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Unilateral Price Effects And Vertical Relations Between Merging And Non-Merging Firms

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Prosjektet har mottatt midler fra det alminnelige prisreguleringsfondet.

Unilateral Price Effects And Vertical Relations Between Merging And Non-Merging Firms*

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Abstract

Mergers sometimes affect vertical relations between merging and non-merging firms. Vertically integrated non-merging firms may, for instance, lose input sales to a downstream rival if the downstream rival is merged with another vertically integrated firm. Thus, price responses from non-merging firms could go in the opposite direction to those of the merging parties. Consequently, estimates of unilateral price effects that do not account for these structural changes are incorrect. We extend the standard framework of unilateral price effects of horizontal mergers with linear demand to account for changes in vertical relations between merging and non-merging firms.

JEL classification: L11, L13, L42

Keywords: Merger analysis, antitrust, unilateral effects, vertical relations

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1 Introduction

In recent years, measures using pre-merger margins and diversion ratios, a measure of differentiation,[1] have been important tools for assessing unilateral effects of horizontal mergers. Upward Pricing Pressure (UPP) and Gross Upward Pricing Pressure Index (GUPPI) (Salop and Moresi, 2009; Farrell and Shapiro, 2010), which are directional measures applied to each merging firm, are now standard tools used by competition authorities to analyze the merging parties' incentives to raise prices. In addition, post-merger equilibrium prices can be estimated by assuming linear demand using the same information as with UPP/GUPPI (Hausman et al., 2011).

These measures of price effects may be incorrect if vertical relations are affected and not controlled for (Moresi and Salop, 2013; Asphjell et al., 2017). This is because sales of inputs can affect the extent to which vertically integrated firms compete over their rivals' customers. In fact, if a merger eliminates vertical relations between a merging and a non-merging firm, the response from the non-merging firm may go in the opposite direction to that of the merging firms.

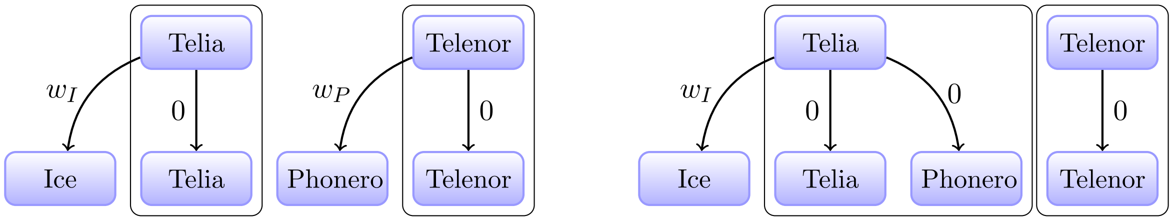
This paper expands the set of tools competition authorities and others use to screen and analyze unilateral effects from mergers. In this context, there are two main contributions: First, we integrate non-merging firms' responses from changes in vertical relations into Hausman et al.'s (2011) framework with linear demand. To the best of our knowledge, we are the first to formally incorporate responses from non-merging firms into a framework of unilateral price effects. Second, we extend the framework of linear demand to account for multiple price effects due to vertical relations previously analyzed in the literature. These effects include reduced competition between downstream merged firms and downstream rivals from sales of input (i.e., vGUPPId by Moresi and Salop (2013)) and mergers where an integrated firm acquires a downstream firm to which it sells inputs before the merger (as studied by Asphjell et al. (2017)).

Our contribution is of practical importance for screening mergers in markets containing a mix of vertically integrated firms and pure downstream retailers who buy inputs from vertically integrated wholesalers with whom they also compete downstream. There are several examples of this: In telecommunications, a few firms typically own the net-

[1] Formally, the diversion ratio from product 1 to product 2 is given by the share of reduced sales of product 1 that is transferred to product 2 a result of a price increase of product 1. A higher diversion ratio corresponds to the products being less differentiated.

work infrastructure or rights to spectrum, while other firms buy access to their competitors' network infrastructure.[2] In grocery markets, it is not uncommon that smaller retail chains have supply agreements with larger vertically integrated chains. Other examples include electronics,[3] web services,[4] and agriculture.[5] Thus, mergers in these markets may involve changes in vertical elements that could affect the incentives of both merging and non-merging firms.

The 2017 merger in the Norwegian mobile telecommunication market between Telia and Phonero is a good example of a horizontal merger that affected multiple vertical relations. Figure 1 provides a simplified illustration of the market structure before and after the Telia/Phonero merger.



(a) Before merger

(b) After merger

Figure 1: The Norwegian mobile telecommunication market before and after the Telia/Phonero merger. Nodes within a box indicate the same owner. Parameters on edges indicate variable input prices.

