

MARKET ANALYSIS IN THE PRESENCE OF INDIRECT CONSTRAINTS AND CAPTIVE SALES

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ABSTRACT

In antitrust cases as well as for regulated industries, the question of how to treat indirect constraint and captive sales correctly has become of major importance in Europe. The (im-)proper treatment of indirect constraints has led the CFI to overturn the Commission's decision in the proposed merger of Schneider and Legrand. Moreover, with regards to the definition of wholesale broadband access markets, there is an ongoing controversy between the Commission and some National Regulatory Authorities, centering on the question of whether to incorporate indirect constraints already at the stage of market definition. To inform this debate, we present in this article some of the insights from a detailed formal analysis into markets with indirect constraints and captive sales. We show how indirect constraints are appropriately taken into account through the elasticity of derived demand and comment also on the informativeness of concentration measures on both the wholesale and retail market. We further derive insights into when indirect constraints may be more or less important compared with direct constraints. Finally, we also discuss the more practical difficulties that are encountered when analyzing (or estimating) market structures where forward integrated firms also sell to other, competing retail firms.

I. INTRODUCTION

In industries with a vertical structure, where not all upstream firms sell directly to final consumers, the consideration of indirect constraints can play an important role in competition cases as well as for investigations into regulated markets. To set the stage, note that upstream competition imposes a *direct constraint* on the market power of any individual supplier. In contrast, vertically integrated firms that compete directly on the retail market or, likewise, firms with different technologies are said to impose an *indirect constraint*. Precisely, if the purchasing price was raised substantially above the competitive level, the supplier's

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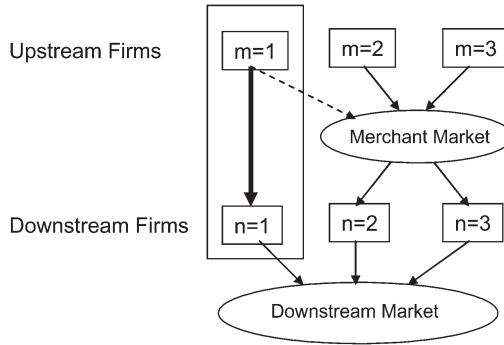


Figure 1. Indirect constraints and captive sales.

customers would become less competitive on the retail market, which would reduce their market share and consequently also their purchases from the suppliers.

How should such indirect constraints, if at all, be taken into account when defining the relevant market, determining whether a firm has a dominant position, or analyzing the potential impact of a merger? Likewise, how shall regulators or antitrust authorities deal with the “captive sales,” that is, the self-supply of vertically integrated firms? To be more specific, consider a market structure as that depicted in Figure 1.

In Figure 1, firms $m = 1$ and $n = 1$ are vertically integrated, with the thick arrow representing the respective volume of self-supply, sometimes also referred to as captive sales. Firm $n = 1$ competes with $n = 2, 3$ on the downstream market. Firms $n = 2, 3$ procure their input from a “merchant market,” into which the stand-alone upstream firms $m = 2, 3$ and potentially also the integrated firm $m = 1$ sell.¹

One question that our subsequent analysis needs to address is how to analyze a merger between firms $m = 2$ and $m = 3$. In the example of Figure 1, this merger leads to a monopoly on the merchant market in case the vertically integrated firm does not sell on the merchant market, either for strategic reasons or due to technological constraints. In contrast, if $m = 1$ was not integrated forwards and thus sold into the merchant market, then the upstream merger would not be to a monopoly. Jumping to the conclusion that in the latter case the merger would have a smaller impact on the price prevailing in the merchant market is, however, erroneous as it ignores

¹ Here, it should be noted that our subsequent analysis also admits for the case where $m = 1$ buys on the merchant market. Generally, cost disadvantages of $m = 1$ or increasing marginal costs may lead to such an outcome. However, our analysis will also show that there could be a strategic motive to buy; in case this is both technologically feasible and permissible, given that it essentially amounts to a strategy of “raising rivals’ costs” on the downstream market.

the difference in indirect constraints that are present through competition on the downstream market. We show precisely how vertical integration tends to increase the elasticity of (derived) demand in the merchant market. This provides insights into the likely effect of an upstream merger under vertical integration, depending on, for instance, whether the integrated firm currently sells in the merchant market or whether this can be expected after the merger.

We present both results for general demand functions as well as for different common functional specifications. We also discuss the relevance of different measures of market power in the wholesale (or merchant) market. In particular, we discuss potential pitfalls when relying too much on either market shares of the wholesale or of (indirect) market shares of the retail market. Using retail market shares, that is, the market shares of those downstream firms that buy from the respective suppliers, has been advocated as a way of incorporating indirect constraints, given that this incorporates both the retail operations of vertically integrated firms as well as the sales of firms that may use different technologies but whose products are substitutes at the retail level. We also discuss the usefulness of information on pass-through rates, which measure the responsiveness of retail prices to changes in the wholesale prices, or of information on dilution factors, that is, the ratios of retail to wholesale prices. Finally, in particular for market structures where integrated firms still sell on the merchant market we show how a too “naive” approach on estimating the impact of a merger, or likewise another change in market structure, could lead to systematic errors.

Our insights should be of immediate practical relevance for both antitrust and regulation. To single out one case, in Europe there is an ongoing controversy on how to take into account indirect constraints in the provision of broadband services. Broadband services, which form part of the same relevant retail market, are provided over different technologies at the wholesale level (ADSL, cable, fiber, and so on). The controversy that has arisen between the Commission and some National Regulatory Authorities (NRAs) with regard to the definition of the wholesale broadband access market (Market 12 of the Commission Recommendation) illustrates the methodological problem at issue.

The 2003 Market Recommendation defines very broadly the wholesale broadband access product market, which is said to cover DSL bit-stream access technology as well as alternative technologies, if and only if they offered facilities equivalent to bit-stream access. Based on this definition, all NRAs have generally included DSL bit-stream access in their market definition. However, their analysis has differed substantially with respect to the inclusion of other technologies, such as cable TV networks that have been upgraded to provide a return path, satellite TV networks, or wireless technologies. While some NRAs (such as RTR, BNetzA, ComReg, Anacom, and Ofcom) have considered that cable-based services formed part of the relevant

market, other NRAs supported by the Commission (such as NITA, Arcep, NCAH, and PTS) have excluded those services in defining the market and have chosen to assess pricing constraints at the subsequent stage of dominance assessment.

The divergence of views was due in particular to a disagreement on whether to assess the “indirect” pricing constraints exercised at the retail level. The Commission and the NRAs who did not include cable in the relevant market generally started their analysis at the wholesale level, and, because cable networks currently do not provide wholesale access and cannot easily enter the market in the short term, cable-based services cannot be included in the broadband access market. There is simply no “direct” constraint on DSL wholesale broadband access products. Consequently, cable’s competitive impact was to be taken into account in the analysis of dominance in terms of “potential competition.” In contrast, those NRAs that did include cable in the market focused first on competition at the retail level. They concluded that, from the demand side, at the retail level all broadband access services belong to a single product market, whatever the platform used at the wholesale level. They also concluded that the indirect pricing constraints exercised by cable-based services at the retail level have a sufficiently significant impact at the wholesale level to justify its inclusion in the wholesale broadband market.²

Here, the question is clearly not “whether” indirect constraints and self-supply must be taken into account in the market analysis but rather “when,” at the stage of defining the relevant market or in the subsequent stage of market power assessment. Clearly, in principle, all approaches should lead to the same outcome as eventually all relevant competitive constraints have to be taken into account to assess market power correctly. In other words, if all relevant factors are taken into consideration and if the applied economic model is the correct one, then the particular procedure should ultimately be irrelevant. In practice, however, the choice of the relevant market may, together with the market share thresholds, be particularly important at the pre-screening stage. By discussing the potential pitfalls when using market shares at the wholesale or retail stage, we hope to also inform the future discussion on this controversy.

