Backward integration and monopsony power*

Philippe Choné* Laurent Linnemer* Thibaud Vergé†

January 31, 2020

Abstract

We show that contractual limitations are not necessary for double marginalization to emerge in procurement markets. This distortion may result from monopsony power and asymmetric information about the suppliers' costs. Its magnitude critically depends on the buyer's commitment ability. It increases with the costs incurred by the buyer and the winning supplier should they renegotiate the terms of trade.

We use this framework to study the welfare effects of backward integrations by monopsonistic buyers. First, such integrations may be pro-competitive (through the elimination of double mark-up) even though nonlinear tariffs were used prior to the merger. Second, backward integrations tend to harm consumers when renegotiation costs are low and the suppliers are ex ante symmetric. Third, when the upstream division is more efficient than the competing suppliers, they help restore allocative efficiency and may benefit consumers even when renegotiation costs are low.

JEL codes: L1, L4, D4, D8

Keywords: Monopsony power, asymmetric information, double marginalization, backward integration, optimal procurement mechanism.

*We are grateful to Giacomo Calzolari, Tobias Gamp, Fabian Herweg, Philippe Jehiel, Laurent Lamy, Raphael Levy, David Martimort, Volker Nocke, Martin Peitz, Armin Schmutzler, Roland Strausz, Thomas Tröger, Nicolas Vieille for constructive comments. This research is supported by a grant of the French National Research Agency (ANR), "Investissements d'Avenir" (LabEx Ecodec/ANR-11-LABX-0047).

†CREST, ENSAE ParisTech, 5 Avenue Henry Le Chatelier, F-91120 Palaiseau (France). Please address any correspondence to philippe.chone@ensae.fr.

1 Introduction

Vertical integration is often perceived as a source of efficiency benefits, the archetype of which is the elimination of double marginalization. As explained by Spengler (1950), suppliers endowed with market power charge prices to intermediate buyers that exceed their marginal cost, which combined with downstream mark-ups results in inefficiently low quantities and high retail prices. Suppressing the distortion is therefore associated with an increase in consumer surplus –the primary objective of competition policy.

The antitrust standards that should be applied to claims of elimination of double marginalization (henceforth EDM) are subject to intense policy discussions, in particular in the United States. Salop (2018) criticizes the perception of such claims as "intrinsic" efficiency justifications, arguing on the contrary that they do not deserve to be silver bullets in vertical merger cases. Although the treatment of double marginalization is not addressed by the non-horizontal guidelines currently in force, it is the subject of a whole section of the new draft circulated by the Department of Justice.[1] The draft shifts the burden of proving that the merger eliminates double marginalization onto the merging parties. Recent practice also shows growing skepticism by U.S. enforcers about EDM claims. For instance, the Department of Justice concluded in the *Comcast-NBCU* merger that "much, if not all, of any potential double marginalization is reduced, if not completely eliminated, through the course of contract negotiations."[2]

By contrast, European enforcers explicitly insist that they take EDM claims into account only if they benefit consumers and are merger-specific.[3] During the merger review process, the Commission challenges whether the problem of double mark-ups is present or significant pre-merger, and checks that the problem may not be solved by other means (e.g. vertical agreements) that achieve similar benefits with less anticompetitive effects.

Industrial Organization models with complete information are ill-suited to inform the treatment of EDM claims in vertical mergers. In such environments, only strong contractual limitations such as the restriction to linear prices can explain the presence of double marginalization. Allowing for two-part tariffs guarantees the elimination of double marginalization, which therefore cannot be merger-specific.[4] In most industries, the assumption that the suppliers costs are common knowledge is not realistic.

The purpose of this paper is twofold. First, we show that double marginalization is present at the equilibrium of the basic procurement model under asymmetric information, and examine how the degree of buyer power affects the severity of the double mark-up problem. Second,

[1]See Section 6 of the draft Vertical Merger Guidelines posted by the Department of Justice in January 2020 for public comment, available at https://www.justice.gov/opa/press-release/file/1233741/download. The current merger guidelines (U.S. Department of Justice (1984)) have not be revised seen 1997, see Salop and Culley (2016).

[2]Competitive Impact Statement at 30, United States v. Comcast Corp., 808 F. Supp. 2d. 145 (D.D.C. 2011) (No. 1:11-cv-00106), http://www.justice.gov/atr/case-document/file/492251/download or http://perma.cc/LE6C-U37X.

[3]See EU Non-Horizontal Merger Guidelines, European Commission (2008), para. 53 and footnote 7.

[4]In the case of a single buyer, the fixed part would be set at the minimum level insuring participation of the most efficient supplier. The integration of the buyer with a supplier does not affect the equilibrium allocation or the consumer surplus.

we derive implications regarding the welfare effects of backward integrations by monopsonistic buyers, and highlight forces that can be pro- or anticompetitive depending on how the monopsony power is exercised and on whether the suppliers are symmetric or asymmetric.

Our setting has a single buyer who purchases a homogenous input from a number of potential suppliers on an upstream market. The buyer is also active as a seller on a downstream market where she sells a final good to consumers. Central to our analysis is the elasticity of the final demand. The upstream and downstream markets are connected in the sense that decreases in the wholesale price (i.e., in the marginal price of the input) are passed on to final consumers through the retail price. On the contrary, lump-sum decreases in the total upstream price (i.e., decreases that are independent of the purchased quantity) do not benefit consumers. The suppliers have heterogenous and unobserved constant marginal costs. Each supplier privately observes his cost, and the distributions of the costs, which are not necessarily symmetric, are common knowledge.

In this framework we ask whether double marginalization can arise pre-merger. For that purpose, we first assume that the buyer's commitment power is unlimited in the sense that she can resort to a revenue maximizing (quantity) auction *à la* Myerson. We find that the full exercise of monopsony power requires the buyer to commit to purchase a quantity that does not maximize his and the winning supplier's joint profit. Specifically, the buyer lowers the input quantity below its efficient level to reduce the informational rent left to her supplier. Hence the double mark-up problem is not an artefact cause by some contractual limitation, but rather is a key part of the optimal procurement mechanism.

We then relax the assumption that the buyer has perfect commitment ability, allowing for the possibility of efficient renegotiation with the winning supplier. If the renegotiation is costless and the buyer cannot commit not to renegotiate, no double marginalization prevails: the input quantity, which must be efficient, cannot be used to extract supplier's rents, and the selection of the supplier is the only available screening device. If renegotiation entails positive costs, the buyer optimally restricts to renegotiation-proof procurement contracts, thus retaining some limited commitment power. The severity of the double mark-up problem increases with the level of the renegotiation costs.

Turning to the welfare of effect of vertical mergers, we highlight two main forces. First, we find that merging with a supplier eliminates double marginalization even if post-merger the buyer still does not know the cost of her upstream division. Under the optimal procurement mechanism, everything is *as if* she knew that cost. Here, the EDM is merger-specific: it is made possible by the merger and could not have been achieved otherwise as no contractual limitations are assumed prior to the merger. The effect, which again exists even though nonlinear tariffs were used pre-merger, is pro-competitive or at worse is neutral for welfare and consumers. Its strength increases with the buyer's commitment power.