Before the merger, the market consisted of four major firms: Telia, Telenor, Phonero, and Ice. Telia and Telenor were vertically integrated mobile network operators (MNOs), whereas Phonero and Ice were mobile virtual network operators (MVNOs), i.e., wholesale customers renting access to Telenor's and Telia's respective networks (at assumed

[2] E.g., in telecommunications, mobile network operators (MNOs), firms who own their own cellular transmission infrastructure compete with "mobile virtual network operators" (MVNOs) or "service providers" (SPs) who buy access to the MNOs' networks.

[3] E.g., Apple uses chipsets and displays manufactured by Samsung in some of its phones. Thus, Samsung serves as a wholesaler for its downstream rival, Apple.

[4] E.g., the video-on-demand service Netflix uses Amazon's cloud computing platform. Amazon also competes with Netflix downstream with the service Amazon Prime Video.

[5] E.g., Montsanto (Bayer) sells seed traits to downstream rival seed companies.

constant unit prices w_P and w_I, respectively). After the merger, Phonero was integrated into Telia's network and stopped renting access to Telenor's network.

The merger resuted in counteracting effects on retail prices: (i) If Telia and Phonero lose customers, a share of these are recaptured by the other merging firm. This gives both Telia and Phonero incentives to increase prices. (ii) Phonero's marginal costs are reduced due to elimination of double marginalization (EDM) (from w_P to 0 in Figure 1). This efficiency gain gives Phonero incentives to reduce prices, as a higher margin is earned for each acquired customer. (iii) After the merger, customers diverted from Phonero to Ice increase sales of input for Telia upstream (revenue w_I for each diverted customer to Ice). This gives Phonero incentives to raise prices.[6] (iv) Before the merger, customers diverted from Telenor to Phonero increased sales of input upstream for Telenor (by w_P for each diverted customer). Elimination of this margin gives Telenor incentives to reduce prices.

Thus, the "first-round" price effect of the merger is positive for Telia, uncertain for Phonero, negative for Telenor, and neutral for Ice.[7] As feedback effects can be substantial, it is challenging to assess the net price effect from "first round" measures alone – both for each firm and in total. Our extension of Hausman et al. (2011) incorporates all these effects into the same system of linear equations to quantify post-merger equilibrium prices.

1.1 Related literature

This paper builds on the literature of Upward Pricing Pressure (UPP) and related literature on unilateral effects of mergers.

Shapiro (1996) was the first to propose using pre-merger margins and diversion ratios to assess horizontal mergers with differentiated products. The diversion ratio, which measures the share of sales lost for one product that is recaptured by another product when the price of the former rises, interacted with profit margins gives a measure of the incentive to raise prices following a merger. Werden (1996) formalized and extended this

[6] The effect corresponds to vGUPPId defined by Moresi and Salop (2013).

[7] In this paper, we assume exogenous wholesale prices. With endogenous wholesale prices, a potential fifth effect from the merger is the possibility of input foreclosure corresponding to vGUPPIu and vGUPPIr defined by Moresi and Salop (2013). I.e., Telia has incentives to increase the input price charged to Ice (w_I), which gives Ice incentives to increase retail prices. This incentive increases in the diversion from Ice to Phonero.

framework to measure the critical value of cost reductions required to restore pre-merger prices. O'Brien and Salop (2000) defined the "Price Pressure Index" (PPI). This index closely relates to the Upward Pricing Pressure (UPP) and Gross Upward Pricing Pressure Index (GUPPI) introduced by Farrell and Shapiro (2010) and Salop and Moresi (2009), respectively. Willig (2011) generalized this framework to account for quality-adjusted prices, output effects, and firms acquiring partial stakes in other firms.[8]

The UPP framework only provides a directional indication of price effects and does not capture equilibrium effects of mergers. Assuming linear demand, Hausman et al. (2011) derived a formula that solves the post-merger equilibrium prices for the merging firms. Further generalizations on among others pass-through and non-Bertrand conduct are provided by Jaffe and Weyl (2013).[9]

Vertical relations have been incorporated by Moresi and Salop (2013) and Asphjell et al. (2017). Moresi and Salop (2013) introduced the vGUPPI concept for vertical mergers, with three types of vGUPPIs: effects on input (wholesale) pricing incentives for the upstream firm to rivals (vGUPPIu), effects on output pricing incentives for downstream rivals due to increased input pricing (vGUPPIr), and effects on retail pricing incentives for the downstream merged firm due to increased input sales for the upstream firm to downstream rivals (vGUPPId).[10]

Asphjell et al. (2017) study unilateral price effects of a vertically integrated firm merging with a downstream rival to which it sells inputs before he merger. In that case, competition is partially internalized before the merger, as diverted sales to the downstream rival partially are recaptured by increased input sales. The authors adjust Hausman et al.'s (2011) formula to account for pre-merger internalized competition from vertical relations.

