4}$$

Importantly, condition (4) requires no more data than condition (2). The same holds for the modified GUPPI that is obtained by taking out the efficiency credit (see the Appendix):

$$\widehat{GUPPI}_1 = GUPPI_1 + D_{12} D_{21} m_1. \tag{5}$$

As long as diversion ratios are positive between the two products (which is the case with substitutable varieties), inequality (4) is more easily satisfied than inequality (2). Similarly, the value of (5) as a threshold triggering the screening of a merger is higher than (3). Farrell and Shapiro (2010) note that as a result, the version of the UPP they promote, i.e. inequality (2), can be considered as a conservative measure of the post-merger incentives for a unilateral price increase: it may underestimate the loss of competition from the merger, in particular when the diversion ratios are relatively high and mark-ups relatively low. In other words, screening mergers based on inequality (2) may *only* lead to false negatives. The point we wish to make in this paper is that this conclusion may not hold when the merger takes place on two-sided markets, for which using the simpler version of the UPP may also lead to false positives.

[17] See Neurohr (2019) for a formal derivation of the fact that Werden's (1996) compensating marginal cost reductions are actually an extension of GUPPIs that takes into account feedback effects between the merging firms' prices.

# 3 UPP in two-sided markets

## 3.1 Extending the basic version to two-sided firms

Let now each firm, 1 and 2, produce two products each, called product $A$ and product $R$. To fix ideas, think about this as two newspapers that have both advertisements and news content.[18] They sell advertisements to advertisers and the newspaper with content (and advertisements) to readers. Let superscript $R$ denote the reader side, and $A$ the advertiser side of the market. The simple approach in Farrell and Shapiro (2010) (as well as the US Horizontal Merger Guidelines) is to consider a possible price increase on the product sold by one of the two merging parties, assuming *all* other prices are constant. Explicitly, we discuss here the incentives for one of the firms, say firm 1, to change one of its prices, $P_1^R$ or $P_1^A$ after the merger, assuming the prices of the other firm remain constant, as well as its own other price ($P_1^A$ or $P_1^R$ respectively) - this is basically the approach in Affeldt et al. (2013). Furthermore, in line with the approach in Farrell and Shapiro (2010), we only allow for possible reductions in marginal costs for firm 1.

Let $\Pi_i = \sum_S \left(P_i^S - C_i^S\right) Q_i^S$ be the profit for firm $i$ before the merger, where superscript $S \in \{A, R\}$ indicates the side of the market. Then $\Pi_{1+2} = \sum_{i=1}^{2} \Pi_i + \sum_S E_1^S C_1^S Q_1^S$ is the joint profit after the merger. Analogous to the one-sided market analysis, there will be a upward pressure on the price for firm 1's product on side $R$, $P_1^R$, as long as $\frac{\partial \Pi_{1+2}}{\partial P_1^R} - \frac{\partial \Pi_1}{\partial P_1^R} \geq 0$, or as long as $\left(P_2^R - C_2^R\right) \frac{\partial Q_2^R}{\partial P_1^R} + \left(P_2^A - C_2^A\right) \frac{\partial Q_2^A}{\partial P_1^R} + E_1^R C_1^R \frac{\partial Q_1^R}{\partial P_1^R} + E_1^A C_1^A \frac{\partial Q_1^A}{\partial P_1^R} \geq 0$. Dividing by $-\partial Q_1^R / \partial P_1^R > 0$ one obtains

$$UPP_1^R = \left(P_2^R - C_2^R\right) D_{12}^{RR} - E_1^R C_1^R + \left(P_2^A - C_2^A\right) D_{12}^{RA} + E_1^A C_1^A D_{11}^{RA} \geq 0, \qquad (6)$$

which is expression (9) in Affeldt et al. (2013). The equivalent condition for side $A$ is

$$UPP_1^A = \left(P_2^A - C_2^A\right) D_{12}^{AA} - E_1^A C_1^A + \left(P_2^R - C_2^R\right) D_{12}^{AR} + E_1^R C_1^R D_{11}^{AR} \geq 0, \qquad (7)$$

which is expression (8) in Affeldt et al. (2013). Ignoring efficiencies for both products (or sides) of firm 1, and using the relative margins $m_2^A = \frac{P_2^A - C_2^A}{P_2^A}$ and $m_2^R = \frac{P_2^R - C_2^R}{P_2^R}$, we obtain