The second force concerns the make-or-buy choice post-merger. It is not optimal for the buyer to remain fully exclusive with her upstream division. Rather, the buyer lets her internal division compete with the other suppliers. As the buyer internalizes the profit of her upstream division and dislikes paying rents to outside suppliers, the optimal mechanism creates a bias towards buying internally, which we call the rent-avoidance effect. This bias may be welfare-enhancing or welfare-detrimental depending on the distributions of the suppliers' costs. It is welfare-enhancing when the upstream division of the merged entity is much more efficient than its rivals, because it then contributes to attenuate the allocative inefficiency inherent to the optimal Myerson procument mechanism. Otherwise, the in-house bias is welfare-detrimental because it creates or aggravates an inefficient asymmetry in the Myerson mechanism.

Under full commitment –or equivalently under infinite renegotiation costs, the vertical integration unambiguously benefits consumers regardless of the distributions of the costs, which reproduces the Chicago-style argument in a framework with asymmetric information. The effect on total welfare is less clear-cut, as the EDM is welfare-enhancing and the in-house bias is most often welfare-detrimental as explained in the previous paragraph. By contrast, backward integrations tend to harm consumers when renegotiation costs are low and the suppliers are ex ante symmetric. Third, when the upstream division is more efficient than the competing suppliers, they help restore allocative efficiency and may benefit consumers even when renegotiation costs are low.

Literature review We build and expand on strands of literature concerned with the welfare effect of mergers, the modeling of asymmetric information in Industrial Organization, and contract theory with limited commitment.

The closest papers to our study are Loertscher and Riordan (2019) and Loertscher and Marx (2019a), who rely on a procurement framework with asymmetric information similar to ours. While Loertscher and Marx endow the buyer with monopsony power as we do, we differ from them in three important dimensions: their focus is on the effects of a horizontal merger between two suppliers, whereas ours is on the backward integration of the buyer with one supplier; they have a single-unit demand, while we posit an elastic buyer demand and examine the quantity distortion due to double marginalization; we allow the extent of the distortion to vary with the possibility of renegotiation, while they do not (see below for more on this issue). In the former paper, Loertscher and Riordan do study the profitability of vertical integration but in a context with limited buyer power and single-unit demand. In their paper, buyer power is limited in the sense that the buyer cannot run an optimal procurement procedure à la Myerson (1981). She can only run a first-price auction and grant a right of first refusal to her upstream division (ROFR and first-price auction literature). Despite the lack of buyer power, vertical integration would always be profitable due to a force the authors call the "markup-avoidance effect", which is close to our rent-avoidance effect. However, Loertscher and Riordan allow the suppliers after the vertical integration to invest to reduce their production costs. The vertical integration reduces investment incentives by the outsiders which is likely to outweigh the markup-avoidance effect if the upstream market is more competitive.

In our paper, the manufacturer has buyer power and we neglect the effect of vertical integration on efficiency enhancing investments.[5] These investments are either sunk at the time of the vertical integration decision or they are driven by other market considerations. Typically, our manufacturer is not the only client of these suppliers. Moreover, our focus is not only on the

[5]Moreover, as we allow for the suppliers to be asymmetric in terms of the distributions of their costs, including investments would be more complicated to study and this question is left for future research.

vertical integration decision but also on what the firms can achieve when vertical integration is forbidden.

Next, many insightful papers on the topic of procurement under asymmetric information have been written. Many of them build on the seminal work of Myerson (1981) and Baron and Myerson (1982). The main insight is that the buyer (in Baron and Myerson case a regulator) does not procure the first best quantity (which is based on the marginal cost) but a smaller distorted quantity (which is based on the virtual marginal cost). However in most of these regulation/procurement models the buyer does not resale to final consumers and there is only one supplier. In presence of several potential suppliers, auctioning contracts has been studied by both Laffont and Tirole (1987) and McAfee and McMillan (1986) . The two papers take a regulation perspective and quantity is fixed. What is auctioned is a project which (gross) social value is fixed and the regulator's goal is to minimize costs (including the social cost of money transfers). The winner of the auction stage then makes an (unobservable) effort to reduce the cost. These models combine adverse selection and moral hazard.

Riordan and Sappington (1987) (see also McAfee and McMillan (1987)) is a model with variable quantity.[6]

Dasgupta and Spulber (1989) also study procurement of a variable quantity (and also combine Baron and Myerson's technics with an auction). On one hand, their model is simpler than Riordan and Sappington's model as there is no effort made by the winning supplier to reduce costs. On the other, they allow for convex cost function. They compare three classes of mechanisms: (I) sole sourcing with output chosen in advance by the buyer; (II) sole sourcing with the output determined by cost revelation and an optimal quantity schedule; and (III) multiple sourcing with the output allocation across suppliers determined by cost revelation and an optimal quantity allocation schedule. It is apparent that type III mechanisms yield greater net benefits than type II mechanisms, which in turn dominate type I mechanisms.

Dasgupta and Spulber's results are discussed in Chen (2007) and Duenyas, Hu, and Beil (2013).

We extend this literature by explicitly considering double marginalization and by studying the consequences of vertical integration.[7] The literature on backward integration in IO emphasizes several antitrust concerns. The most famous is probably the "raising rival's cost" phenomenon Ordover, Saloner, and Salop (1990) [8] Riordan (1998) (see also Linnemer (2003) Loertscher and Reisinger (2014)) ; Hart and Tirole (1990) bargaining effect De Fontenay and Gans (2004) (see also Reisinger and Tarantino (2015)) ; hold-up problems for rivals Allain,

[6]The timing in the model is as follows. First, the firms (costlessly) acquire private signals about their respective technologies. Second, the regulator announces the terms of the bidding procedure (i.e., the menu of contracts). Third, each firm simultaneously announces a bid for the franchise. Next, the franchise is awarded to the highest bidder. The winning bidder then pays the requisite franchise fee. Next, the winning bidder incurs fixed costs, learns marginal production cost, and makes a report about the realized cost parameter. Next, the regulated price is established and production occurs to fulfill demand. Finally, sales revenues flow to the producer, who also receives the production subsidy specified in the franchise contract.

[7]Regarding efficiency motives for vertical integration there is an embarrassment of riches, see Gibbons (2005) and the Handbook of organizational economics Gibbons and Roberts (2012). For example, vertical integration can eliminate inefficient bargaining ex-post (rent seeking), Williamson (1971) and Klein, Crawford, and Alchian (1978).

[8]See also the comment by Reiffen (1992) and the authors' reply Ordover, Saloner, and Salop (1992).

Chambolle, and Rey (2016) Here, we assume that the buyer has both monopoly power (downstream) when selling to final consumers and monopsony power upstream (when buying the input). We therefore exclude the foreclosure or raising rivals' costs theories of anticompetitive vertical integration.