Our contribution to the literature is twofold: First, we incorporate price effects from non-merging firms due to changes in vertical relations. To the best of our knowledge,

[8]The "Price Pressure Index" (PPI) defined by O'Brien and Salop (2000), which closely relates to GUPPI, also quantifies competitive effects of partial ownership.

[9]Werden and Froeb (2011) provide an excellent overview and discussion over quantitative tools for assessing unilateral effects of horizontal mergers.

[10]As our framework assumes exogenous wholesale prices, the two former vGUPPI concepts are not incorporated into the model, whereas the vGUPPId effect is captured. In addition, our framework captures the pricing incentives of non-merging firms (rivals) from (merger-specific) changes in vertical relations.

we are the first to formally incorporate this price effect.[11] Second, we adjust Hausman et al.'s (2011) formula to account for unilateral effects from vertical relations previously highlighted in the literature.[12]

The remainder of the paper is structured as follows: Section 2 sets up the model. Section 3 solves the model and provides the price effects formula. Examples where our framework is applied is given in Section 4. Section 5 concludes.

2 Model

As in Hausman et al. (2011), we assume linear demand. Provided that firms set profit maximizing prices before the merger and are not coordinating, the slope of the demand curve can be calibrated from observed margins and quantities (or market shares). When demand is linear, slopes and diversion ratios remain constant if prices change, which allows us to combine pre- and post-merger first-order conditions when solving for post-merger prices.[13]

We treat post-merger wholesale prices as exogenous. This means that potential foreclosure effects are not included in the formula of post-merger prices.[14] Moreover, the calibration should only include wholesale prices that constitute marginal costs for the downstream firms. This means that, e.g., potential effects on fixed (non-variable) fees in two-part tariffs should not be accounted for, as changes in fixed costs do not affect retail pricing. Thus, the design of vertical agreements must be evaluated on a case-by-case basis. However, wholesale contracts with linear elements and input pricing exceeding marginal costs are indeed common.[15] Double marginalization may also be strategically

[11]Example 1 in Section 4 highlights this effect.

[12]Example 2 in Section 4 incorporates the vertical effects put forward by Moresi and Salop (2013) and Asphjell et al. (2017).

[13]Whereas linear demand is a strong assumption, it arguably serves as a reasonable approximation for small price changes. If the demand curve is concave (convex) at observed prices, assuming linear demand will overestimate (underestimate) a price reduction and underestimate (overestimate) a price increase. See also Froeb et al. (2005) for analyses on merger simulations and demand forms.

[14]See Moresi and Salop's (2013) analysis on foreclosure effects. Vertical agreements are often negotiated for a certain duration of time. Thus, in the short run, exogenous wholesale prices may be a reasonable approximation.

[15]E.g., it is well-known that double marginalization is present in mobile telecommunications. MVNOs (pure retailers) pay MNOs (network owners) substantial consumption-based fees for inputs that the MNOs produce at close to zero marginal cost.

imposed by the upstream firms to influence downstream rivals' retail prices (Moresi and Salop, 2013).

In what follows, we show how the formula for post-merger prices is derived. To do this, we first calibrate demand parameters based on pre-merger data (prices, marginal costs, variable input prices, diversion ratios, and market shares).[16] We then show how first-order conditions are affected by the merger and changes in vertical elements between firms, before pre- and post-merger first-order conditions are combined to give expressions for post-merger prices for each product.

2.1 Pre-merger

We consider a market with n single-product firms.[17] Before a merger or other structural changes between firms, the profit of Firm i is given by (parameters with superscript "0" are observed in the data before the merger):

$$\pi_i^0 = Q_i^0(p_i^0 - c_i^0 - \sum_{j \neq i}^{n} w_{ji}^0) + \sum_{j \neq i}^{n} Q_j^0(w_{ij}^0 - \gamma_{ij}^0),$$

where Q_i^0 is the quantity sold by Firm i, p_i^0 is the price, c_i^0 is the (constant) marginal cost, and w_{ji}^0 is the price of input that Firm i pays to Firm j.[18] Likewise, w_{ij}^0 is the price Firm i receives for each unit produced by Firm j and γ_{ij}^0 is the marginal cost of production for that input.

In the case with no vertical relations, i.e., $w_{ij}^0, \gamma_{ij}^0 = 0$ for all i, j, we have the standard setup for one-product firms applied by, among others, the European Commission. The special case of $n = 2$ with no vertical relations is the pre-merger situation by Hausman et al. (2011).