[18] Alternatively, we could think of this as an online platform with users (instead of readers) and advertisers.

the corresponding GUPPIs:

$$GUPPI_1^R = m_2^R \frac{P_2^R}{P_1^R} D_{12}^{RR} + m_2^A \frac{P_2^A}{P_1^R} D_{12}^{RA} \tag{8}$$

and

$$GUPPI_1^A = m_2^A \frac{P_2^A}{P_1^A} D_{12}^{AA} + m_2^R \frac{P_2^R}{P_1^A} D_{12}^{AR} \tag{9}$$

respectively.[19] The first term in each of these expressions is simply the 'standard' one-sided market GUPPI measure, whereas the second term is a cross-side effect induced by the indirect externality (see below).

Before comparing the two-sided UPPs to the one-sided expressions, it is useful to start by listing the effects of a price increase on two-sided markets. Changes in both $P_1^R$ and $P_1^A$ will affect firm 2 in both markets, readers and advertisers. An increase in $P_1^R$ will shift some readers of firms 1 to firm 2, which will make the latter more appealing to advertisers, hence an additional shift from firm 1 to firm 2, of advertisers. If readers dislike/like ads, this will trigger some readers switching to/from firm 1 from/to firm 2. In other words, the indirect network effects create some cross-side effects following a price increase on two-sided markets, which add up to the 'standard' demand effects triggered on the same side, as in one-sided situations.

Turning now to inequality (6) for instance, let us explain the trade-off behind the UPP measure. The incentive to raise price for firm 1 on side $R$ basically comes from the value of diverted sales to firm 2 on the same side: the first term in condition (6), $\left(P_2^R - C_2^R\right) D_{12}^{RR}$. This upward pricing pressure is mitigated by the merger-related synergies on the same side, hence a downward pricing pressure from the second term in condition (6), $-E_1^R C_1^R$. These two opposite effects are standard in one-sided markets. Note however that on two-sided markets it is often the case that firms set prices below cost on one side (say, the readers side) to reap the highest possible return on the other side (the advertisers' side) through the indirect network externality. In other words, it is possible that the first term of (6) may actually be negative, indicating a downward pricing pressure. This is completely opposite from the one-sided framework.

The last two terms in inequality (6) capture effects which are specific to the two-sided framework, due to the indirect externality. $\left(P_2^A - C_2^A\right) D_{12}^{RA}$ is the value of diverted sales

[19] These are denoted as $GUPPI_1^{R+}$ and $GUPPI_1^{A+}$ in Affeldt et al. (2013).

from firm 1 to firm 2 on the advertising side due to a price raise of firm 1 on the reader side, for which the diversion ratio $D_{12}^{RA}$ captures the proportion of advertisers that switch to firm 2 because firm 1 ends up with fewer readers. Assuming a positive margin, this effect may either strengthen or weaken the same-side upward pricing pressure, i.e. $\left(P_2^R - C_2^R\right) D_{12}^{RR}$, depending on the sign of the network externality and hence of the diversion ratio. In the case of newspapers for instance, $D_{12}^{RA}$ is likely to be positive, but this need not be generally the case. This is an additional, cross-side effect, not present in one-sided markets. Note furthermore that, with a positive diversion ratio $D_{12}^{RA}$, a negative margin on the opposite side (here, side $A$) can lead to a downward pricing pressure on the side under consideration (side $R$).

The last term in condition (6), $E_1^A C_1^A D_{11}^{RA}$, is the synergy effect for firm 1 on the opposite side (side $A$) due to the change in the number of advertisers following an increase in reader price. For our newspaper market example this effect likely induces a downward pricing pressure for $P_1^R$: advertising cost savings, $E_1^A C_1^A$, lead to a higher margin on advertisers, and hence a higher opportunity cost of a price increase on the reader side (which would first reduce the number of readers but then also the demand from advertisers). To put it differently, the within-firm but across sides diversion ratio $D_{11}^{RA}$ is likely to be negative for newspaper markets, but again, this need not be the case in every two-sided market. Therefore this opposite-side synergy term may either weaken or strengthen the same-side downward pricing pressure from cost savings, $-E_1^R C_1^R$, depending once more on the sign of the diversion ratio.