For a final motivating example outside the area of electronic communications, consider the prominent case of the proposed merger of Schneider Electric SA, a producer of products and systems in the electrical distribution, industrial control, and automation sectors, and Legrand SA, a producer of electrical equipment for low voltage installations. While Schneider and Legrand were not vertically integrated, other firms competed only through

² See Cave et al. (2006) and Madiega (2006).

self-supply at the retail level (of panel-board components, which use low voltage electrical equipment as produced by Schneider and Legrand as input). The merger was blocked by the Commission, whose decision was subsequently overruled (without appeal) by the CFI.³ The CFI argued that, by not incorporating ABB's and Siemens' market shares at the downstream market (namely, that of panel-board components), "the Commission underestimated the economic power of the merged entity's two main competitors and correspondingly overestimated that entity's strength."⁴ Below, we will use the Commission's argument in this case to highlight where we believe that some of the insights from our study can inform future antitrust decisions.

Before turning to the analysis, we want to mention briefly several caveats. Figure 1 already contains one of the key assumptions that we make in the paper, namely that independent up- and downstream firms interact through a "market interface," the merchant market, in which the undifferentiated upstream goods are traded. This assumption is by no means innocuous. Basically, it implies that firms derive market power by withholding supply.⁵ Our precise specification for the merchant market, which we share with most of the related literature, is that upstream firms compete by committing quantities of a homogeneous input and, consequently, sell all at a uniform and constant price per unit.⁶ We focus on a particular type of model, that of two-stage quantity competition on the wholesale and retail market, though by using a conjectural variation approach at each level we span the whole set of outcomes between Bertrand and Cournot competition.⁷ Though this approach was pioneered more than two decades ago, to our knowledge many of the issues that are of practical relevance have received almost no

³ CFI Judgement of 22.10.2002 on case T-310/01: Schneider v. Commission (Application for the annulment of Commission Decision C(2001)3014 of 10.10.2001 on case COMP/M.2283 - Schneider-Legrand).

⁴ Id., Para. 296. For a survey of recent competition case law concerning indirect constraints and captive sales, see CRA, *Indirect Constraints and Captive Sales: Overview of Regulatory Practice and Competition Case Law*, Report for Ofcom, May 2006.

⁵ In our analysis, we follow most of the literature in only allowing upstream firms to exercise market power on the merchant market. For a different set-up see, for instance, Hendricks and McAfee (2005).

⁶ An orthogonal approach would be that, where suppliers are differentiated and where supply contracts are bilaterally negotiated, the respective suppliers and retail firms are potentially also to some extent locked into the relationship. In current contemporaneous research we argue that it may then no longer be always meaningful to take into account simultaneously direct and indirect constraints for the whole market given that for some suppliers only one of the two constraints may become binding. Gans (2005) also compares an approach with a market interface to that with bilateral negotiations.

⁷ As noted also below, the conjectural variation approach is taken despite its (obvious) theoretical flaws. It allows for a parsimonious characterization of the mode of competition (next to product differentiation and the number of competing firms) and it is important both in empirical research and policy analysis.

consideration, for example, the interplay of direct and indirect constraints for the determination of the merchant price.⁸

Finally, the analysis in this paper is focused squarely on the price prevailing in the merchant market. From an economist's perspective this may seem somewhat odd given that we can not expect it to be an appropriate indicator for either overall welfare or consumer surplus, particularly if at the same time one or more firms are also integrated. Arguably, however, for investigations concerning the impact of upstream mergers or the existence of substantial market power, the current and predicted conditions prevailing on the merchant market will play a key role. Our focus on the merchant market derives from these practical considerations.

The rest of this article is organized as follows. In Section II we deal first with the benchmark case where no firm is vertically integrated. There, we show how to calculate derived demand and we study the factors that are likely to affect its elasticity and the prevailing price on the upstream market. Sections III and IV extend the analysis to the case where a vertically integrated firm either completely withdraws from the upstream (merchant) market or where it continues to supply competing retail firms. Section V offers concluding remarks.

II. ANALYSIS WITHOUT VERTICALLY INTEGRATED FIRMS

A. Analytical Framework: The Two-Stage Cournot Model

We consider a setting with $M \geq 2$ independent upstream firms that produce a homogeneous good and compete in quantities. Each upstream firm m has constant marginal costs equal to c_m^u . Most of our analysis will be restricted to the symmetric case with $c_m^u = c^u$. At the downstream level, $N \geq 2$ firms serve final consumers. Downstream firms use the upstream good in fixed proportions. We normalize to one the ratio of inputs to output.⁹ We will first specify that also downstream firms produce homogeneous goods, though this is relaxed below. Downstream demand is then characterized by the inverse demand function $P(q)$. Each downstream firm n has constant marginal costs c_n^d though we again mostly restrict consideration to the symmetric case where $c_n^d = c^d$. Competition is in quantities. We will refer to the upstream (or, wholesale) price as p^u and to the downstream (or, retail) price as p^d .

⁸ The respective literature begins with Salinger (1988) and includes Gaudet and Long (1996), Schrader and Martin (1998), Higgins (1999), and Avenel and Barlet (2000). For a more detailed discussion of each of these papers see European Commission (2004).

⁹ While it is possible to modify the model in a way that allows for *vertical* differentiation, for example, by specifying that more or less units of a given input are required to produce one unit of output at the downstream level, this model is not geared towards allowing for *horizontal* differentiation in the sense that different downstream firms have a preference for a particular supplier.

As noted above, competition at both the upstream and the downstream level is in quantities. Conceptually, the three steps in deriving an equilibrium are the following. Taking a uniform input price as given, one solves for the (Nash) equilibrium in quantities at the downstream level. Aggregate demand is referred to as the derived demand function. At the upstream level, we can likewise solve for some given derived demand function for the (Nash) equilibrium in quantities. The third step is then to ensure that the upstream and downstream markets are jointly in equilibrium.

In our subsequent analysis, we will introduce one major modification to this setting by allowing for vertical integration. Importantly, depending on circumstances, the vertically integrated firm may then still be active on the upstream (“merchant”) market.

B. Preview of Key Results

The subsequent analysis will be, at points, somewhat technical. Though we omit all proofs as well as numerical derivations, all of which can be found in the technical working paper available from the authors, we still intend to provide a formal characterization of the market equilibrium. For this reason, we briefly summarize here and also subsequently at the beginning of all future sections the key results and insights in a less technical way.

1. Without vertically integrated firms or, likewise, retail firms that procure at a different market, the analysis of the upstream market is straightforward once the derived demand has been obtained. Our analysis yields the following insights for the elasticity of derived demand, ε^u :
 - (a) Intuitively, the higher the elasticity of final demand ε^d , the higher also ε^u .
 - (b) However, in contrast to some views that we have encountered, ε^u should *not* be expected to depend on retail competition in a systematic and robust way. Importantly, this will be markedly different once indirect constraints play a role through the presence of vertically integrated firms. Without vertical integration, ε^u does not depend, in particular,
 - (i) on the number of competing downstream firms;
 - (ii) on the degree of downstream product differentiation;
 - (iii) and on the mode of downstream competition, which we capture in a standard way through a “conjectural variation parameter” that spans the range from the most competitive “Bertrand” conjectures to the least competitive Cournot conjectures.
2. We can decompose the elasticity of derived demand as

$$\varepsilon^u = \varepsilon^d \delta \tau \tag{1}$$

where δ is the ratio between the wholesale (upstream) and the retail (downstream) price, p^u/p^d , which is sometimes referred to as the “dilution factor,” and where the “pass-through” rate τ measures the responsiveness of the common retail price to changes in the wholesale price. However, it can be misleading to use expression (1) to draw inferences on how ε^u should vary with changes in either the dilution ratio or the pass-through rate. More precisely:

- (a) All parameters in equation (1) are endogenous and will, in equilibrium, change following an adjustment in some exogenous variables such as the mode of up- or downstream competition.
- (b) As we show, this often gives rise to true relations that are orthogonal to those that would be “naively” predicted by equation (1).