The first-order condition is given by:

$$Q_i^0 + \frac{\partial Q_i}{\partial p_i}(p_i^0 - c_i^0 - \sum_{j \neq i}^{n} w_{ji}^0) - \frac{\partial Q_i}{\partial p_i} \sum_{j \neq i}^{n} D_{ij}(w_{ij}^0 - \gamma_{ij}^0) = 0, \tag{1}$$

[16] Prices, costs, and margins are typically calibrated from accounting data. Input prices may, for instance, be calibrated using accounting data, contracts, or a combination of these. Diversion ratios may be estimated from customer transaction data, econometric analyses, or surveys.

[17] It is straightforward to extend the current framework to multiproduct firms. For a model framework of unilateral price effects with multi-product firms (without taking into account vertical relations), see, e.g., European Commission (2015), "Case M.7421 - Orange/Jazztel", Annex A, Section 2.

[18] E.g., if the wholesale price is characterized by a two-part tariff, only the variable part should be included.

where we have replaced cross-price derivatives and taken advantage of the definition of diversion ratios, as defined by Shapiro (1996) and Werden (1996):[19]

$$D_{ij} = -\frac{\partial Q_j}{\partial p_i} / \frac{\partial Q_i}{\partial p_i}. \tag{2}$$

Rewriting the first-order condition gives the slope of Firm i's demand as a function of parameters observed before the merger:

$$\frac{\partial Q_i}{\partial p_i} = \frac{-Q_i^0}{p_i^0 - c_i^0 - \sum_{j \neq i}^n w_{ji}^0 - \sum_{j \neq i}^n D_{ij}(w_{ij}^0 - \gamma_{ij}^0)}. \tag{3}$$

2.2 Post-merger

2.2.1 Merging firms

Without loss of generality, we assume a merger between Firm 1 and Firm 2. The profit of the merged entity is then:

$$\begin{aligned} \pi_1 + \pi_2 = Q_1(p_1 - c_1 - \sum_{j \neq 1}^n w_{j1}) + \sum_{j \neq 1}^n Q_j(w_{1j} - \gamma_{1j}) \\ + Q_2(p_2 - c_2 - \sum_{j \neq 2}^n w_{j2}) + \sum_{j \neq 2}^n Q_j(w_{2j} - \gamma_{2j}). \end{aligned}$$

Solving for the first-order condition of Firm 1 and replacing cross-price derivatives with the diversion ratio in equation (2) gives:

$$\begin{aligned} Q_1 + \frac{\partial Q_1}{\partial p_1}(p_1 - c_1 - \sum_{j \neq 1}^n w_{ji}) - \frac{\partial Q_1}{\partial p_1} \sum_{j \neq 1}^n D_{1j}(w_{1j} - \gamma_{1j}) \\ - \frac{\partial Q_1}{\partial p_1} D_{12}(p_2 - c_2 - \sum_{j \neq 2}^n w_{j2}) - \frac{\partial Q_1}{\partial p_1} \sum_{j \neq 2}^n D_{1j}(w_{2j} - \gamma_{2j}) = 0. \end{aligned} \tag{4}$$

The two last terms in the above equation capture two effects on prices from a merger. First, Firm 1 has an incentive to raise prices, as some of the reduced demand from a price increase is recaptured through diverted sales to Firm 2. Second, if Firm 2 has a wholesale margin on sales to non-merging firms downstream, Firm 1 has an additional incentive to raise prices, as some of the reduced demand from this price increase is diverted to Firm

[19] I.e., we have used the relationship $\partial Q_j/\partial p_i = -(\partial Q_i/\partial p_i)D_{ij}$.

2's wholesale customers. The second effect corresponds to vGUPPId defined by Moresi and Salop (2013).

To account for changes in parameters post-merger, we replace all post-merger parameters v_i with $v_i^0 + \Delta v_i$. We then combine equations (1) and (4) to obtain the price change of Firm 1:

$$\Delta p_1 = \frac{1}{2}\Bigg[\sum_{j\neq 1}^{n}[\frac{\partial Q_j}{\partial p_j}/\frac{\partial Q_1}{\partial p_1}]D_{j1}\Delta p_j + D_{12}\Delta p_2 + \Delta c_1 + \sum_{j\neq i}^{n}\Delta w_{j1} + \sum_{j\neq 1}^{n} D_{1j}(\Delta w_{1j} - \Delta\gamma_{1j})$$
$$+D_{12}(p_2^0 - c_2^0 - \Delta c_2 - \sum_{j\neq 2}^{n}(w_{j2}^0 + \Delta w_{j2})) + \sum_{j\neq 2}^{n} D_{1j}(w_{2j}^0 + \Delta w_{2j} - \gamma_{2j}^0 - \Delta\gamma_{2j})\Bigg], \tag{5}$$

where we have taken advantage of the following relation:[20]

$$Q_i - Q_i^0 = \frac{\partial Q_i}{\partial p_i}\Delta p_i - \sum_{j\neq i}^{n}\frac{\partial Q_j}{\partial p_j}D_{ji}\Delta p_j. \tag{6}$$

The price change of Firm 2, the other merging firm, has a symmetric expression to equation (5).