To sum up so far, the incentive for upward pricing pressure on the reader side for firm 1 is therefore due to (i) the diversion of readers to firm 2 ($D_{12}^{RR}$), and (ii) the diversion of advertisers to firm 2 ($D_{12}^{RA}$). The first is a traditional same-side effect, while the latter is across the two sides of the market (a cross-side effect therefore).

Recall now that all the analysis behind the upward pricing pressure tests, i.e. (6) - (9) above, holds under the simplifying yet crucial assumption that *all* other prices are kept constant. To put it differently, inequality (6) for instance holds under the implicit assumption that firm 1 has enough cost savings on side $A$ to annihilate its incentive to raise $P_1^A$ post-merger. Otherwise, i.e. if firm 1 really made a higher post-merger margin on side $A$, it would have incentives to actually lower its price on side $R$ as long as there is a positive effect of readership on the demand of advertisers, so as to increase circulation and thereby the return from the higher margin on side $A$ (see the discussion above on the last term of condition (6)). In other words, the upward pricing pressure on side $R$ will be overestimated as soon as one implicitly assumes that firm 1 enjoys enough merger synergies on side $A$ to make credible the lack of incentives to change its price on that side, but without explicitly taking it into account. This was not the case in the one-sided framework, where the 'simpler' version of the UPP was always a conservative, or underestimating, index.

Below we propose to adapt for two-sided markets the modified version of the UPP (and GUPPI) developed by Farrell and Shapiro (2010). For this we employ, by the same token, the compensating marginal cost approach of Werden (1996). In so doing we incorporate into the pricing pressure index for one side the incentives of the same firm to change its price on the other side. We propose to call this within-firm across-sides effect a *rebalancing*[20] effect, to distinguish it from the feedback effect mentioned by Farrell and Shapiro (2010) when taking into account the cost savings of the other insider, and also from the cross-side effect already present in the UPP measure of Affeldt et al. (2013) (i.e. the third term of (6)).[21] In what follows we also explain why the 'simpler' versions considered so far (expressions (6) - (9)) may either understate or overstate the post-merger upward pricing pressure. Note that in the latter case this would mean type I errors, i.e. situations where competition agencies waste resources investigating mergers that should have been cleared at an earlier stage.

## 3.2 Incorporating rebalancing effects for two-sided platforms

To capture the rebalancing effect between firm 1's products, consider the hypothetical efficiency gains that are required to keep the price of firm 1 from rising after the merger on the opposite side, all else equal. Explicitly, we look for $\widehat{E}_1^S$, $S = A, R$ that solves $UPP_1^S = 0$, and then we substitute $\widehat{E}_1^A$ for $E_1^A$ in (6), and $\widehat{E}_1^R$ for $E_1^R$ in (7). We then eventually obtain (see the Appendix) the modified expressions for the upward pricing

[20]The 2018 OECD report "Rethinking Antitrust Tools for Multi-Sided Platforms" labels as 'rebalancing' this effect that we point out. We opt to keep this terminology.

[21]Note that in terms of vocabulary, Affeldt et al. (2013) label as feedback effects what we call here cross-side effects.

pressure for each side:

$$\widehat{UPP}_1^R = \left(P_2^R - C_2^R\right)\left(D_{12}^{RR} + D_{11}^{RA} D_{12}^{AR}\right) - E_1^R C_1^R \left(1 - D_{11}^{RA} D_{11}^{AR}\right) \\ + (P_2^A - C_2^A)\left(D_{12}^{RA} + D_{11}^{RA} D_{12}^{AA}\right) \quad (10)$$

and

$$\widehat{UPP}_1^A = \left(P_2^A - C_2^A\right)\left(D_{12}^{AA} + D_{11}^{AR} D_{12}^{RA}\right) - E_1^A C_1^A \left(1 - D_{11}^{AR} D_{11}^{RA}\right) \\ + \left(P_2^R - C_2^R\right)\left(D_{12}^{AR} + D_{11}^{AR} D_{12}^{RR}\right) \quad (11)$$

respectively. We can now see that the 'simpler' versions of the UPP for two-sided markets derived by Affeldt et al. (2013) can scale both up and down the modified UPPs, depending on the sign of the within-firm but across-side diversion ratios. In our newspaper market example, advertisers typically benefit from facing more readers, i.e. $D_{11}^{RA} < 0$, whereas readers may either like or dislike ads, $D_{11}^{AR} \lesseqgtr 0$. So the difference between their UPP index and ours can go one way on one side of the market, but the opposite way on the other side of the market. Furthermore, the difference also depends on the price incentives of the same firm on the opposite side. Hence, to better assess a platform's pricing incentives on one side, one should look at both sides.