C. Derived Demand

For a given upstream price p^u , we first calculate the downstream Cournot equilibrium. This analysis is standard and only reproduced for the readers’ convenience. We first denote profits for some retail firm n by

$$\pi_n := (p^d - p^u - c_n^d)q_n.$$

Here, q_n denotes the chosen quantity, p^d the prevailing retail price, and $p^u + c_n^d$ the respective total marginal costs, comprising both own marginal product costs and the upstream price p^u . At an interior solution, the optimal quantity satisfies the first-order condition with $d\pi_n/dq_n = 0$. Writing this out explicitly, we have that

$$p^d - p^u - c_n^d + q_n P'(Q)(1 + \lambda^d) = 0, \quad (2)$$

where $\lambda^d := \sum_{n' \neq n} (\partial q_{n'} / \partial q_n)$ denotes the, by assumption symmetric and constant, conjectural variation parameter for the downstream market. Note that $\lambda^d = 0$ obtains the Cournot conjectures and $\lambda^d = -1$ the Bertrand conjectures, with lower values of λ^d corresponding to more intense downstream competition.¹⁰ More generally, we will have that, holding all else constant, the equilibrium retail price p^d will be strictly increasing in $\lambda^d \in [-1, 0]$.

¹⁰ Note that λ^d aggregates the “total response” of all other firms. We also are perfectly aware of the conceptual criticism of this approach. Nevertheless, we will use it, both at the up- and the downstream market, due to importance both for empirical work and policy-making. Finally, we will also extend our insights to the case with differentiated goods (and Cournot conjectures, $\lambda^d = 0$), allowing for a different way to capture various degrees of competition on the downstream market.

Rewriting equation (2), the optimal pricing policy as summarized by the well-known (downstream) Lerner index

$$L_n^d := \frac{p^d - (p^u + c_n^d)}{p^d} = \frac{s_n}{\varepsilon} (1 + \lambda^d), \tag{3}$$

where we use $s_n := q_n/Q$ for the market share of firm n and $\varepsilon^d := -p^d/QP'$ for the elasticity of downstream demand. In case of symmetric own marginal costs $c_n^d = c^d$, (3) becomes more simply

$$L_n^d = L^d = \frac{1}{N} \frac{1}{\varepsilon^d} (1 + \lambda^d).$$

Observe next that, in equilibrium, the quantity of inputs purchased on the upstream market must equal the quantity of output sold on the downstream market. Writing now p^u as a function of this quantity and aggregating over the first-order conditions (2), we can simply obtain the derived demand function. This is reported in the following result.

Result. *Without vertically integrated firms, derived demand on the upstream (or wholesale) market is characterized by the inverse demand function*

$$P^u(Q) = P(Q) - \frac{\sum_{n=1}^N c_n^d}{N} + \frac{Q}{N} P'(Q)(1 + \lambda^d), \tag{4}$$

where P denotes inverse demand for the retail market, N the number of retail firms with own costs c_n^d , and λ^d the conjectural variations parameter for the retail market. In case of symmetry, this simplifies to

$$P^u(Q) = P(Q) - c^d + \frac{Q}{N} P'(Q)(1 + \lambda^d). \tag{5}$$

Equation (5) gives the derived demand in case of symmetric downstream firms. A first intuitive observation is that, as $N \rightarrow \infty$, the derived demand converges to $P(Q) - c^d$, that is, to the final demand adjusted for downstream firms' own marginal costs. The same holds as λ^d approaches the Bertrand conjectures with $\lambda^d \rightarrow -1$.

The elasticity of the derived demand curve,

$$\varepsilon^u := -\frac{p^u}{Q} \frac{dQ}{dP^u},$$

can now, by using just algebraic transformations, be written as¹¹

$$\varepsilon^u = \varepsilon^d \delta \tau, \quad (6)$$

where $\delta := p^u/p^d$ is the dilution factor and $\tau := dP^d/dP^u$ is the pass-through rate.

The pass-through rate is commonly used in empirical studies to analyze how, in particular, exogenous changes to marginal costs (for example, due to exchange rate fluctuations or changes in commodity prices) feed through the supply chain. Both an estimate of the pass-through rate and of the dilution factor may often be available. As we argue further below, however, this should not suggest the somewhat naively use of the decomposition in equation (6) to draw inferences about ε^u .

We next illustrate our derivations with a few common functional specifications.

1. “Generalized linear” demand.¹² $Q = (\alpha - p)^z$

Note first that this function has elasticity

$$\varepsilon^d = \frac{p^d}{\alpha - p^d} z.$$

An increase in the exponent parameter z is directly related to an increase in the elasticity of downstream demand; similarly for a decrease in the intercept parameter α . A change in the intercept parameter also affects the size of the market.

Derived demand is characterized by

$$P^u(Q) = (\alpha - c^d) - Q^{1/z} \left(1 + \frac{1 + \lambda^d}{NZ} \right)$$

with elasticity

$$\varepsilon^u = \frac{p^u}{\alpha - c^d - p^u} z.$$

Note that, in this case, the derived demand function belongs to the *same* class of functions as the downstream demand function.

¹¹ Simply note that $\varepsilon^u = -(p^u/Q)(dQ/dP^u) = [-(p^d/Q)(dQ/dP^d)](p^u/p^d)((dp^d/dQ)/(dp^u/dQ))$.

¹² It should be noted that any demand function $Q = (\alpha - bp)^z$ can be rewritten as $Q = b^z (\alpha - p)^z$ with $\alpha = a/b$, which yields the same equilibrium prices as $Q = (\alpha - p)^z$.

2. Isoelastic demand $Q = \alpha p^{-z}$

With this demand function, α affects only the market size but not the downstream elasticity, because the elasticity is $\varepsilon^d = z$. Derived demand is now characterized by

$$P^u(Q) = \left(1 - \frac{1 + \lambda^d}{NZ}\right) Q^{-1/z} - c^d$$

with elasticity

$$\varepsilon^u = \frac{p^u}{p^u + c^d} z.$$

Notice that, unless $c^d = 0$, the derived demand function is *no longer* isoelastic. Instead, ε^u is strictly increasing in p^u .

3. Linear demand with differentiated goods

Though, to our knowledge, almost all applications of the sequential Cournot model are to markets where goods are also undifferentiated at the downstream level, the conceptual framework is clearly equally applicable to differentiated goods. With symmetric differentiation and linear demand, let the (appropriately normalized) inverse demand for firm n , given own output q_n and output q_i of each one of its downstream rivals, be given by

$$p_n = \alpha - q_n - \gamma \sum_{i \neq n} q_i \text{ with } 0 \leq \gamma \leq 1 \tag{7}$$

whenever this is positive.