2.2.2 Non-merging firms

Non-merging firms react by changing their prices if (i) other firms change their prices and/or (ii) there are changes in the vertical relations between merging and non-merging firms, e.g., if one of the non-merging firms stops selling inputs to one of the merging firms.

Using equation (1) and accounting for changes in parameters and other firms' prices, it can be shown that the change in the price of a non-merging firm $i \neq 1, 2$ is given by:

$$\Delta p_i = \frac{1}{2}\Bigg[\sum_{i\neq j}^{n}[\frac{\partial Q_j}{\partial p_j}/\frac{\partial Q_i}{\partial p_i}]D_{ji}\Delta p_j + \Delta c_i + \sum_{j\neq i}^{n}\Delta w_{ji} + \sum_{j\neq i}^{n} D_{ij}(\Delta w_{ij} - \Delta\gamma_{ij})\Bigg]. \tag{7}$$

[20]For linear demand, the change in demand for Firm i is:

$$Q_i - Q_i^0 = \frac{\partial Q_i}{\partial p_i}\Delta p_i + \sum_{j\neq i}^{n}\frac{\partial Q_i}{\partial p_j}\Delta p_j.$$

The relation $\partial Q_i/\partial p_j = -(\partial Q_j/\partial p_j)D_{ji}$ yields equation (6).

3 Solving the model

Having obtained expressions for profit-maximizing changes in prices for merging and non-merging firms following the structural change(s) in equations (5) and (7), we can solve for the vector of price changes $\boldsymbol{\Delta p} = (\Delta p_1, \cdots, \Delta p_n)$ using standard linear algebra techniques.

For ease of notation, we define R_{ij} as Firm i's (non-cooperative) reaction to a change in Firm j's price. The reaction is given by the ratio of the slope of demand for products j and i (calibrated by equation (3)) interacted with the diversion ratio from j to i:

$$R_{ij} = [\frac{\partial Q_j}{\partial p_j} / \frac{\partial Q_i}{\partial p_i}] D_{ji}. \tag{8}$$

As merging firms maximize joint profits, they account for the effect on other merging firm's margin when "reacting" to the other merging firm's price change. Thus, if Firm i and j are merging, then Firm i's cooperative reaction to Firm j's price change is given by the expression:

$$R_{ij} + D_{ij}. \tag{9}$$

Matrix $\boldsymbol{A}$ represents the reaction of each firm to price changes of other firms. The first two rows represent the merging firms (1 and 2), while rows 3 to n represent the non-merging firms.

$$\boldsymbol{A} = \begin{pmatrix} 2 & -(R_{12} + D_{12}) & -R_{13} & \cdots & -R_{1n} \\ -(R_{21} + D_{21}) & 2 & -R_{23} & \cdots & -R_{2n} \\ -R_{31} & -R_{32} & 2 & \dots & -R_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ -R_{n1} & -R_{n2} & -R_{n3} & \cdots & 2 \end{pmatrix} \tag{10}$$

The $n \times 1$ column vector $\boldsymbol{b}_1$ represents exogenous changes in parameters like costs (e.g., elimination of double marginalization) and vertical ties, which are not directly associated with the internalization of competition between Firms 1 and 2:[21]

$$\boldsymbol{b_1} = \begin{pmatrix} \Delta c_1 + \sum_{j \neq i}^{n} \Delta w_{j1} + \sum_{j \neq 1}^{n} D_{1j}(\Delta w_{1j} - \Delta \gamma_{1j}) \\ \vdots \\ \Delta c_n + \sum_{j \neq i}^{n} \Delta w_{jn} + \sum_{j \neq n}^{n} D_{nj}(\Delta w_{nj} - \Delta \gamma_{nj} \end{pmatrix} \tag{11}$$

[21] These changes may also include remedies, e.g., elimination of vertical relations or commitments to lower wholesale prices.