In this paper, we weaken the commitment power of the buyer by allowing efficient renegotiation with the winning supplier. Our weakened notion of buyer power is different from that of Loertscher and Marx (2019b). Extending the merger review analysis of Loertscher and Marx (2019a), the authors model intermediate buyer power through the specification of her objective function, namely a positive weight given to the profit of the suppliers. By contrast, we consider the bilateral relationship with the winning supplier rather than the set of all suppliers, and an elastic demand rather than in singme-unit environment. Our approach is more in the spirit of Baron (1988) Green and Laffont (1992) Green and Laffont (1994) . Emipirical papers: Reduced-from studies Hortaçsu and Syverson (2007) Atalay, Hortaçsu, and Syverson (2014) (see also Atalay, Hortaçsu, Li, and Syverson (2019)) The structural literature often assumes linear pricing. Crawford, Lee, Whinston, and Yurukoglu (2018)

As alluded earlier, a central element of our procurement model is the buyer power of the manufacturer.[9] We use the same definition as Bulow and Klemperer (1996) and Loertscher and Marx (2019a): a manufacturer with buyer power and can run a revenue maximizing auction, i.e. *à la* Myerson (1981). With no buyer power and she can only use a standard auction. Admittedly this is a zero-one definition. Either a manufacturer has or she has not it. Yet, to quote Loertscher and Marx "It is useful to think of buyer power as consisting of both bargaining power, which captures the ability of the buyer to discriminate among suppliers, and monopsony power, which is the buyer's ability to set a binding reserve price." See also Chen (2008) for a similar point and a general discussion.

The paper is organized as follows. Section 2 presents our framework, showing that it encompasses both selling and procurement situations. Section 3 presents the revenue maximizing mechanism under vertical separation. Section 4 explains the effects of vertical integration. Section 5 offers various extensions, in particular addresses the decision to merge and the choice of the target by the acquiring buyer.

2 Framework

A buyer B contemplates a new business opportunity which requires an essential input. This input can be procured from one of several suppliers denoted $S_0, S_1, \dots, S_n$. These (risk neutral) firms produce with a constant marginal cost c_0, $c_1, \dots, c_n$, which are independently drawn from distributions F_j, $j = 0, 1, \dots, n$, with supports $[\underline{c}_j, \bar{c}_j]$. The buyer transforms one unit of input into one unit of output and sells this output to final consumers. Selling a quantity q generates a revenue $R(q)$ from which B should deduce the procurement costs. For example, $R(q) = P(q)q - C(q)$ where $P(.)$ is the inverse demand and $C(.)$ is B's cost of production.

[9] In a companion paper we study the case the manufacturer lack buyer power and can only run a standard auction instead of a revenue maximizing auction.

Let $\Pi(q,c) = R(q) - cq$ be the joint profits for a quantity q of B and of a supplier with cost c. Moreover let $q^m(c) = \arg\max_q \Pi(q,c)$ and $\Pi^m(c) = \max_q \Pi(q,c)$ we make the usual assumptions insuring that $q^m(c)$ is unique and decreasing with c.

Without loss of generality we can assume that q.

The manufacturer, B, is endowed with *buyer power*, defined as the ability to run a revenue maximizing auction, Myerson (1981). In practice, B can run a second price auction where the bids are distorted in a discriminatory way and where B can impose a reserve price to the winner.

Procurement mechanisms Without loss of generality, the manufacturer can optimize by using direct mechanisms where each supplier reports a cost to B and for each vector of announcements $\widehat{\mathbf{c}} = (\widehat{c_0}, \widehat{c_1}, \cdots, \widehat{c_n})$ the mechanism indicates the probabilities of being selected $\mathbf{X} = (X_0(\widehat{\mathbf{c}}), X_1(\widehat{\mathbf{c}}), \cdots, X_n(\widehat{\mathbf{c}}))$, the quantities $\mathbf{Q} = (Q_0(\widehat{\mathbf{c}}), Q_1(\widehat{\mathbf{c}}), \cdots, Q_n(\widehat{\mathbf{c}}))$ produced by each suppliers and the payment $\mathbf{M} = (M_0(\widehat{\mathbf{c}}), M_1(\widehat{\mathbf{c}}), \cdots, M_n(\widehat{\mathbf{c}}))$ made by the manufacturer to them. In such a mechanism, for a given $\widehat{\mathbf{c}}$, the utility of supplier i writes:

$$(M_i(\widehat{\mathbf{c}}) - c_i Q_i(\widehat{\mathbf{c}}))\, X_i(\widehat{\mathbf{c}})$$

Admittedly, $\mathbf{X}$ and $\mathbf{Q}$ are slightly redundant but it proves more convenient to keep both.

First-best benchmark In this framework, the first best is obtained whenever the supplier with the lowest marginal cost is selected. This is easily achieved without vertical integration through an inverse second price auction with no reserve price.

Limits to buyer power In section 3.1 we impose no limit to buyer power whereas in section 3.2 we assume that B cannot commit not to renegotiate with the winner of the procurement mechanism. The effect of vertical integration on consumers' surplus crucially depend with the renegotiation possibility. In section 3.3 the extent of renegotiation is limited by a renegotiation cost.

Virtual costs We define the virtual costs as

$$\Psi_i(c) = c + \frac{F_i(c)}{f_i(c)}, \quad i = 0 \text{ to } n \tag{1}$$

and we assume they are nondecreasing functions of c.

3 Vertical separation

In this section, we study the procurement procedure followed by B. For that purpose, we built on the work of Dasgupta and Spulber (1989).

3.1 Full buyer power

Proposition 1 details the revenue maximizing mechanism used by B which has a flavour of Myerson's revenue maximizing auction but takes into account the quantities.

Proposition 1. *The optimal revenue maximizing mechanism leads to double marginalization. The buyer B procures exclusively from the supplier i^* with the smallest virtual cost. The quantity ordered is $q^m(\Psi_{i^*})$ provided that $\Pi(q^m(\Psi_{i^*}), \Psi_{i^*}) \geq 0$.*

Proof. See Appendix A.3 □

Example 1. *Assume all c_i are uniformly distributed over $[0,1]$ and $R(q) = (a-q)q$. As $F(c) = c$ and $f(c) = 1$, the virtual cost is $\Psi(c) = 2c$. The monopoly quantity $q^m(c) = (a-c)/2$ and $\Pi(q^m(2c), 2c) = (a-2c)^2/4$. Hence the manufacturer select the supplier with the lowest cost if lower than $a/2$ and order the quantity $(a-2c)/2$. Assuming $a \geq 2$ is enough to insure that the equilibrium quantity is always positive.*

The most striking property from an IO/Vertical relationship point of view is the presence of double marginalization. Indeed, when the winner has a marginal cost of c the quantity procured is $q^m(\Psi(c))$ and not $q^m(c)$. It is as if B were buying units at a unitary price of $\Psi(c)$ instead of c. The joint profit of B and the selected supplier is not maximized and consumers pay too high a price. A counterintuitive result at least at first sight.

A simple implementation is a discriminatory ascending auction followed by a take-it-or-leave-it offer by B to the auction winner.

What are the welfare effects of the procurement procedure followed by B?

3.2 Costless renegotiation

In this section, we assume that the buyer cannot commit not to renegotiate the quantity after the auction. Formally, we extend the mechanism of the previous section to include a renegotiation stage. The renegotiation is limited to the winner of the auction. In particular the buyer and the selected supplier always agree on a Pareto improving renegotiation. We are agnostic about the renegotiation procedure but we assume it is efficient. Our purpose is not to include artificially a source of inefficiency trough a specific bargaining game (under asymmetric information).