The parameter $0 \leq \gamma \leq 1$ describes the degree of homogeneity. When $\gamma = 1$ we are back to homogeneous goods, while when $\gamma = 0$ we have independent demand. We drop conjectural variations here such that firms simply compete in quantities, taking rivals' quantities as given. Derived demand is characterized by

$$P^u(Q) = (\alpha - c^d) - Q \frac{2 + \gamma(N - 1)}{N}$$

with elasticity

$$\varepsilon^u = \frac{p^u}{\alpha - c^d - p^u}.$$

4. Some comments and comparisons

All three specifications share the feature that ε^u is *independent* of measures of all downstream competition, that is, of the number of firms N , the mode of competition as captured by λ^d , and product differentiation γ in the linear case. In

fact, working with a general (inverse) demand P reveals that more generally no systematic and robust relations between retail competition and the elasticity of derived demand should be expected, at least not in the case without vertically integrated firms. On the other hand, in all three cases ε^u increases as we change the respective parameters that unambiguously increase ε^d . It seems worthwhile to record these results more explicitly.

Result. *Without vertically integrated firms and for the chosen functional specifications, the elasticity of derived demand is independent of competition in the retail market, though it is higher the more elastic retail demand is.*

These common functional specifications yield markedly different results for the pass-through, which goes into the decomposition in (6). In case of “generalized linear” demand we have

$$\tau = \frac{Nz}{Nz + 1 + \lambda^d}, \quad (8)$$

implying that always $\tau < 1$ and that both $d\tau/dN > 0$ and $d\tau/d\lambda^d < 0$. In words, the pass-through rate is less than full (unless there is perfect downstream Bertrand competition) and increases with competition (a higher number of firms, or tougher conjectures). For the isoelastic case we have that

$$\tau = \frac{Nz}{Nz - 1 - \lambda^d}, \quad (9)$$

which is strictly larger than one unless $\lambda^d = -1$. Moreover, we have now that $d\tau/dN < 0$ and $d\tau/d\lambda^d > 0$, which is in stark contrast to the previous case of generalized linear demand. We thus conclude that no generalization is possible on how the pass-through is related to retail competition.

D. Upstream Equilibrium Analysis

Once derived demand is obtained, the analysis of the upstream market is completely analogous to that of the downstream market. As M firms compete, this yields the upstream Lerner index

$$L_m^u := \frac{p^u - c_m^u}{p^u} = \frac{s_m}{\varepsilon^u} (1 + \lambda^u),$$

where we now have the respective market shares $s_m := q_m/Q$ and use the (symmetric) conjectures λ^u for the upstream market. With symmetric costs and using (6), we thus have that

$$L^u = \frac{1}{M} \frac{1}{\varepsilon^d} \frac{1}{\delta\tau} (1 + \lambda^u). \quad (10)$$

When using the formula (10) for the Lerner index in the upstream market, a potential pitfall is to conduct comparative statics of the individual components in isolation, for example, when comparing different markets or business scenarios without access to all data.

A naive comparative analysis could possibly suggest that the lower the dilution factor, the lower the elasticity of derived demand and thus the lower the competitive constraints on the wholesale market. An intuitive argument for this would be that, as the respective input accounts for a smaller fraction of the total price, a given percentage increase in p^u would only lead to a small percentage increase in p^d and, thereby, possibly only a small shift in total demand. In what follows, we show why this argument could sometimes be misleading.¹³

Importantly, what must be born in mind is that p^d and p^u , as well as the other parameters, jointly adjust to a change in some exogenous parameter. A possible error that can be made when naively conducting a comparative analysis based on equation (10) is that, while a change of δ is taken into account, changes in ε^d and τ are ignored. For instance, δ is higher in a more competitive retail market while this does not affect ε^u . Also, if the wholesale market becomes more competitive, implying a reduction in L^u , we find that the dilution factor decreases. Table 1 provides more details on what relationship between L^u and δ should be (empirically) expected, depending on the exogenous change.¹⁴

Table 1. Implied Relationship between δ and L

Changes in/Impact on	δ	L^u	Implied correlation
N	+	0	Zero
λ^d	-	0	Zero
M	-	-	Positive
λ^u	+	+	Positive
c^d Generalized linear:	-	-	Positive
Isoelastic:	-	+	Negative
c^u	+	-	Negative
\tilde{z}	Ambiguous	-	Ambiguous
\rightarrow . Generalized linear	Ambiguous	+	Ambiguous

It has also been suggested that the pass-through τ may be informative on the competitive constraints that upstream firms face. (In fact, once again a naïve interpretation of equation (10) would support such a conjecture.) However, our previous results for the two functional specifications already suggest that generally one should next expect a robust relationship between ε^u and τ .

¹³ Of course, this argument has some economic foundation. To see this most easily, suppose that c^u is the total cost of two input components. If these two components are procured in two separate (but perfectly symmetric) markets with costs $c^u/2$, both wholesale prices are strictly higher than $p^u/2$.

¹⁴ All the analytical expressions are available in the authors' Technical Working Paper.

When changing z in equations (8) and (9), which characterizes retail demand and is in both cases the only exogenous parameters that affects both ε^u and τ , we have for the generalized linear case that a larger z , that is, a more elastic final demand, results in a higher ε^u and a higher τ , whereas in the isoelastic case a higher z results in a higher ε^u but a lower τ .

A related remark concerns the relationship between the dilution factor δ and the pass-through rate τ . For low δ , it could be argued, the wholesale price is only a small part of the retail price, which should result in a lower pass-through τ . As we know, however, for the chosen functional specifications τ depends in equilibrium only on N , λ^d , and z , where the sign is also orthogonal for the two specifications. Together with Table 1, we should thus again not expect a robust relationship between τ and δ .

Finally, it is also noteworthy to point out that, though suggested differently by a naive view on equation (10), there is also no clear-cut (equilibrium) relationship between L^u and ε^d . If the exogenous change is in the parameters z or α that characterize ε^d in the two functional specifications, our previous results tell us that ε^d and ε^u indeed move in the same direction, implying a negative correlation between ε^d and L^u . However, if the exogenous change is, for instance, with respect to the upstream number of firms M , then we would find a positive correlation between ε^d and L^u . Table 2 provides more details for the case with generalized linear demand.

Table 2. Implied relationship between ε^d and L^u for Generalized Linear

Changes in/Impact on	ε^d	L^u	Implied correlation
N	–	0	Zero
λ^d	+	0	Zero
M	–	–	Positive
λ^u	+	+	Positive
c^d	+	–	Negative
c^u	+	–	Negative
$z, 1/\alpha$	+	–	Negative

It seems again useful to record these insights.

Result. *While the decomposition $\varepsilon^u = \varepsilon^d \delta \tau$, where δ is the dilution factor and τ the pass-through rate may be useful to link ε^u to data that is potentially more easily obtainable, it is generally misleading to use this decomposition for a naive comparative analysis. In particular, generally ε^u may not be positively related to either ε^d , δ , or τ , given that all parameters are endogenous and determined jointly in equilibrium.*

Before proceeding with the analysis, it should be recalled that the preceding remarks all relate to the currently analyzed case where there is no vertical integration. As we note below, with indirect constraints from vertical integration there will be a much tighter link between characteristics of the retail market, most notably the degree of competition, and both ε^u and L^u .

III. VERTICAL INTEGRATION: THE ROLE OF INDIRECT CONSTRAINTS UNDER CAPTIVE SALES

A. Preview of Key Results

We allow now for vertical integration. If vertically integrated firms do not participate in the merchant market, this reduces competitive pressure in the merchant market. Whether vertically integrated firms still participate on the merchant market or whether they can be expected to do so after a change in market structure, may first of all depend on technological factors. This section analyzes the case where participation in the merchant market is not feasible. If participation is feasible, then in turn the integrated firms' willingness to participate may depend on how competitive markets are. This case is analyzed in the subsequent section.