To further examine this modified version of the pricing pressure measures, let us consider next the corresponding modified GUPPIs (denoted $\widehat{GUPPI}_1^R$ and $\widehat{GUPPI}_1^A$). These are obtained by taking out the efficiency credits from conditions (10) and (11) respectively, and dividing by the corresponding price (see the Appendix):

$$\widehat{GUPPI}_1^R = m_2^R \frac{P_2^R}{P_1^R}\left(D_{12}^{RR} + D_{11}^{RA} D_{12}^{AR}\right) + m_2^A \frac{P_2^A}{P_1^R}\left(D_{12}^{RA} + D_{11}^{RA} D_{12}^{AA}\right) \quad (12)$$

and

$$\widehat{GUPPI}_1^A = m_2^A \frac{P_2^A}{P_1^A}\left(D_{12}^{AA} + D_{11}^{AR} D_{12}^{RA}\right) + m_2^R \frac{P_2^R}{P_1^A}\left(D_{12}^{AR} + D_{11}^{AR} D_{12}^{RR}\right). \quad (13)$$

The indices (12) and (13) are the result of the following thought experiment: Suppose that absent any price change on side $R$ [$A$], there is no incentive for firm 1 to change its price on side $A$ [$R$] after the merger. This has to mean that firm 1's efficiency on side $A$ is large enough to counter any incentive to increase the price on that side. Taking this efficiency into account, what are firm 1's incentives for a price change on side $R$, gross of any efficiencies on that side, and holding constant the prices and costs for firm 2?

To seize the implications of flagging mergers for deeper scrutiny based on the modified indexes, we can check how ignoring the rebalancing effect modifies the GUPPI for each side. For this we can subtract $\widehat{GUPPI}_1^S$ from $GUPPI_1^S$, to obtain

$$\Delta_1^R = -D_{11}^{RA}\left[m_2^R\frac{P_2^R}{P_1^R}D_{12}^{AR} + m_2^A\frac{P_2^A}{P_1^R}D_{12}^{AA}\right] \tag{14}$$

for side $R$ and

$$\Delta_1^A = -D_{11}^{AR}\left[m_2^A\frac{P_2^A}{P_1^A}D_{12}^{RA} + m_2^R\frac{P_2^R}{P_1^A}D_{12}^{RR}\right] \tag{15}$$

for side $A$. $\Delta_1^S, S = A, R$ is the above mentioned difference, i.e. the amount by which the simpler GUPPI measures that neglect the rebalancing effects, i.e. (8) and (9) respectively, overstate or understate the pricing pressure on side $S$.

The intuition for the difference between the GUPPIs proposed here, and the ones proposed by Affeldt *et al.* (2013), is the following. When Affeldt *et al.* (2013) calculate the pricing pressure on the reader side for a given platform, they do not take into account that the merger may also cause higher margins on the advertising side for the same platform, which is not unreasonable to assume, given that the media firms are rivals (i.e., $D_{12}^{AA} > 0$). Hence, if we assume that firm 1 does not change its price on the advertising side, then the implicit assumption which is made is that there are efficiencies for firm 1 on side $A$ that are large enough to counteract any price increase, i.e. $E_1^A C_1^A > 0$. As a result, whether we assume a price increase on side $A$ or not, the implication is that margins are higher on side $A$ after the merger, as long as $E_1^R = 0$ and $D_{12}^{AA} > 0$. This is not taken into account in eq. (8). Higher margins on side $A$ imply that firm 1 should reduce its price on side $R$, as long as there is a positive effect of readership on advertising demand. Hence, in that case the price effect in (8) may overstate the incentive to increase the price, as indicated by (14).[22]

To better seize this result, it is useful to give an example. Suppose advertisers benefit from having more readers, so that $D_{11}^{RA} < 0$. If readers are largely unaffected by advertising (which some studies seem to indicate[23]), then we expect that $D_{11}^{AR} = D_{12}^{AR} = 0$.