Proposition 2. *Efficient renegotiation ex-post implies that the buyer and the selected supplier share the complete information monopoly profit. That is, they maximize their joint profit and share it through a lump sum transfer which depends on the competitive offers. Costless renegotiation eliminates double marginalization.*

Proof. See Appendix A.2 □

Example 2. *Assume all c_i are uniformly distributed over $[0,1]$ and $R(q) = (a-q)q$. As $F(c) = c$ and $f(c) = 1$, the virtual cost is $\Psi(c) = 2c$. The monopoly quantity $q^m(c) = (a-c)/2$ and $\Pi(q^m(c), c) = (a-c)^2/4$. The virtual profit is $\Pi(q^m(c), c) - q^m(c) F(c)/f(c) = (a-c)(a-3c)/4$. Assuming $a \geq 3$ is enough to insure that the profit is always positive. The buyer selects the supplier with the lowest cost.*

3.3 Costly renegotiation

We assume that renegotiating the terms of trade entails a fixed cost K to be shared by the buyer and the winning supplier. We define $\underline{q}(c, K)$ as the lowest root of the equation

$$R\left(\underline{q}(c, K)\right) - c\underline{q}(c, K) = \pi^m(c) - K.$$

For the contractual quantity to be renegotiation-proof, it must be higher than the minimal quantity $\underline{q}(c, K)$. The function $\underline{q}$ is decreasing in c and does not depend on the supplier even if the distributions F_i are asymmetric.

Proposition 3. *Suppose that renegotiation entails cost $K \geq 0$. The buyer purchases $q_i^*(c_i; K)$ units of input, with*

$$q_i^*(c_i; K) = \begin{cases} q_i^*(c_i; \infty) = q^m(\Psi_i(c_i)) & \text{for small } c_i \\ \underline{q}(c_i; K) & \text{for large } c_i \end{cases}$$

from the supplier i that yields the highest virtual profit

$$\Pi_i(q_i^*(c_i; K), \Psi_i(c_i)) = R(q_i^*(c_i; K)) - \Psi_i(c_i) q_i^*(c_i; K). \tag{2}$$

When suppliers are symmetric, the most efficient supplier wins the contract.

Proof. The virtual profit decreases with c_i, hence when the suppliers are ex ante symmetric, the most efficient one serves the buyer. See Appendix A.3. The quantities are shown on Figure 1. □

Both the optimal quantity $q_i^*(c_i; K)$ and the virtual profit $\Pi_i(q_i^*(c_i; K), \Psi_i(c_i))$ decrease with c_i.

3.4 Implementation with two-part tariffs

In this section, we show that for any given level of the renegotiation costs the optimal procurement mechanism can be implemented by a dominant strategy auction with the winning supplier being given the opportunity to pick into a menu of two-part tariffs and the buyer finally deciding how much input she wants to purchase:

1. The suppliers report their cost $\hat{c}_i$;

2. The winner i is the supplier with the highest virtual profit $\Pi_i(q_i^*(c_i; K), \Psi_i(c_i))$. Let c_i^* be such that $\Pi_i(q_i^*(c_i^*; K), \Psi_i(c_i^*))$ is the second-highest value of $\Pi_j(q_j^*(c_j; K), \Psi_j(c_j))$

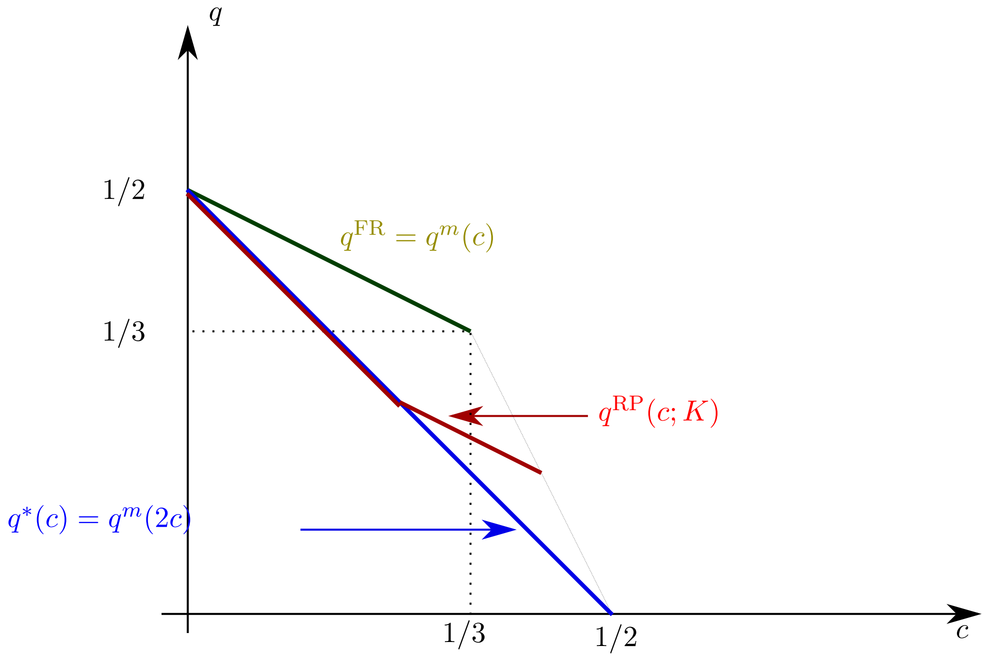


Figure 1: Optimal and renegotiation-proof quantities

. The winner i can pick his preferred price schedule in the menu of two part-tariffs $(w_i(\tilde{c}_i), M_i(\tilde{c}_i))$ indexed by $\tilde{c}_i \leq c_i^*$, with the wholesale price $w_i(\tilde{c}_i)$ and the fixed part $M_i(\tilde{c}_i)$ being given by:

$$w_i(\tilde{c}_i) = R'(q^*(\tilde{c}_i)) \quad \text{and} \quad [w(\tilde{c}_i) - \tilde{c}_i]q_i^*(\tilde{c}_i) + M_i(\tilde{c}_i) = \int_{\tilde{c}_i}^{c_i^*} q_i^*(c)\,\mathrm{d}c.$$

3. Facing the two-part tariff $(w_i(\tilde{x}_i), M_i(\tilde{x}_i))$ chosen by the winning supplier, the buyer chooses the quantity and pays according to the tariff.

As the virtual profits are decreasing function of c_i, the auction can be organized as a modified descending auction, applying the corresponding decreasing transformation of the bids.

Proof. At the last stage, the buyer chooses to purchase $q_i^*(\tilde{c}_i)$ because this choice maximizes her profit $R(q) - wq$ as $w_i(\tilde{c}_i) = R'(q^*(\tilde{c}_i))$.