Restrictions, both technological and strategic, on the participation of vertically integrated firms in the merchant market clearly exert upward pressure on the prevailing merchant price p^u . With only one vertically integrated firm, say a firm comprising the formerly independent supplier $m = 1$ and buyer $n = 1$, the number of suppliers competing on the merchant market reduces from M to $M - 1$.¹⁵ This ignores, however, changes in the elasticity of derived demand. As in the previous section, we again provide first an overview of our key results.

1. If vertically integrated firms do not participate on the merchant market due to strategic reasons or technological constraints, the analysis of the upstream market is straightforward once the derived demand has been obtained. In contrast to the previous case, the presence of vertically integrated firms makes now derived demand *more elastic*:
 - (a) First, under the chosen functional specification as well as with more general demand functions, for given p^u the quantity Q^u that is sold on the (upstream) merchant market is lower (given the self-supply of backwards integrated firms and as integrated firms become more competitive).
 - (b) Second, as backward integrated firms are not affected by a change in the merchant price, derived demand becomes now more responsive.
2. The elasticity of derived demand is affected by the following factors:
 - (a) Intuitively, and in analogy to the case without vertically integrated firms, ε^u is higher if ε^d is higher.
 - (b) In stark contrast to the case without indirect constraints from vertically integrated firms, ε^u is higher if the retail market is more competitive as

¹⁵ If we were to hold the elasticity of derived demand constant, then the elasticity of each competing supplier's perceived (or, residual) demand would decrease from ε^u/M to $\varepsilon^u/(M - 1)$, which in turn would push up p^u .

- (i) either final products are less differentiated;
 - (ii) or competition (as captured again by conjectural variations) is fiercer.
3. Indirect constraints can be very effective, in particular more effective than direct constraints.
- (a) To make this precise, we show that in a broad range of cases the withdrawal of one upstream firm from the merchant market due to forward integration will be more than compensated by the additional indirect constraints. We can thus conclude that:
 - (i) it seems misleading to argue that indirect substitution is, in general, less effective as its effects are cushioned by multiple layers in the vertical chain;
 - (ii) in fact, the effectiveness of indirect constraints stems precisely from the fact that it does not work directly through the wholesale market, in particular in case wholesale competition is less effective than retail competition.
 - (b) As noted already above, however, the relative effectiveness of indirect substitution is diminished if product differentiation or low competition reduce the competitiveness of the retail market.
4. When assessing market power in the merchant market, the use of market shares calculated in the merchant market ignores the presence of indirect constraints. These are taken into account when calculating retail market shares. However, retail shares can also be misleading indicators as stronger indirect constraints have the same implication as weaker direct constraints.

B. Derived Demand and Equilibrium Characterization

Observe first that with Q^u as the merchant quantity, the total quantity Q that is supplied to the downstream market satisfies $Q = Q^u + q_1$. (Recall that firm $n = 1$ is vertically integrated with $m = 1$.) With this additional notation, we have in analogy to the case without vertical integration the following result.

Result. *If firms $m = n = 1$ are vertically integrated and do not participate on the wholesale (merchant) market, then inverse demand is characterized by*

$$P^u(Q^u) = P(Q^u + q_1) - \frac{\sum_{n=2}^N c_n^d}{N - 1} + \frac{Q^u}{N - 1} P'(Q^u + q_1)(1 + \lambda^d),$$

where q_1 denotes the retail sales of the integrated firm. In case of symmetry, this simplifies to

$$P^u(Q^u) = [P(Q) - c^d] + \frac{Q^u}{N - 1} P'(Q)[1 + \lambda^d]. \tag{11}$$

Even with symmetry, the backwards integrated firm must be treated separately given that it operates at total marginal costs $c^u + c^d < p^u + c^d$. Most importantly, however, total marginal costs of the backward integrated firm do not depend on p^u . As we argue next, this tends to make derived demand more elastic, a fact to which we referred above as an indirect constraint on p^u .

The working of indirect constraints can be seen very clearly from the following comparative argument. Consider changes to the mode of retail competition, λ^d . Without vertical integration, we argued that generally λ^d should not affect the respective elasticity ε_{NVI}^u in a systematic way. (For our functional specifications it was independent of λ^d .) With vertical integration, however, it is immediate that this is no longer the case. In fact, as λ^d tends to the Bertrand conjectures with $\lambda^d \rightarrow -1$, then the market share of the nonintegrated downstream firms would be zero if p^u remained bounded away from c^u . Putting it differently, for low λ^d derived demand will be very elastic even at values of p^u close to upstream firms' costs c^u .

In what follows, we only obtain explicit solutions for the case with linear demand. Here, we take first the case of homogenous goods with $Q = \alpha - p$. With vertical integration, we obtain the derived demand function

$$Q^u(p^u) = \frac{(N - 1)[(\alpha - c^d - p^u)(1 + \lambda^d) + c^u - p^u]}{(1 + \lambda^d)(N + 1 + \lambda^d)} \tag{12}$$

with elasticity

$$\varepsilon^u = \frac{(2 + \lambda^d)p^u}{(\alpha - c^d - p^u)(1 + \lambda^d) + c^u - p^u},$$

which is decreasing in λ^d . That is, derived demand is more elastic the closer retail competition is to Bertrand competition (with $\lambda^d = -1$).

It is now useful to denote the elasticity of derived demand under vertical integration by ε_{VI}^u . We then obtain for the Lerner index

$$L_{VI}^u = \frac{1}{M - 1} \frac{1}{\varepsilon_{VI}^u} (1 + \lambda^u), \tag{13}$$

which can be compared with that without vertical integration, which we now denote as

$$L_{NVI}^u = \frac{1}{M} \frac{1}{\varepsilon_{NVI}^u} (1 + \lambda^u). \tag{14}$$

The reduction in the number of upstream firms that compete in the merchant market from M to $M - 1$ tends to push p^u up. However, vertical integration also makes derived demand more elastic.

In the linear case with homogeneous goods, we obtain for the equilibrium merchant price without vertical integration

$$p_{NVI}^u = c^u + (\alpha - c^d - c^u) \left(\frac{1 + \lambda^u}{\lambda^u + M + 1} \right), \quad (15)$$

and with vertical integration

$$p_{VI}^u = c^u + (\alpha - c^d - c^u) \left(\frac{1 + \lambda^u}{\lambda^u + M} \right) \left(\frac{1 + \lambda^d}{2 + \lambda^d} \right). \quad (16)$$

A comparison of equations (15) and (16) reveals immediately the trade-off between the reduction in direct constraints due to a decrease from M to $M - 1$ competitors on the merchant market and the addition of indirect constraints as captured by the additional term

$$\frac{1 + \lambda^d}{2 + \lambda^d} < 1$$

in equation (16). The comparison also reveals that the impact of the additional indirect constraints is stronger if the retail market is sufficiently competitive, with $p_{VI}^u \rightarrow c^u$ as we approach the Bertrand conjectures ($\lambda^d = -1$). In fact, in the linear case it is easy to see that given $M \geq 3$, the merchant market price is always lower under vertical integration. The effect is, however, stronger the more competitive the retail market is. Intense competition downstream feeds into the upstream price through making the derived demand very elastic. As we noted previously, this effect would be absent without a vertically integrated firm.¹⁶ Moreover, though we do not report the respective results explicitly, it is also intuitive that a similar conclusion holds with respect to the degree of differentiation if we allow for heterogeneous products.¹⁷

Result. *If firms $m = n = 1$ are vertically integrated and do not participate on the wholesale (merchant) market, then under linear demand we have that despite the fact that this reduces the number of competing suppliers to $M - 1$, the merchant market price is strictly lower if goods are sufficiently homogenous or retail competition is sufficiently intense.*

Finally, a more detailed comparison of equations (15) and (16) also reveals that, under vertical integration, the merchant price tends to be lower relative to the case without vertical integration:

¹⁶ Note that it is intuitive that this conclusion does not apply likewise to changes in N , given that these do not affect the competitive pressure exerted by the backward integrated firm $n = 1$.