[22]Note that the rebalancing effects we highlight are only partial, to the extent that we have not allowed for changes in firm's 2 prices. Typically, with a positive externality from side $R$ to side $A$, one would expect an increase in firm's 2 price on side $A$ to trigger a downward pressure on the prices of both 1 and 2 on side $R$.

[23]For instance, Argentesi and Filistrucchi (2007), van Cayselee and Vanormelingen (2019) and Fan

We are then left with $\Delta_1^R = -m_2^A D_{11}^{RA} \frac{P_2^A}{P_1^R} D_{12}^{AA} > 0$ and $\Delta_1^A = 0$. Hence, in this case our GUPPI measure and the measure of Affeldt *et al.* (2013) predict the same pricing pressure on side $A$, while our measure predicts a weaker pricing pressure than Affeldt *et al.* (2013) on side $R$, given that the value of diverted sales $(P_2^A - C_2^A)D_{12}^{AA}$ is strictly positive on side $A$. On the other hand, if readers enjoy advertisements[24], then we have both $D_{11}^{RA} < 0$ and $D_{11}^{AR} < 0$, while $D_{12}^{AR} \geq 0$ and $D_{12}^{RA} \geq 0$. In this case our measures predict a weaker pricing pressure than Affeldt *et al.* (2013) on *both* sides of the market. Finally, if readers dislike ads[25], then $D_{11}^{AR} > 0$ while $D_{12}^{AR} \leq 0$. In this case we may find that our GUPPI measure predicts a weaker pressure on side $R$, assuming of course that $\left(P_2^R - C_2^R\right) D_{12}^{AR} + \left(P_2^A - C_2^A\right) D_{12}^{AA} > 0$, while our measure predicts a stronger pricing pressure on side $A$, both compared to the measures of Affeldt *et al.* (2013). The following table summarizes this insight (assuming $P_i^S - C_i^S > 0$ for both $i \in \{1, 2\}$ and $S \in \{A, R\}$):

| (advertisers prefer more readers, $D_{11}^{RA} < 0$) | $\Delta_1^R$ | $\Delta_1^A$ |
|---|---|---|
| readers indifferent to ads ($D_{11}^{AR} = D_{12}^{AR} = 0$) | + | 0 |
| readers like ads ($D_{11}^{AR} < 0, D_{12}^{AR} \geq 0$) | + | + |
| readers dislike ads ($D_{11}^{AR} > 0, D_{12}^{AR} \leq 0$) | + | − |

Notice that as long as the network externality from readers to advertisers is positive, ignoring the rebalancing effect causes us to consistently predict a stronger pricing pressure on the side causing the network externality (the readers side), compared to when we incorporate the rebalancing effect.

To get a sense of what the potential difference may be in practice between our indices and the indices presented in Affeldt et al. (2018), we provide below a comparison based on the data for the hypothetical newspaper merger presented in Affeldt et al. (2013, 2018):

(2013) find no effect of advertising on the sales of daily newspapers in Italy, Belgium and the US respectively.

[24] Kaiser and Song (2009) for instance report that readers of magazines do not dislike advertising, and may even like it depending on the type of magazine.

[25] It would appear that ads are mainly disliked when they are not targeted and cannot be avoided, as it is rather the case for TV and radio - see for instance Wilbur (2008).

Comparison table

| | GUPPIs without rebalancing | GUPPIs with rebalancing | difference |
|---|---|---|---|
| Advertising: 1st firm with newspapers... | | | |
| AD1 | 0.0017 | 0.0002 | 0.0015 |
| NRC | 0.0029 | 0.0003 | 0.0026 |
| NRN | 0.0020 | 0.0003 | 0.0017 |
| PAR | 0.0037 | 0.0003 | 0.0034 |
| TRO | 0.0031 | 0.0003 | 0.0028 |
| VOL | 0.0036 | 0.0002 | 0.0034 |
| ...merging with 2nd firm with newspapers... | | | |
| GOO | 0.0065 | 0.0006 | 0.0059 |
| HAR | 0.0039 | 0.0004 | 0.0035 |
| LEI | 0.0024 | 0.0001 | 0.0023 |
| NOR | 0.0038 | 0.0005 | 0.0033 |
| TEL | 0.0063 | 0.0001 | 0.0062 |
| Subscriptions: 1st firm with newspapers... | | | |
| AD1 | 0.0315 | 0.0311 | 0.0004 |
| NRC | 0.0362 | 0.0357 | 0.0005 |
| NRN | 0.0508 | 0.0506 | 0.0002 |
| PAR | 0.0573 | 0.0565 | 0.0008 |
| TRO | 0.0375 | 0.0372 | 0.0003 |
| VOL | 0.0442 | 0.0436 | 0.0006 |
| ...merging with 2nd firm with newspapers... | | | |
| GOO | 0.0773 | 0.0761 | 0.0012 |
| HAR | 0.0684 | 0.0670 | 0.0014 |
| LEI | 0.0684 | 0.0673 | 0.0011 |
| NOR | 0.0393 | 0.0386 | 0.0007 |
| TEL | 0.0620 | 0.0601 | 0.0019 |