Finally, the $n \times 1$ column vector $\boldsymbol{b}_2$ represents changes in incentives directly associated with internalization of competition between the merging firms.[22]

$$\boldsymbol{b_2} = \begin{pmatrix} D_{12}(p_2^0 - c_2^0 - \Delta c_2 - \sum_{j\neq 2}^{n}(w_{j2}^0 + \Delta w_{j2})) \\ D_{21}(p_1^0 - c_1^0 - \Delta c_1 - \sum_{j\neq 1}^{n}(w_{j1}^0 + \Delta w_{j1})) \\ 0 \\ \vdots \\ 0 \end{pmatrix} \tag{12}$$

The set of equations describing how optimal prices change from a structural change can be formulated as:

$$\boldsymbol{A}(\boldsymbol{\Delta p}) = \boldsymbol{b}_1 + \boldsymbol{b}_2. \tag{13}$$

Thus, the vector of changes in prices is obtained by the following formula:

$$\boldsymbol{\Delta p} = \boldsymbol{A}^{-1}(\boldsymbol{b}_1 + \boldsymbol{b}_2). \tag{14}$$

4 Examples

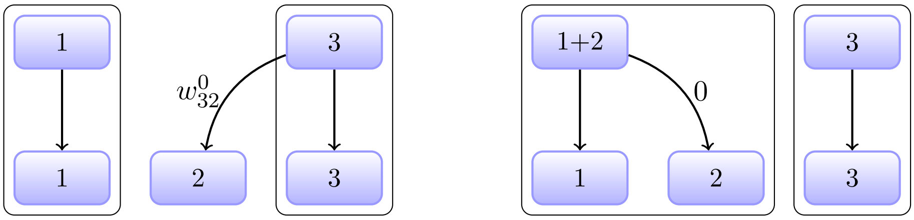
This section provides two examples to illustrate how the framework can be applied to mergers that affect vertical relations between firms. The first example illustrates how a response from a non-merging firm may significantly affect post-merger prices. The second example shows how to simultanously incorporate the vertical effects highlighted by Moresi and Salop (2013) (vGUPPId) and Asphjell et al. (2017) into the linear demand framework of Hausman et al. (2011).

4.1 Example 1: Non-merging firm ceases to be a wholesaler to merging firm

Consider a merger between Firm 1 and Firm 2, as depicted in Figure 2. In the initial situation, there are three competing firms downstream: Firms 1 and 3 are vertically integrated, while Firm 2 has no production upstream and buys input from Firm 3 at a unit price w_{32}^0.

After the merger, Firm 2 becomes vertically integrated with Firm 1. Consequently the vertical relation between Firm 2 and 3 is eliminated, i.e., $\Delta w_{32} = -w_{32}^0, \Delta\gamma_{32} = -\gamma_{32}^0$.

[22]The framework can also be applied to estimate price effects of non-merger related structural changes. In that case, $\boldsymbol{b_2}$ is a zero vector, i.e., $\boldsymbol{b_2} = \boldsymbol{0}$.



(a) Before merger **(b)** After merger

Figure 2: After the merger between Firms 1 and 2, Firm 2 is vertically integrated with Firm 1. Firm 3 ceases to internalize input sales to Firm 2. Nodes within a box indicate the same owner. Parameters on edges indicate variable input prices.

The effects on pricing for the three products following the structural change are given by equations (15)-(17) below:

$$\Delta p_1 = \frac{1}{2}\left[(R_{12} + D_{12})\Delta p_2 + R_{13}\Delta p_3 + \underbrace{D_{12}(p_2^0 - c_2^0 - w_{32}^0)}_{\text{UPP}_1} \underbrace{+D_{12}w_{32}^0}_{\substack{\text{Cost reduction}\\ \text{of Firm 2}}}\right] \tag{15}$$

$$\Delta p_2 = \frac{1}{2}\left[(R_{21} + D_{21})\Delta p_1 + R_{23}\Delta p_3 + \underbrace{D_{21}(p_1^0 - c_1^0)}_{\text{UPP}_2} \underbrace{-w_{32}^0}_{\substack{\text{Cost}\\ \text{reduction}\\ \text{(EDM)}}}\right] \tag{16}$$

$$\Delta p_3 = \frac{1}{2}\left[R_{31}\Delta p_1 + R_{32}\Delta p_2 \underbrace{-D_{32}(w_{32}^0 - \gamma_{32}^0)}_{\substack{\text{Reduced margin on sales}\\ \text{diverted to Firm 2}}}\right] \tag{17}$$

The effects on pricing for the merging firms are traditionally accounted for in merger simulations. Ignoring the price responses of other firms, Firm 1 (equation (15)) has incentives to raise prices due to internalizing previous rivalry (UPP_1). The effect is amplified by the marginal cost reduction by Firm 2 ($D_{12}w_{32}^0$). Firm 2 (equation (16)) has incentives to raise prices from internalization of rivalry (UPP_2), but the reduction in marginal costs (EDM from vertical integration) gives incentives to lower prices since higher margins are earned for each acquired customer.