¹⁷ In the technical paper we derive conditions for when $p_{VI}^u < p_{NVI}^u$ holds also under more general demand functions. Amongst other things, we show that this is the case if derived demand is concave.

- The less intense upstream competition is (higher λ^u). With perfect (Bertrand) competition on the upstream market, the price is always equal to marginal cost. If instead upstream competition is not very intense, then it matters more that firm $m = 1$ creates indirect competitive pressure through the downstream market.
- The lower the number of upstream firms (low M). Clearly, if M was arbitrarily large, then the upstream price would tend to marginal cost and the indirect constraint would not play any role. If instead there is little upstream competition, now proxied by the number of firms participating in the upstream market, once again the presence of the vertically integrated firm makes the derived demand more elastic and pushes down the equilibrium upstream price.

In particular, the last two observations seem noteworthy. Though it may seem at first somewhat counterintuitive, the loss of $m = 1$ as a direct competitor on the merchant market weighs in less if upstream competition is not intense. The intuition for this is, once again, that it is precisely in these cases that the indirect constraint can exert a greater pressure, through circumventing the less competitive wholesale market.

C. Assessment of Market Power

The assessment of market power is important, both for merger inquiries as well as to establish whether one or several firms jointly have a dominant position. In this section, we explore two issues that are typically at the core of an analysis of market power: (i) firms' incentives to raise prices and (ii) the informativeness of firms' actual market shares.

1. Incentives to raise prices

We take as a starting point prices equal to symmetric marginal costs at the upstream market: $p^u = c^u$. For this benchmark we analyze, both for a single firm and for a set of firms, how large incentives are to (marginally) reduce quantity and raise p^u .¹⁸ For this note first that with $p^u = c^u$ all retail firms are in the same competitive position, implying that each of them serves $1/N$ of the total

¹⁸ It should be noted that, though this analysis will clearly point to the same factors, it is not meant to mimic an SSNIP test. In fact, in a simplistic model framework it is typically not clear how to "conduct" a SSNIP test in a meaningful way given that, on the one hand, at $p^u = c^u$ firms make zero profits, implying that any price increase up to the point where sales are zero would be profitable, while, on the other hand, taking as a benchmark a higher price, for example, the pre-merger price in a merger inquiry, would run the risk of committing the cellophane fallacy.

market. This in turn implies that each of the $M - 1$ independent suppliers sells

$$q_m^* = \frac{1}{M - 1} \frac{N - 1}{N} Q^*$$

into the merchant market, where Q^* is the equilibrium quantity for the retail market if all N firms have symmetric marginal costs $c^d + c^u$. We obtain the following result.

Result. *When one firm is vertically integrated and does not participate in the merchant market, we have the following measure of firms' incentives to raise prices above the competitive level. At the point where suppliers price at marginal costs, we have that the marginal benefits D for a subset $M' < M - 1$ of suppliers to jointly lower quantities and push up the merchant price is given by¹⁹*

$$D = (1 + \lambda^u)c^u \frac{M'}{M - 1} \frac{1}{\varepsilon^u}. \tag{17}$$

As previously, indirect constraints affect D through their impact on ε^u . By making derived demand, evaluated now at $p^u = c^u$ and $Q^u = Q^*/(N - 1)$, more elastic, the benefits to reduce quantities and raise prices, as given by D , decrease. In the framework of our model it seems interesting to study how informative thresholds on the measure D , as given by (m) , could be to arrive at a meaningful definition of the relevant market.

For a second line of attack, we now start from the *actual* merchant price p^u and analyze the incentives of a subset of firms to raise it by some given percentage. We denote the subset of firms by M' and imagine that they reduce their quantity jointly by some value Δ_q such that p^u increases up to $p^u (1 + r)$. For simplicity, we now only deal with the case of Cournot upstream conjectures, $\lambda^u = 0$.²⁰ We now have the following result.

Result. *When one firm is vertically integrated and does not participate in the merchant market, we now have that, starting from the current equilibrium price, a reduction in quantities so that the merchant price rises by r percent would be optimal for a group of M' suppliers only if*

$$M' \geq 1 + r + \frac{c^u(2 + \lambda^d)Mr}{(\alpha - c^d - c^u)(1 + \lambda^d)}.$$

¹⁹ If $M'=M-1$ we have $D = c^u (1/\varepsilon^u)$. Note that as long as $M' < M - 1$ we leave λ^u unchanged. This ensures that, irrespective of the number of competing firms, λ^u still maps out the full range between Cournot and Bertrand conjectures.

²⁰ This allows to avoid case distinctions as we do not have to treat separately a merger to monopoly on the upstream market.

The threshold on M' depends monotonically on r : To raise the price substantially and profitably, it is necessary that a sufficiently high number of firms coordinate on the quantity reduction. The threshold is also decreasing in λ^d , that is, the tougher competition is downstream the more difficult it is to find profitable incentives to reduce quantity and increase price. Once again, this is a result of indirect constraints. When, to take an example, λ^d is relatively low, then it would also not pay *all* independent firms $M' = M - 1$ to jointly raise prices by r percent even if r is small.

If the preceding analysis forms part of an exercise to determine the relevant market, this would naturally raise the question of how to extend further the market in a meaningful way. It has been suggested that this should be undertaken through incorporating the vertically integrated firm and thus its captive sales. In our exercise, the role of the vertically integrated firm, given that it does not participate on the merchant market, would be to internalize additional benefits of a higher p^u , namely from raising its rivals' costs on the retail market. In contrast, if we increase M' , we also adjust the strategic behavior of the newly included firms. The question whether this difference should give rise to conceptually different approaches must be left to future research.

2. The use of market shares

The previous analysis made also clear that in the presence of vertically integrated firms, market shares in the merchant market may not be very reliable indicators of the extent to which suppliers can exert market power. This section provides now a first and preliminary analysis of the role of *retail* market shares for the assessment of upstream market power. Broadly speaking, in our simple model the market power of each of the $M - 1$ independent upstream firms would then be measured by their indirect share of the retail market, which is equal to $Q^u / (N - 1)$ or $(Q - q_1) / (N - 1)$.

The obvious benefit of this approach, namely to focus on retail market shares, is that it incorporates indirect constraints. To be of further value, however, we would expect that these market shares provide relevant information on the level of competitive constraints faced by upstream firms. Formally, this could mean, for instance, the following. It could be presumed that the larger the backward integrated firm's market share, the more independent upstream firms are constrained in their pricing on the wholesale market. Consequently, this should imply an *inverse* relationship between $s_1 := q_1 / Q$, the retail market share of $n = 1$, and p^u . With

$$s_1 = \frac{1}{N} + \frac{(1 + \lambda^u)(N - 1)(N + \lambda^d + 1)}{N[N(M(2 + \lambda^d) - 1 + \lambda^u - \lambda^d) + 1 + \lambda^u + \lambda^d + \lambda^u \lambda^d]} \quad (18)$$

for the linear case, we can see immediately that s_1 is equal to $1/N$ only when there is perfect upstream Bertrand competition. Otherwise, it is always

greater than $1/N$. By taking the derivative of equation (18), we have that a high market share of the integrated firm is an indicator and result of:

- A smaller number of independent downstream firms $n = 2, \dots, N$. This is intuitive as an increase in N essentially scales up the segment of the retail market that is served through the merchant market. Precisely, though each one of the downstream firms produces less the higher N , in aggregate they take away market share from the integrated firm. Note, however, that N has *no* effect on p^u .
- High downstream competition, as proxied by λ^d . Though a reduction of λ^d , which intensifies retail competition, also lowers p^u , with linear demand this is not sufficient to compensate for the direct effect, namely that market share flows to the more competitive firm $n = 1$.
- Low upstream competition: s_1 increases both when M goes down and when λ^u goes up. A less competitive merchant market results in a higher equilibrium price p^u , which places the nonintegrated downstream firms at a further competitive disadvantage.