At stage 2, the winner chooses $\tilde{c}_i$ to maximize

$$\max_{\tilde{c}_i}[w(\tilde{c}_i) - c_i]q_i^*(\tilde{c}_i) + M_i(\tilde{c}_i).$$

Reporting $\tilde{c}_i = c_i$ is equivalent to

$$[w(\tilde{c}_i) - c_i]q_i^*(\tilde{c}_i) + M_i(\tilde{c}_i) = \int_{\tilde{c}_i}^{c_i^*} q_i^*(c)\,\mathrm{d}c + [\tilde{c}_i - c_i]q_i^*(\tilde{c}_i) \leq \int_{c_i}^{c_i^*} q_i^*(c)\,\mathrm{d}c$$

The last inequality follows from the convexity of $\int_{\tilde{c}_i}^{c_i} q_i^*(c)$ in c_i:

$$\int_{\tilde{c}_i}^{c_i} q_i^*(c)\,\mathrm{d}c \leq [c_i - \tilde{c}_i]q_i^*(\tilde{c}_i).$$

At stage 1, supplier i anticipates that he is awarded the contract he will earn

$$\int_{c_i}^{c_i^*} q_i^*(c)\,\mathrm{d}c,$$

which does not depend on $\hat{c}_i$. The supplier's payoff therefore depends on his report $\hat{c}_i$ only through the allocation rule. As it is positive if and only if $c_i < c_i^*$, reporting $\hat{c}_i = c_i$ is a dominant strategy. □

4 Vertical integration

We assume that the buyer maximizes the joint profit of the merged entity. On the other hand, we do not assume that the merger eliminates the informational asymmetry within the merger entity. We show that it makes it free to extract the upstream division's cost and that the extent to which the upstream division internalizes the buyer's profit does not matter.

Proposition 4. *[Post-merger equilibrium] Suppose renegotiation entails cost $K \in [0, \infty]$. Then, after the vertical integration,the buyer compares*

- *the monopoly profit $\Pi^m(c_0)$ generated with its upstream division*
- *the virtual profit $\Pi_i(q_i^*(c_i; K), \Psi_i(c_i))$ generated with each of the rivals,*

allocating the contract to the supplier with the highest of these profits.

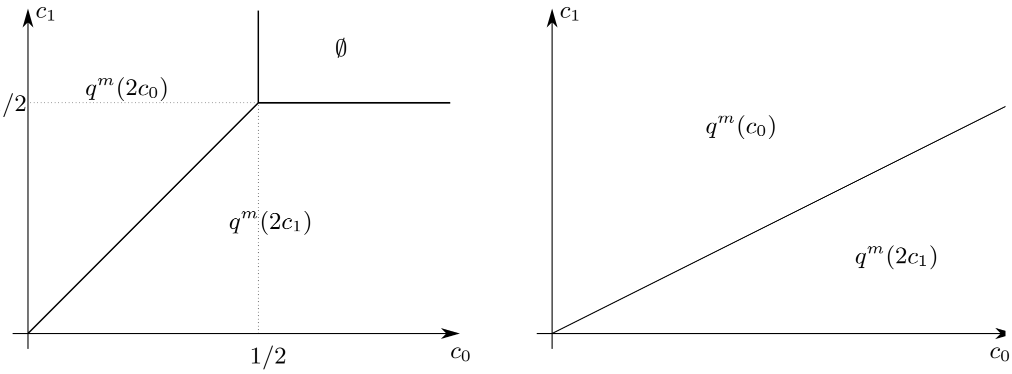
4.1 Full buyer power: EDM

We now study how vertical integration between B and S_0 modifies the optimal procurement. After vertical integration it is not assumed that B buys exclusively from S_0, on the contrary B still tries to procure at the lowest possible cost. Yet B internalizes the profits made by S_0.

Proposition 5. *Suppose that renegotiation costs are large. Vertical integration reduces double marginalization and unambiguously benefits consumers.*

Proof. The buyer B procures externally if the smallest virtual cost among the n outside suppliers is lower than the marginal cost of S_0 the internal division. If so the quantity ordered is $q^m(\Psi_{\min})$. Otherwise B procures internally and the quantity is set at $q^m(c_0)$. The probability of S_0 winning increases after vertical integration. Each time S_0 wins, the welfare is increased. Whereas welfare is unchanged when an outsider wins. □

Prior to vertical integration, the winning supplier and the purchased quantity are driven by the minimum of the virtual costs $\Psi_i(c_i)$. Post-merger, the winner and the allocation are driven by the minimum of the upstream division's cost $c_0 < \Psi_0(c_0)$ (the inequality reflects the EDM) and its rivals' virtual costs $\Psi_i(c_i)$. The elimination of the double markup leads to a change in the allocation that is always associated with a higher quantity and a higher consumer surplus., see Figure 2.



(a) Vertical separation

(b) Vertical integration

Figure 2: Effect of the merger under full commitment

4.2 Renegotiation

Proposition 6. *Suppose renegotiation costs are small and the suppliers are symmetric. The vertical merger harms consumers.*

The rent avoidance effect bias the choice towards the upstream division, which creates misallocation effect, see Figure 3.

Proposition 7. *Suppose now the upstream division is more efficient ex ante than its rivals. The vertical integration benefits consumers even when renegotiation costs are small.*

Buyer compares $\pi^m(c_0)$ and $\pi^m(c_1) - c_1 q^m(c_1)$

5 Discussion

Many contractual buyers If all potential competitors ex ante can contract with B and transfers are feasible, then the firms maximize their joint expected surplus. In particular, if all firms reject the option, then they all participate in a symmetric auction, and there is nothing to gain from agreeing on an option contract in the first place. It is nevertheless interesting to check that our main finding is robust to increasing the number of competitors with whom B can contract ex ante. To this aim, we now assume that B can contract ex ante firms $C_1, \ldots, C_k$, $k \geq 1$, but that ex ante contracting is not feasible with potential competitors $C_1, \ldots, C_n$, $n \geq 1$, who are fully rational. We stick to the IPV setting where B runs a first-price auction without reserve price if firms $C_1, \ldots, C_k$ all reject the option.[10]

[10]If many firms exercise the option, it is agreed that the good is allocated to the one with highest surplus.

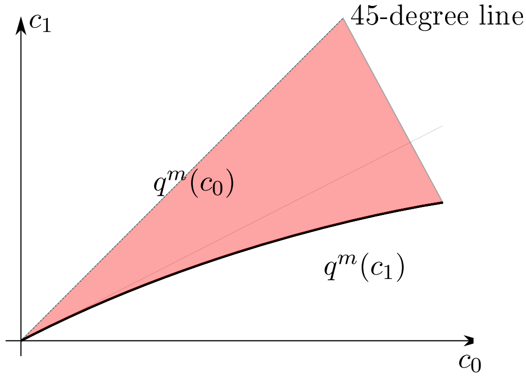
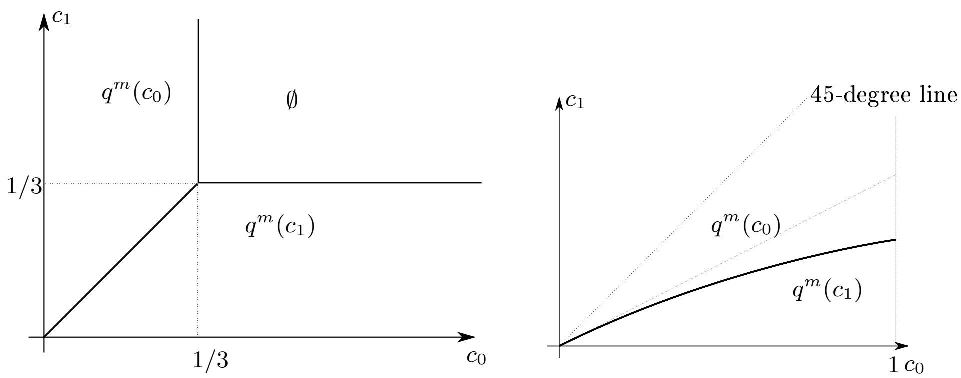