The comparison table[26] shows that the differences, (14) and (15), are positive for the hypothetical merger presented in Affeldt et al. (2013), and our modified indices, (12) and (13), are more conservative due to the rebalancing effects. However, the differences

[26] The Matlab code that generates the values of the differences based on the data in Affeldt et al. (2013) is available upon request.

between the GUPPIs with and without rebalancing effects appear to be quite small in absolute terms - although they are often comparable in size to the simpler, unbalancing GUPPIs of Affeldt et al. (2018).[27] This is likely due to the values of the inter-firm diversion ratios, $D_{ij}^{AA}$, $D_{ij}^{AR}$, $D_{ij}^{RR}$ and $D_{ij}^{RA}$, which are very small (zero or close to zero in many cases) in the data set used, probably because of the assumption made by Affeldt et al. (2013), that the advertising demands only depend on own prices (for ads) and own circulation.[28] This assumptions essentially assumes away any direct substitution (by advertisers) between newspapers when the prices for ads change – only indirectly through the effects on circulation. In a different context the biases may of course turn out to be more substantial, such as for instance with (much) stronger (and still positive) cross-side externalities.

Merger investigations generally involve quite substantial costs for competition authorities, so it would be best to have an initial screening test based on a conservative estimate for the likely price effects of the merger, i.e. providing a lower benchmark for them. Such a screening device would avoid flagging for further scrutiny mergers that are unlikely to raise competitive concerns, i.e. waste the agency's budget on Type I errors. We argue that the modified GUPPIs that we propose are likely to be more conservative than the simpler versions that ignore the rebalancing effects between the two sides. However, we cannot rule out situations where for example we would have $\Delta_1^R > 0$ and $\Delta_1^A < 0$, i.e. where the original test is less conservative on one side but more conservative on the other. For these cases, one obvious solution would be to use the most conservative test on each side, whatever it turns out to be – for instance, using $\widehat{GUPPI}_1^R$ on side $R$ and $GUPPI_1^A$ on side $A$.

Note also that our results are also relevant for the case of multi-product firms. To see this, one could to re-interpret the two-sided platforms as two multi-product firms each selling two products, say $R_1$ and $A_1$ (for firm 1), and $R_2$ and $A_2$ (for firm 2). Our approach shows that the 'simpler' indices (without rebalancing effects) are then more conservative than indices that take the rebalancing effects into account, given that all four products are substitutes. However, the opposite may be true when some of the products are complements, e.g., if products $R_1$ and $A_1$ are complements, and similarly $R_2$ and $A_2$ are complements (similar to the newspaper market we considered): then the

[27]For illustrative purposes, the values reported in the comparison table exhibit four decimal digits and not only two, as in Affeldt et al. (2013, 2018).

[28]See also footnote 19 on page F517 in Affeldt et al. (2013).

indices without the rebalancing effects may overstate the incentives to increase prices.

Finally, note that the modified indices that we propose require no additional information as compared with that required by the indices computed by Affeldt et al. (2013, 2018), but rather a more thorough exploitation of the available data.[29] Indeed, in order to fully take into account the interaction between the two sides, it is necessary to estimate three types of diversion ratios: across products on each side of the market ($D_{12}^{RR}$ and $D_{12}^{AA}$ in our newspaper market example), across products and sides ($D_{12}^{AR}$ and $D_{21}^{RA}$) and finally, within the same firm but across sides ($D_{11}^{AR}$ and $D_{11}^{RA}$). Estimates for these diversion ratios can be obtained by means of market survey data from the different customer groups, but on both sides of the market. We will argue that this is not a problem, as competition authorities are normally required to perform screening tests on *both* sides of the market anyway. The data should therefore already be collected. However, the surveys would need to be quite comprehensive: as Affeldt at el. (2013) note, it is necessary to ask the different customer groups not only how they would react to a price change, but also what their reaction would be to a participation change on the other side.