If a larger market share of $n = 1$ is due to the fact that the retail market is more competitive, then a comparison in s_1 is indeed informative about the constraints imposed from indirect substitution. However, s_1 could also be high as there is little competition between the remaining independent suppliers. In this case, s_1 and p^u would increase jointly.

A similar message emerges from analyzing the case with differentiated products, where the market share of the integrated firm in the retail market is

$$s_1 = \frac{2M + \gamma(N - 1)}{2 + \gamma(N - 1) + 2N(M - 1)}.$$

As in the previous case, s_1 is higher the smaller the number of independent downstream firms and the lower the number of upstream firms. In addition, we can now also see the role of product differentiation. In analogy to a change in λ^d , a high γ leads to a low s_1 .

IV. VERTICAL INTEGRATION WITH CONTINUED PARTICIPATION IN THE MERCHANT MARKET

A. Preview of Key Results

We assumed so far that the integrated firm cannot participate in the merchant market, say for technological reasons. In this section, we analyze both when nonparticipation is also an equilibrium outcome for purely *strategic* reasons and what the equilibrium outcome is if this is not the case. Again, we first summarize our key insights.

1. If an integrated firm still participates in the merchant market, or is likely to participate after an upstream merger, then this can considerably complicate the analysis of the merchant market.
 - (a) A forward integrated firm faces opportunity costs from selling on the merchant market, given that this will imply lost sales and/or a lower price on the retail market.
 - (b) As these opportunity costs are endogenous and vary with, in particular, the prevailing retail price, generally an estimation of ε^u and costs based on the (standard) assumption of asymmetric but *constant* marginal costs for upstream firms is inappropriate.
 - (c) In particular, for merger analysis, if the opportunity cost was wrongly taken and estimated as being constant, then the “true” effect of a merger would be underestimated. This is because the output expansion of the vertically integrated firm, following a merger of other suppliers, would be overestimated.
 - (d) However, the opposite conclusion, namely that the impact of a merger would be overestimated, applies if an integrated firm does not sell on the merchant market before the merger of competing suppliers and if this is erroneously assumed to be also the case after the merger.
2. To assess the incentives for a vertically integrated firm to sell (or to sell more) on the merchant market. Our analysis points to the following factors:
 - (a) Incentives are higher if there are fewer upstream independent suppliers,
 - (b) but also if competition, as captured again by conjectural variations, is stronger. The latter result follows from the fact that, if competition is more intense, and thus closer to Bertrand, then the participation of the integrated firm will tend more to take away market share from other suppliers without resulting in much higher total sales.

B. Incentives to Participate in the Merchant Market

The formal analysis on when an integrated firm still finds it optimal to sell on the merchant market, even though this will compromise its profits on the retail market, is straightforward. Starting from a candidate equilibrium without participation, we only need to check whether a marginal deviation for the forwards integrated firm $m = 1$ to supply $q^1 > 0$ would be profitable or not.²¹ (Note that to avoid confusion we now denote supplied quantities in the upstream market by q^m and those in the downstream market by q_n .) Whether this is profitable depends on a trade-off between realizing profits on the upstream market and, through reducing p^u and thereby increasing competition among downstream firms, losing profits on the retail market.

²¹ Of course, this presumes a sufficient degree of concavity in profit functions.

As at $q^1 = 0$ the marginal profits from selling at the upstream markets are just $p^u - c^u$, this is profitable if

$$p^u - c^u > -\frac{dQ^u}{dq^1} \frac{dp^u}{dQ^u} \frac{d}{dp^u} [q_1 [P(Q) - c^u - c^d]], \quad (19)$$

where the right-hand side of equation (19) walks through the mechanism by which $q^1 > 0$ affects the firm's retail profits, namely through the resulting equilibrium change in total supply on the merchant market, Q^u , which through a reduction in p^u then affects retail competition and, consequently, retail profits $q_1 [P(Q) - c^u - c^d]$. After some transformations, we obtain the following result.

Result. *The integrated firm, $m = n = 1$, will still find it profitable to participate on the merchant market if at the equilibrium outcome where it did not participate it would hold that*

$$\frac{p - c^u}{1 + \lambda^u} > \left(\frac{P - c^u - c^d}{1 + \lambda^d} \right) \frac{dp^u}{dQ^u} \left(-\frac{dq_1}{dp^u} \lambda^d + \frac{dQ^u}{dp^u} \right). \quad (20)$$

For the case of Cournot conjectures at the downstream market, $\lambda^d = 0$, (20) simplifies to

$$\frac{p^u - c^u}{1 + \lambda^u} > p^d - c^u - c^d. \quad (21)$$

There are some immediate observations that follow from equation (21). In our technical paper we work out in detail which implications hold for general demand functions and which implications hold in addition for the case of linear demand, for which we have explicit conditions.

- An increase in M makes participation *less attractive*, provided that the pass-through rate is not too high.²² Intuitively, an increase in M results in a reduction of *both* p^u and p^d , thereby affecting both the benefits of the integrated firm and its costs of setting q^1 . If the pass-through rate is not too high, which is always the case with linear demand, then the first effect dominates.
- With upstream Cournot conjectures, $\lambda^u = 0$, there is no participation as equation (21) transforms to $p^d < p^u + c^d$, which does not hold. In short, the integrated firm has no incentive to participate on the upstream market as there is a bigger margin to be protected downstream.
- As the mode of competition on the upstream market becomes fiercer, that is, more like Bertrand as λ^u decreases, then it becomes *more* likely that the integrated firm will still sell on the merchant market. This seems at first counterintuitive compared with the comparative statics in M , the other

²² Generally, a sufficient condition for this to hold is that the pass-through is not above one.

measure of competition on the upstream market. However, the two situations are clearly different because, for a given number of upstream firms, the participation decision can, for low λ^u , sufficiently “displace” the upstream rivals that, in equilibrium, end up producing less when upstream competition is made more intense.

- The impact of conditions on the retail market is, in general, ambiguous. While we find for a large range of parameters that an increase in N increases incentives to participate, given that this allows indirectly to recoup market share on the retail market that would otherwise be lost, we find that the opposite result could prevail if downstream competition is very fierce. In the latter case, both the increase in N and the reduction in λ^d push up the pass-through rate sufficiently such that a reduction in p^u through the firm’s participation on the merchant market would have too large an effect on the retail price to make participation profitable.

With linear demand, we also analyze the case of differentiated goods. Here, the results are very intuitive: Incentives to sell on the merchant market are higher if goods are more differentiated. Still for the linear case with differentiated goods, we also find the following stark result. Recall that, when we exogenously specified that there was no participation, then the merchant price was strictly lower under vertical integration, that is, $p_{VI}^u < p_{NVI}^u$, if and only if goods were not too differentiated. As goods become more heterogeneous, however, also incentives to participate increase. We can show that the increase in participation by the vertically integrated firm is more than sufficient to ensure that $p_{VI}^u < p_{NVI}^u$ holds now always. That is, in the linear (differentiated) case the reduction in direct constraints, taking into account that the integrated firm may only scale back its sales on the merchant market instead of fully withdrawing from it, is always more than compensated for by the increase in indirect constraints.²³

We next summarize some of the obtained results.