Before the merger, Firm 3 earned an expected input margin of $D_{32}(w_{32}^0 - \gamma_{32}^0)$ for each sale diverted to Firm 2 (equation (17)). After the merger, this margin is eliminated, which creates an incentive for Firm 3 to reduce its retail price, as diverted sales to Firm 2 no longer lead to increased input sales. In fact, the response from Firm 3 may go in the opposite direction to that of the merging firms.[23] Thus, not accounting for Firm 3 ceasing to be a wholesaler for Firm 2, we overestimate the unilateral price effects of the merger.

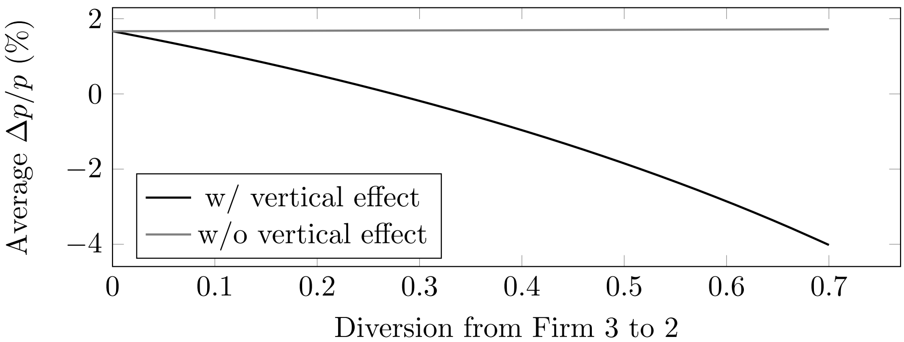


Figure 3: Average percentage price change of merger as a function of diversion from Firm 2 to 3. Parameters: $p_i^0 = 10, c_i^0 = 4.5, Q_i^0 = 1/3$ for all i. $D_{ij} = 0.3, i, j \neq 3, 2$. $w_{32}^0 = 2.5, \gamma_{32}^0 = 0$.

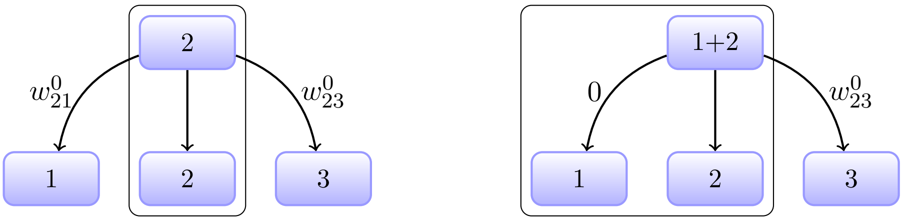
Figure 3 provides a numerical example of how the average percentage price change is affected when the change in vertical relation between Firms 3 and 2 is accounted for. The grey graph represents the average price change without this vertical effect, i.e., ignoring the term $D_{32}(w_{32}^0 - \gamma_{32}^0)$ in equation (17). As one would expect, this measure is not sensitive to the diversion from Firm 3 to 2.

However, when the vertical effect is accounted for, represented by the black graph, there is a clear negative relationship between post-merger prices and the diversion from Firm 3 to Firm 2. This is primarily because Firm 3 lowers its price, but also because of feedback effects as the merged entity (Firms 1 and 2) responds to Firm 3's price reduction. Thus, if diversion from Firm 3 to 2 is high, then ignoring the response from Firm 3 could substantially overestimate the price effects of the merger.

[23]If Firm 1 only is present upstream, i.e., the merger between Firms 1 and 2 is a "pure" vertical merger, the merger only has negative effects on retail prices within our framework. Reduced marginal costs give Firm 2 incentives to decrease prices and reduced input sales from Firm 3 to 2 gives Firm 3 incentives to decrease prices.

4.2 Example 2: Vertically integrated firm with multiple wholesale customers acquires one downstream firm

Consider a merger between Firm 1 and Firm 2, as depicted in Figure 4. In the initial situation, there are three retailers downstream. Only Firm 2 is vertically integrated, whereas both Firm 1 and Firm 3 buy inputs from Firm 2 at unit prices of w^0_{21} and w^0_{23}, respectively.



(a) Before merger **(b)** After merger

Figure 4: Firm 2 internalizes the wholesale margin to Firm 1 before the merger. After the merger between Firms 1 and 2, Firm 1 internalizes that sales diverted to Firm 3 increase sales of input upstream. Nodes within a box indicate the same owner. Parameters on edges indicate variable input prices.

After the merger, Firm 1, as an integrated part of Firm 2, effectively is a wholesaler for Firm 3. As shown by Moresi and Salop (2013), this structural change gives Firm 1 incentives to raise retail prices, as substitution away from Firm 1 to Firm 3 increases the merged entity's input sales upstream. Also, Firm 2 earned a wholesale margin from sales to Firm 1 *before* the merger. As shown by Asphjell et al. (2017), Firm 2's incentives to raise prices downstream are overestimated when the pre-merger wholesale margin is not controlled for. This is because competition between the firms is partially internalized before the merger.