# 4 Some concluding remarks

The upward pricing pressure analysis has been applied in many merger cases recently, and competition agencies receive increasing numbers of two-sided merger submissions. It is therefore potentially very important to adapt the UPP methodology to two-sided markets. The approach proposed by Affeldt et al. (2013) enables to capture cross-side effects, such that higher reader prices for one merging party leads to diversion of advertisers – in addition to the traditional one-sided diversion of readers – to the other merging party. However, their approach neglects what we call here the rebalancing effect: a price change on one side of the market feeding back into the optimal pricing on the opposite side of the market. We show that by ignoring these rebalancing effects the indices suggested by Affeldt et al. (2013) may overstate the firms' incentives to increase prices. Therefore, using UPP indices for two-sided markets without rebalancing effects can flag for further scrutiny mergers that are actually unlikely to raise prices. We show instead that the

[29] More precisely, both our UPPs and GUPPIs need the within-firm across-side diversion ratios, whereas Affeldt. et al. (2013) only need them for their UPP measure. By the same token, to calculate our $\widehat{GUPPI}_1^R$, we need the information required to calculate both $GUPPI_1^R$ and $GUPPI_1^A$.

rebalancing effect could reverse the potential upward pricing pressure on the initial side. As a result, a merger leading to a price increase on one side of the market may lead to a price reduction on the other side, even if there are no efficiencies on that side and margins are non-negative.

This can be very relevant for mergers in, for example, the newspaper industry. Empirical studies indicate that there is a positive externality from reader to advertisers: more readers will increase the demand for advertising, quite obviously.[30] However, there is no consensus on the existence of a positive or negative externality the opposite way: readers may not care much about, or even dislike, advertising.[31] Given this, the most important rebalancing effect would be from readers to advertisers. As a result, with higher prices on the advertising side of the market after the merger, there is actually a potential for a downward pricing pressure on the reader side of the market.

A similar mechanism can be present following a merger between two competing online platforms. If the main externality is from users to advertisers – more users makes the platform more attractive for the advertisers – then a merger might lead to a downward pressure on the user prices. If prices are not flexible, so that users have access to the platform for free, what we label a downward pressure on prices can lead to an investment in higher quality of the platform. The point is that the rebalancing effect makes it more valuable for the platform to attract more users after the merger. More users can be attracted to the platform either by lowering the user payment, or increasing the quality of the platform. For these reasons we argue that competition authorities should be careful about ignoring rebalancing effects in two-sided markets, as this could lead to type I errors, i.e., situations where the competition authorities waste time and resources on in-depth investigations of mergers that should have been cleared at an earlier stage.

A further implication for the practice of competition agencies is that in order to

[30] See for instance Kaiser and Wright (2006) and Kaiser and Song (2009) for evidence that advertising increases readers demand for magazines in Germany

[31] Sonnac (2000) provides empirical evidence on the effects of advertising, and finds that the effect of advertising on readers depends on the type of media and on the country. More importantly, agencies sometimes explicitly ignored that the level of advertising in a newspaper might affect demand from readers - see for example the 2002 decision of the French Competition Council in Socpresse/Groupe Express-Expansion (available at http://www.bercy.gouv.fr/fonds_documentaire/dgccrf/boccrf/04_01/a0010008.htm), that of the U.K. Competition Commission in Regional Independent Media Ltd and Gannett Ltd/Johnston Press plc/Guardian Media Group in 2000 (Case No. 447, Competition Commission ) and the 2006 decision concerning Springer and ProSieben/Sat where the Bundeskartellamt did not take into account that TV viewers might dislike advertising (Axel Springer AG & ProSiebenSat.1 Media AG, Case No. B 6 - 92202 - Fa – 103/05).