Result. *A forwards integrated firm may still find it optimal to sell on the merchant market, albeit to lesser extent than if the firm was not integrated. Its incentives to sell to other retail firms, and thus the direct constraints that it still exerts on the merchant market, are higher if, in particular, there are fewer other upstream firms or if retail products are more differentiated.*

Once participation is taken into account, we obtain for the case with linear demand that the wholesale price p^u is always lower under vertical integration. In particular, as retail goods become more differentiated, which makes indirect constraints weaker, the integrated firm will scale up its sales on the merchant market, thereby increasing again direct constraints.

²³ In principle, the integrated firm could also *buy* on the merchant market, thereby raising the costs of competing retail firms. In the linear case we can show that this would be optimal whenever goods are sufficiently homogeneous. Even if such (anticompetitive) purchases were feasible, however, the merchant price would still be lower under vertical integration.

C. Assessment of Market Power

In this section, we turn again to somewhat more practical issues regarding the assessment of market power. Here, we confine ourselves to considering a proposed merger of two upstream firms. As we argue, taking a somewhat “naive” approach to the assessment of the possible impact of a merger may lead to two types of systematic mistakes.

The first type of mistake could arise if one does not appropriately take into account the possibility that integrated firms could start to sell also on the merchant market following a change in market structure. If this is technologically feasible, then an integrated firm’s incentives to participate in the merchant market are strictly higher the fewer other suppliers there are, implying that they are higher after the envisaged merger of competing suppliers. Consequently, if this was not taken into account, then the impact of the merger would be systematically overestimated.

The second type of mistake arises also from taking as a given the incentives of the integrated firm, though now this leads to a systematic underestimation of a merger’s impact. If a vertical integrated firm already participates in the merchant market, then “standard techniques” are applied and we are likely to now overestimate the extent to which the integrated firm increases its sales on the merchant market following an upstream merger. In what follows, we explore this second, somewhat less immediate, observation in more detail.

As also noted previously, there exist well-known procedures for the joint estimation of sellers’ constant marginal costs and the elasticity of demand. Without vertical integration and even in case of vertical integration where integrated firms cannot participate in the merchant market, these techniques are applicable to the estimation of derived demand. As a vertically integrated firm that participates in the merchant market has a smaller market share, given that it takes into account the cannibalization of profits on the retail market, this would be taken into account by a higher estimate of marginal costs. More precisely, the difference in costs would simply reflect the integrated firm’s *opportunity* cost of lost sales or lower prices at the retail market. However, while it may often be reasonable to assume that marginal costs of production are constant, at least over the relevant range, this does not hold for the integrated firm’s opportunity costs. Taking for brevity only the case with Cournot conjectures ($\lambda^d = \lambda^u = 0$), we obtain the following result.

Result. *Under Cournot conjectures, the integrated firm’s total marginal costs of increasing its sales on the merchant market, that is, the sum of its marginal costs of production c^u and its opportunity costs, are in equilibrium given by $P - c^d$. This opportunity cost is strictly larger than c^u , and it is also strictly decreasing in the total volume Q .*

The fact that the opportunity cost is not constant, but rather is a strictly decreasing function of total retail sales Q and thus also of wholesale sales Q^u , if ignored when assessing market power, will tend to overestimate the effects arising from participation of the integrated firm, and thus to

underestimate the extent of market power of the other upstream firms. In our technical paper, we illustrate this by providing precise expressions for the systematic error that one would make under linear demand when taking the opportunity costs of the integrated firm to be constant.

V. CONCLUDING REMARKS

The question of how to treat indirect constraint and captive sales correctly has become of major importance in Europe. As we noted in the Introduction, the (im-)proper treatment of indirect constraints has lead the CFI to overturn the Commission's decision in the proposed merger of Schneider and Legrand. Moreover, with regards to the definition of the wholesale broadband access market there is an ongoing controversy between the Commission and some National Regulatory Authorities, centering on the question of whether to incorporate indirect constraints already at the stage of market definition.

We hope that the insights and results presented in this paper somewhat inform these debates. Based on a specific model of how wholesale markets operate, we derived a series of results both on the role and scope of indirect constraints as well as on the formally correct way of how to incorporate them into an assessment of market power.

Throughout the paper, we have somewhat avoided taking a clear stance on the question of market definition, or more precisely of whether to take into account indirect constraints already at the stage of market delineation or only at the later stage of the assessment of market power. In principle, all approaches should lead to the same outcome. Regardless of whether this is already sufficiently done so at the market definition stage, ultimately all relevant competitive constraints have to be taken into account to assess market power correctly. In other words, if all relevant factors are taken into consideration and if the applied economic model is the correct one, then the particular procedure should ultimately be irrelevant.

In practice, however, neither the "right" economic model to assess market power is known nor is typically all the required data available, in particular not in the short time that antitrust authorities or regulators usually have to decide whether to refer a case or whether to conduct a more detailed market inquiry. The precise procedural steps and how they are undertaken may well matter in practice. For instance, if absent better information market shares are used as a prescreening device, then the particular delineation of the market is crucial. With this background, we want to conclude by taking, albeit cautiously given the limited research in this area, side with a procedure that preserves a clear distinction between the wholesale and the retail market and, thereby, between direct and indirect constraints.

As we have shown in this article, in the chosen formal model the correct way to incorporate indirect constraints is through the elasticity of indirect demand. Direct constraints, including both the present and potential participation of

integrated firms on the merchant market, are then taken into account when solving for the upstream equilibrium. Hence, if the elasticity of derived demand was known, or estimated, with sufficient precision, then additionally taking into account captive sales of integrated firms by calculating retail market shares would not be necessary. What is more, a reliance on these additional measures may run the risk of “double counting.”

To see why, suppose that, in the absence of sufficient reliable data to conduct a full-scale estimation, an analyst collects various information about both the wholesale and the retail market. For the wholesale market, this information should relate, in particular, to measures that indicate, say based on survey evidence, how any given supplier’s sales are likely to respond to changes in prices. Importantly, such information already incorporates indirect constraints. Even if nonintegrated suppliers have low retail market shares, this information cannot be used as an additional defence. For instance, if the analysis of the wholesale market suggests that sales are not very responsive to changes in firms’ prices, then this clearly holds *despite* the presence of indirect constraints, which make derived demand more elastic.

Moreover, the (naive) use of retail market shares may also be misleading. While, as we noted above, small retail market shares of nonintegrated suppliers may indeed be indicative of strong indirect constraints, they may also be the outcome of weak direct constraints on the merchant market. We feel that these different factors may be more readily disentangled and identified by keeping distinct the analysis of the wholesale and of the retail market.

This as well as the preceding implications and conclusions all hinge on the particular model that we have chosen for our analysis. Generally, it is well known that the analysis of intermediate goods markets is quite sensitive to the choice of the particular (modeling) framework. The analysis of indirect constraints should certainly not be an exception to this. For the insights developed in this article, we have taken the perspective that intermediate goods are traded on a market that is captured adequately by strategically behaving sellers and a (derived) demand curve. In work that we are currently undertaking, we take the somewhat orthogonal perspective of bilaterally negotiated supply contracts, which would be more adequate for differentiated wholesale goods and if suppliers and buyers were to some extent locked into their relations. There, we show that it may then no longer be always meaningful to take into account simultaneously direct and indirect constraints.

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