Figure 3: Vertical integration under costless renegotiation: Misallocation effect



(a) Vertical separation (b) Vertical integration

Figure 4: Effect of the merger under costless renegotiation

Choosing contractual buyer Two potential suppliers C_0 and C_1 with distributions F_0 and F_1 with densities f_0 and f_1. We assume that B can approach either suppliers and make them take-it-or-leave-it offer with a payment in exchange of VI.

Proposition 8. *If c_0 is lower than c_1 in the likelihood ratio order, then total welfare is higher when the buyer integrates with firm 0 than when it integrates with firm 1. As a result, the buyer prefers to integrate with firm 0.*

Proof. B prefers to approach C_0 if and only if

$$\Pi_{OM}^{0M} - \Pi_0^{1M} \geq \Pi_{1M}^{1M} - \Pi_1^{0M}$$

hence if and only if the total welfare is higher under $0M$ than under $1M$.

Welfare (compared to efficiency) loss when B integrates with C_0

$$L^{OM} = \iint_{w_0 \leq w_1 \leq \Psi_1^{-1}(w_0)} (w_1 - w_0) f_0(w_0) f_1(w_1) \,\mathrm{d}w_0 \,\mathrm{d}w_1$$

Same if when B integrates with C_1

$$L^{1M} = \iint_{w_1 \leq w_0 \leq \Psi_1^{-1}(w_1)} (w_0 - w_1) f_0(w_0) f_1(w_1) \, \mathrm{d}w_0 \, \mathrm{d}w_1$$

The latter can be rewritten, exchanging labels:

$$L^{1M} = \iint_{w_0 \leq w_1 \leq \Psi_1^{-1}(w_0)} (w_1 - w_0) f_0(w_1) f_1(w_0) \, \mathrm{d}w_0 \, \mathrm{d}w_1$$

We now make two observations. Since C_0 is greater than C_1 in the likelihood ratio order, we have: $f_0(w_1)f_1(w_0) > f_0(w_0)f_1(w_1)$. Second, it is a fortiori true that C_0 is greater than C_1 in the sense of the hazard rate, which implies $\Psi_0 \leq \Psi_1$ and hence $\Psi_0^{-1} \geq \Psi_1^{-1}$. It follows from these observations that L^{1M} is larger than L_{0M}, which yields the desired result. $\square$

APPENDIX

A Proofs

A.1 Proof of Proposition 1

Let $x_i(z_i)$ denote the expected probability of winning by i for a given report z_i and truthful behavior of the others: $x_i(z_i) = \mathbb{E}_{\mathbf{c_{-i}}}[X_i(z_i, \mathbf{c_{-i}})]$

Let $q_i(z_i)$ denote the expected quantity produced by i when winning for a given report z_i and truthful behavior of the others: $q_i(z_i) = \mathbb{E}_{\mathbf{c_{-i}}}[Q_i(z_i, \mathbf{c_{-i}}) X_i(z_i, \mathbf{c_{-i}})]$, and similarly, let $m_i(z_i)$ denote the expected payment to a winning i for a given report z_i and truthful behavior of the others: $m_i(z_i) = \mathbb{E}_{\mathbf{c_{-i}}}[M_i(z_i, \mathbf{c_{-i}}) X_i(z_i, \mathbf{c_{-i}})]$.

Supplier S_i's expected payoff is: $m_i(z_i) - q_i(z_i) c_i$. Therefore the equilibrium expected payoff is

$$U_i(c_i) = \max_{z_i} m_i(z_i) - q_i(z_i) c_i$$

That is, $U_i(c_i)$ is a maximum of a family of affine functions which implies that $U_i(c_i)$ is a convex function and therefore it is differentiable almost everywhere. Hence from the envelop theorem:

$$U_i'(c_i) = -q_i(c_i) \text{ and therefore } U_i(c_i) = U_i(\bar{c}_i) + \int_{c_i}^{\bar{c}_i} q_i(x)\, dx$$

the expected payoff only depends on $\mathbf{Q}$ the allocation rule whereas the payment $\mathbf{M}$ only changes the additive constant. Moreover U_i being convex implies q_i is non increasing with c_i.

If a direct mechanism $(\mathbf{X}, \mathbf{Q}, \mathbf{M})$ is IC then necessarily

$$m_i(c_i) = U_i(\bar{c}_i) + q_i(c_i) c_i + \int_{c_i}^{\bar{c}_i} q_i(x)\, dx$$

and $U_i(\bar{c}_i) = 0$ as there is no reason to leave a rent to the worst type.

The expected revenue of the manufacturer is $\mathbb{E}[\Pi_B] = \mathbb{E}[R(\sum q_i(c_i)) - \sum m_i(c_i)]$ thus

$$\begin{aligned}
\mathbb{E}[m_i(c_i)] &= \int_{\underline{c}_i}^{\bar{c}_i} m_i(c_i) f_i(c_i) dc_i \\
&= \int_{\underline{c}_i}^{\bar{c}_i} q_i(c_i) c_i f_i(c_i) dc_i + \int_{\underline{c}_i}^{\bar{c}_i} \left(\int_{c_i}^{\bar{c}_i} q_i(x)\, dx \right) f_i(c_i) dc_i
\end{aligned}$$

integrating by part the last term

$$\begin{aligned}
\int_{\underline{c}_i}^{\bar{c}_i} \left(\int_{c_i}^{\bar{c}_i} q_i(c)\, dc \right) f_i(c_i) dc_i &= \left[F_i(c_i) \int_{c_i}^{\bar{c}_i} q_i(c)\, dc \right]_{\underline{c}_i}^{\bar{c}_i} + \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i) q_i(c_i)\, dc_i \\
&= \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i) q_i(c_i)\, dc_i
\end{aligned}$$

$$\begin{aligned}\mathbb{E}\left[m_i\left(c_i\right)\right] &= \int_{\underline{c}_i}^{\bar{c}_i} q_i\left(c_i\right)c_i f_i(c_i)dc_i + \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i)q_i\left(c_i\right)dc_i \\ &= \int_{\underline{c}_i}^{\bar{c}_i}\left(c_i+\frac{F_i(c_i)}{f_i(c_i)}\right)q_i\left(c_i\right)f_i(c_i)dc_i \\ &= \int_{\underline{c}_i}^{\bar{c}_i}\Psi_i\left(c_i\right)q_i\left(c_i\right)f_i(c_i)dc_i\end{aligned}$$