properly assess the incentives for a price increase on one side, it is necessary to account for the full, two-sided impact of that price raise. This conclusion is best understood in the context of the debate on antitrust decisions for platforms revived and partially settled by the American Express SCOTUS case. Basically, the SCOTUS had to decide whether the appropriate antitrust analytical framework for platforms was the separate or rather the integrated markets approaches. According to the former, the two sides of a platform should be defined as two relevant markets, and hence the competitive assessment would also follow this distinction. The integrated approach in contrast focuses on the cross-group externalities and concludes that a proper competitive effects analysis must include all sides of the platform. SCOTUS held in the AmEx case that the latter approach should be applied for transaction platforms (such as payment cards), while leaving the question unanswered for non-transaction platforms (advertising platforms such as online search engines and newspapers). Albeit dealing with an alleged anticompetitive conduct and not a merger, the SCOTUS recognition that in some cases it takes looking to both sides of a market to properly evaluate the competitive harm will likely open the door to a similar argument for platform mergers. Our analysis of the UPP measure for two-sided markets does not rely on the distinction between transaction and non-transaction markets, and provides support for the concept that incentives on parties' pricing on *both* sides must be taken into account when assessing a merger's impact on any one side of the market.

The main take-away from our analysis is that the existing UPP approach in two-sided markets may overstate the incentive to increase prices on one side if the incentive to adjust margins on the opposite side is not taken into account. Arguably, the rebalancing effects we highlight from one side of the market to the other are only partial, so just like the approach of Affeldt et al. (2013), ours cannot be deemed a fully accurate assessment of the pricing pressure. As a matter of fact it would be of interest to analyze how our extended UPP approach compares to a full-fledged merger simulation. This comparison of the UPP approach to a full-fledged merger simulation is done in one-sided markets (see, for example, Miller et al. 2017, or Dutra and Sabarwal, 2020). We leave to future research to do the same for two-sided markets.

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# 5 Appendix

## 5.1 One-sided framework

From (1) one obtains the amount of efficiencies $\widehat{E}_1$ that keep constant $P_1$, all else constant: $\widehat{E}_1 = \frac{P_2 - C_2}{C1} D_{12} + E_2 \frac{C_2}{C_1} D_{12}$.

From the similar condition to (1) holding for product 2, i.e. $(P_1 - C_1) D_{21} + E_1 C_1 D_{21} - E_2 C_2 \geq 0$, we get the efficiencies $\widehat{E}_2$ that keep constant $P_2$, all else constant: $\widehat{E}_2 = \frac{P_1 - C_1}{C_2} D_{21} + E_1 \frac{C_1}{C_2} D_{21}$.

Substituting $\widehat{E}_2$ for $E_2$ in (1) and $\widehat{E}_1$ for $E_1$ in the similar condition to (1) holding for product 2, we obtain that there is an UPP on product 1 as soon as $(P_2 - C_2) D_{12} - E_1 C_1 + (P_1 - C_1 (1 - E_1)) D_{12} D_{21} \geq 0$, which can be rewriten as (4).

By setting $E_1 = 0$ and dividing then by $P_1$ we get $\frac{P_2 - C_2}{P_2} D_{12} \frac{P_2}{P_1} + \frac{P_1 - C_1}{P_1} D_{12} D_{21} = m_2 D_{12} \frac{P_2}{P_1} + m_1 D_{12} D_{21} = \widehat{GUPPI}_1$.

## 5.2 Two-sided framework

Solving $UPP_1^R = 0$ for $E_1^R$ yields

$$\widehat{E}_1^R = \frac{\left(P_2^R - C_2^R\right) D_{12}^{RR} + \left(P_2^A - C_2^A\right) D_{12}^{RA} + E_1^A C_1^A D_{11}^{RA}}{C_1^R}.$$

Solving $UPP_1^A = 0$ for $E_1^A$ yields

$$\widehat{E}_1^A = \frac{\left(P_2^R - C_2^R\right) D_{12}^{AR} + \left(P_2^A - C_2^A\right) D_{12}^{AA} + E_1^R C_1^R D_{11}^{AR}}{C_1^A}.$$

Substituting $\widehat{E}_1^A$ for $E_1^A$ in (6), and $\widehat{E}_1^R$ for $E_1^R$ in (7), and rearranging, yields (10) and (11).

The corresponding modified GUPPIs are obtained first by taking out the efficiency credits for firm 1 on both sides from the UPP expressions, i.e., set $E_1^R = 0$ in (10) and set $E_1^A = 0$ in (11). Second we divide through by the price, $P_1^R$ in (10) and $P_1^A$ in (11) to obtain the expressions (12) and (13).

CRediT authorship contribution statement

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