Thus, there are several merger-specific price effects going in opposite directions. The effects on pricing for the three products following the structural change are given by equations (18)-(20) below:

$$\Delta p_1 = \frac{1}{2}\Bigg[(R_{12}+D_{12})\Delta p_2 + R_{13}\Delta p_3 + \underbrace{D_{12}(p_2^0 - c_2^0)}_{\text{UPP}_1} \underbrace{-w_{21}^0}_{\substack{\text{Cost}\\ \text{reduction}\\ \text{(EDM)}}} + \underbrace{D_{13}(w_{23}^0 - \gamma_{23}^0)}_{\substack{\text{Wholesale margin on sales}\\ \text{diverted to Firm 3 (vUPPd)}\\ \text{(Moresi and Salop, 2013)}}}\Bigg] \tag{18}$$

$$\Delta p_2 = \frac{1}{2}\Bigg[(R_{21}+D_{21})\Delta p_1 + R_{23}\Delta p_3 + \underbrace{D_{21}(p_1^0 - c_1^0)}_{\text{UPP}_2} \underbrace{+D_{21}w_{21}^0}_{\substack{\text{Cost reduction}\\ \text{of Firm 1}}} - \underbrace{D_{21}(w_{21}^0 - \gamma_{21}^0)}_{\substack{\text{Pre-merger wholesale margin}\\ \text{on sales diverted to Firm 1}\\ \text{(Asphjell et al., 2017)}}}\Bigg] \tag{19}$$

$$\Delta p_3 = \frac{1}{2}\Bigg[R_{31}\Delta p_1 + R_{32}\Delta p_2\Bigg] \tag{20}$$

Equation (18) shows the price response of Firm 1. The terms labeled UPP_1 and EDM correspond to the "standard' price effects of internalized rivalry and efficiency gains, respectively. The term labeled "vUPPd" corresponds the upward pricing pressure caused by Firm 1's added wholesale margin to Firm 3 (corresponding to vGUPPId from Moresi and Salop (2013)).

Equation (19) shows the price response of Firm 2. As Firm 2 is a wholesaler to Firm 1 before the merger, Firm 2 partially internalizes rivalry from Firm 1. To account for this, we subtract the term $D_{21}(w_{21}^0 - \gamma_{21}^0)$ within brackets (as in Asphjell et al. (2017)).

Thus, there are counteracting effects on prices. Ignoring the first effect overestimates the net price effects of the merger, whereas ignoring the second effect underestimates the net price effects.

In addition, the merger may involve input foreclosure effects, as described in Moresi and Salop (2013). Firm 1+2 (upstream) post-merger may have incentives to increase the input price w_{23} to influence Firm 3 to raise its retail price. This is because a share of the reduced demand facing Firm 3 is recaptured by Firm 1. As pricing of inputs is not modeled in our framework, price effects could be underestimated.[24] However, input foreclosure could be analyzed "ad hoc" by modeling an exogenous increase in w_{32} (i.e., adding $\Delta w_{23} > 0$ to the system of equations).

[24] It is challenging to endogenize input pricing within our framework. Both between markets and between firms operating in the same market, there can be great variation in how input prices are determined and how vertical contracts are designed. Design of vertical agreements must be evaluated on a case-by-case basis.

5 Conclusion

In this paper, we extend the linear demand formula of unilateral price effects of horizontal mergers by Hausman et al. (2011) to account for price responses from vertical relations between merging and non-merging firms. Non-merging firms' responses may be significant if vertical elements with merging firms are affected. We show how to formally quantify this price effect.

We also show how the formula can incorporate multiple vertical effects previously studied in the literature. In this context, the framework serves as a practical tool for analyzing mergers where it is challenging to assess the net price effect by studying each first-round effect separately.

The framework is flexible and can be adapted to estimate price effects of non-merger-related structural changes. These include changes in vertical relations and exogenous changes to wholesale prices (e.g., from new regulations). When assessing mergers, our framework can be used to quantify price effects of remedies proposed by the merging parties. Such remedies may include selling downstream businesses, commitments to lower input prices, or termination of vertical agreements with downstream rivals.

Restrictions Hausman et al.'s (2011) framework also apply to the formula presented in this paper. These restrictions include assumptions on linear demand, demand slopes, and diversion ratios. In addition, other merger-specific sources of price effects may not be captured in the model, including input foreclosure and effects on vertical contracting. Finally, as with all UPP-related measures, there are empirical challenges from calibrating parameters from accounting data, market data, and contracts.

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