As a result, the expected revenue of the manufacturer writes

$$\mathbb{E}\left[\Pi_B\right] = \mathbb{E}\left[R\left(\sum q_i\left(c_i\right)\right)\right] - \sum \mathbb{E}\left[\Psi_i\left(c_i\right)q_i\left(c_i\right)\right]$$

after une petite explication

$$\mathbb{E}\left[\Pi_B\right] = \mathbb{E}\sum X_i\left(\mathbf{c}\right)\left[R\left(Q_i\left(\mathbf{c}\right)\right) - \Psi_i\left(c_i\right)Q_i\left(\mathbf{c}\right)\right]$$

from which it should be apparent that if B buys a positive quantity, then it should procure all of it from the supplier with the lowest virtual cost $\Psi_i\left(c_i\right)$. Calling i^* the index such that $\Psi_{i^*}\left(c_{i^*}\right)$ this lowest value of all the $\Psi_i\left(c_i\right)$, the solution is to order the quantity

$$q^m\left(\Psi_{i^*}\left(c_{i^*}\right)\right) \text{ provided that } \Psi_{i^*}\left(c_{i^*}\right) \geq 0$$

to the supplier i^* and nothing from the other suppliers.

A.2 Proof of Proposition 2

Assume the initial mechanism takes the form $\left(\mathbf{M}\left(\widehat{\mathbf{c}}\right), \mathbf{Q}\left(\widehat{\mathbf{c}}\right), \mathbf{X}\left(\widehat{\mathbf{c}}\right)\right)$ where $\widehat{\mathbf{c}} = \left(\widehat{c_0}, \widehat{c_1}, \cdots, \widehat{c_n}\right)$ is the vector of announcements by the suppliers, $\mathbf{M} = \left(M_0\left(\widehat{\mathbf{c}}\right), M_1\left(\widehat{\mathbf{c}}\right), \cdots, M_n\left(\widehat{\mathbf{c}}\right)\right)$ is the vector of the payments made by the manufacturer to the suppliers, and $\mathbf{X} = \left(X_0\left(\widehat{\mathbf{c}}\right), X_1\left(\widehat{\mathbf{c}}\right), \cdots, X_n\left(\widehat{\mathbf{c}}\right)\right)$ is the vector of winning probabilities.

We solve first the renegotiation subgame. Renegotiation is described by a new cost announcement $\check{c}_i$, a new payment $M_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right)$, and a new quantity $Q_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right)$ which replace the planned M_i and Q_i. Both parties should benefit from renegotiation:

$$U_i^r\left(\check{c}_i, c_i;\widehat{\mathbf{c}}\right) = M_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right) - c_iQ_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right) \geq M_i\left(\widehat{\mathbf{c}}\right) - c_iQ_i\left(\widehat{\mathbf{c}}\right) \quad (A.1)$$

$$R\left(Q_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right)\right) - M_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right) \geq R\left(Q_i\left(\widehat{\mathbf{c}}\right)\right) - M_i\left(\widehat{\mathbf{c}}\right) \quad (A.2)$$

Ex post efficiency implies

$$Q_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right) = q^m(c_i)$$

indeed, just adding the two inequalities above shows renegotiation gains are not exhausted otherwise. Let

$$U_i^r\left(c_i;\widehat{\mathbf{c}}\right) = \max_{\check{c}_i}\left[M_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right) - c_iQ_i^r\left(\check{c}_i;\widehat{\mathbf{c}}\right)\right] \text{ s.t. (A.1)}$$

then, by the envelope theorem (applied to the Lagrangian of the above programm)

$$\frac{\partial U_i^r}{\partial c_i} = -Q_i^r\left(\check{c}_i; \widehat{\mathbf{c}}\right) = -q^m(c_i)$$

and using $-q^m(c_i) = \frac{\partial \pi^m(c_i)}{\partial c_i}$

$$U_i^r\left(c_i; \widehat{\mathbf{c}}\right) = \max_{\check{c}_i} U_i^r\left(\check{c}_i, c_i\right) = \pi^m(c_i) - T\left(\widehat{c}\right)$$

which means that at the first stage mechanism the payoff of supplier i is

$$\left(\pi^m(c_i) - T_i\left(\widehat{c}\right)\right) X_i\left(\widehat{c}\right)$$

the initial mechanism can only be composed of a transfer and a winning probability (the quantity is constrained by the renegotiation). Standard auction technics can now be applied to find the optimal direct mechanism. Let $t_i\left(\widehat{c}_i\right) = \mathbb{E}_{c_{-i}} T_i\left(\widehat{c}_i, c_{-i}\right) X_i\left(\widehat{c}_i, c_{-i}\right)$ and $x_i\left(\widehat{c}_i\right) = \mathbb{E}_{c_{-i}} X_i\left(\widehat{c}_i, c_{-i}\right)$ then the expected gain of i is

$$U_i\left(c_i; \widehat{c}_i\right) = x_i\left(\widehat{c}_i\right) \pi^m(c_i) - t_i\left(\widehat{c}_i\right)$$

Incentive compatibility (and $U_i(\overline{c}) = 0$) then implies that the equilibrium payoffs is

$$U_i\left(c_i\right) = \max_{\widehat{c}_i} U_i\left(c_i; \widehat{c}_i\right) = \int_{c_i}^{\overline{c}} x_i\left(c\right) q^m(c) dc$$

as $U_i\left(c_i\right) = U_i\left(c_i; c_i\right) = x_i\left(c_i\right) \pi^m(c_i) - t_i\left(c_i\right)$ it follows that

$$t_i\left(c_i\right) = x_i\left(c_i\right) \pi^m(c_i) - \int_{c_i}^{\overline{c}} x_i\left(c\right) q^m(c) dc$$

The expected revenue of B is simply $\mathbb{E}\left[\Pi_B\right] = \mathbb{E}\left[\sum T_i\left(\mathbf{c}\right) X_i\left(\mathbf{c}\right)\right]$ and

$$\begin{aligned}
\mathbb{E}\left[T_i\left(\mathbf{c}\right) X_i\left(\mathbf{c}\right)\right] &= \int_{\underline{c}_i}^{\overline{c}_i} t_i(c_i) f_i(c_i) dc_i \\
&= \int_{\underline{c}_i}^{\overline{c}_i} \left[x_i(c_i) \pi^m(c_i)\right] f_i(c_i) dc_i \\
&\quad - \int_{\underline{c}_i}^{\overline{c}_i} \left[\int_{c_i}^{\overline{c}} x_i(c) q^m(c) dc\right] f_i(c_i) dc_i
\end{aligned}$$

integrating by parts the last integral

$$\begin{aligned}
\int_{\underline{c}_i}^{\bar{c}_i}\left[\int_{c_i}^{\bar{c}} x_i(c)q^m(c)dc\right] f_i(c_i)dc_i &= \left[F_i(c_i)\int_{c_i}^{\bar{c}_i} x_i(c)q^m(c)dc\right]_{\underline{c}_i}^{\bar{c}_i} \\
&\quad + \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i)x_i(c_i)q^m\left(c_i\right)dc_i \\
&= \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i)x_i(c_i)q^m\left(c_i\right)dc_i
\end{aligned}$$

thus

$$\begin{aligned}
\mathbb{E}\left[t_i\left(c_i\right)\right] &= \int_{\underline{c}_i}^{\bar{c}_i}\left[x_i(c_i)\pi^m(c_i)\right] f_i(c_i)dc_i - \int_{\underline{c}_i}^{\bar{c}_i} F_i(c_i)x_i(c_i)q^m\left(c_i\right)dc_i \\
&= \int_{\underline{c}_i}^{\bar{c}_i}\left[\pi^m(c_i) - \frac{F_i(c_i)}{f_i(c_i)}q^m\left(c_i\right)\right] x_i(c_i)f_i(c_i)dc_i \\
&= \mathbb{E}\left[X_i\left(\mathbf{c}\right)\left\{R\left(q^m\left(c_i\right)\right) - \Psi_i\left(c_i\right)q^m\left(c_i\right)\right\}\right]
\end{aligned}$$

As a result, the expected revenue of the buyer writes

$$\mathbb{E}\left[\Pi_B\right] = \sum \mathbb{E}\left[X_i\left(\mathbf{c}\right)\left[R\left(q^m\left(c_i\right)\right) - \Psi_i\left(c_i\right)q^m\left(c_i\right)\right]\right]$$

from which it should be apparent that B allocates the market to the supplier giving the largest virtual profit: $R\left(q^m\left(c_i\right)\right) - \Psi_i\left(c_i\right)q^m\left(c_i\right) = \pi^m(c_i) - \frac{F_i(c_i)}{f_i(c_i)}q^m\left(c_i\right)$

A.3 Proof of Proposition 3

Assume the initial mechanism takes the form $\left(\mathbf{M}\left(\widehat{\mathbf{c}}\right), \mathbf{Q}\left(\widehat{\mathbf{c}}\right), \mathbf{X}\left(\widehat{\mathbf{c}}\right)\right)$ where $\widehat{\mathbf{c}} = \left(\widehat{c_0}, \widehat{c_1}, \cdots, \widehat{c_n}\right)$ is the vector of announcements by the suppliers, $\mathbf{M} = \left(M_0\left(\widehat{\mathbf{c}}\right), M_1\left(\widehat{\mathbf{c}}\right), \cdots, M_n\left(\widehat{\mathbf{c}}\right)\right)$ is the vector of the payments made by the manufacturer to the suppliers, and $\mathbf{X} = \left(X_0\left(\widehat{\mathbf{c}}\right), X_1\left(\widehat{\mathbf{c}}\right), \cdots, X_n\left(\widehat{\mathbf{c}}\right)\right)$ is the vector of winning probabilities.

The renegotiation possibility implies the following constraint (for the winner):

$$X_i\left(\widehat{\mathbf{c}}\right) = 1 \Rightarrow \pi^m(c_i) - \left[R\left(Q_i\left(\widehat{\mathbf{c}}\right)\right) - c_iQ_i\left(\widehat{\mathbf{c}}\right)\right] \leq K \tag{A.3}$$

Solving the problem without taking into account this constraint leads as in section to the following objective for the buyer

$$\mathbb{E}\left[\Pi_B\right] = \mathbb{E}\sum X_i\left(\mathbf{c}\right)\left[R\left(Q_i\left(\mathbf{c}\right)\right) - \Psi_i\left(c_i\right)Q_i\left(\mathbf{c}\right)\right]$$

B maximizes this objective with respect to $\mathbf{Q}$ and $\mathbf{X}$ which have to verify the constraint (A.3).

Calling i^* the index such tahat $\Psi_{i^*}\left(c_{i^*}\right)$ this lowest value of all the $\Psi_i\left(c_i\right)$, the solution is to order the quantity $q^m\left(\Psi_{i^*}\left(c_{i^*}\right)\right)$ if it satisfies the constraint (A.3).

A.4 Proof of Proposition 4

Consider any direct mechanism $(q_i(w_i, w_{-i}), m_i(w_i, w_{-i}))$, where $q_i(w_i, w_{-i})$ is the probability that i gets the good and $m_i(w_i, w_{-i})$ is the associated payment. Below, $\mathbb{E}$ is the expectation against the distribution of $w_0, w_1, \ldots, w_n$ and $\mathbb{E}_{w_{-i}}$ is the expectation against the distribution of w_{-i} given w_i. The expected joint profit of the pair $B - S_0$ is

$$\mathbb{E}\,\Pi_B = \mathbb{E}\left[\sum_{i=0}^{n} m_i q_i + (w_0 - m_0) q_0\right]$$

The expected utility of supplier i is

$$U_i(w_i) = \max_{\hat{w}_i}\ \mathbb{E}_{w_{-i}}\ \{q_i(\hat{w}_i, w_{-i})\,[w_i - m_i(\hat{w}_i, w_{-i})]\ \}$$

By the envelope theorem, we have

$$U'(w_i) = \mathbb{E}_{w_{-i}} q_i(w_i, w_{-i}).$$

Substituting for m_i

$$\mathbb{E}_{w_{-i}}\ \{m_i(w_i, w_{-i})\, q_i(w_i, w_{-i})\ \} = \mathbb{E}_{w_{-i}}\ \{q_i(w_i, w_{-i})\, w_i\ \} - U_i(w_i)$$

By integration by parts

$$\begin{aligned}
\mathbb{E}\, m_i q_i &= \int_{w_i} \mathbb{E}_{w_{-i}}(m_i q_i)\,\mathrm{d}F_i(w_i) = \mathbb{E}\,(q_i w_i) - \int U_i(w_i)\,\mathrm{d}F_i(w_i) \\
&= \mathbb{E}\,(q_i w_i) - \int \mathbb{E}_{w_{-i}} q_i(w_i, w_{-i})\ \frac{1 - F_i(w_i)}{f_i(w_i)}\,\mathrm{d}F_i(w_i) \\
&= \mathbb{E}\, q_i \left[w_i - \frac{1 - F_i(w_i)}{f_i(w_i)}\right].
\end{aligned}$$

Rewriting the expected joint profit yields

$$\mathbb{E}\,\Pi_B = \mathbb{E}\left\{w_0 q_0 + \sum_{i=1}^{n} q_i \left[w_i - \frac{1 - F_i(w_i)}{f_i(w_i)}\right]\right\}.$$

It follows that the buyer's decision to supply from her upstream division or from rival suppliers is based on the (virtual) profits presented in the proposition.

References

M.-L. Allain, C. Chambolle, and P. Rey. Vertical Integration as a Source of Hold-up. *Review of Economic Studies*, 83(1 (294)):1–25, 2016.

E. Atalay, A. Hortaçsu, and C. Syverson. Vertical Integration and Input Flows. *American Economic Review*, 104(4):1120–48, April 2014.

E. Atalay, A. Hortaçsu, M. J. Li, and C. Syverson. How wide is the firm border? *forthcoming in the Quarterly Journal of Economics*, 2019.

D. P. Baron. Procurement contracting: efficiency, renegotiation and performance evaluation. *Information Economics and Policy*, 3(2):109–142, 1988.

D. P. Baron and R. B. Myerson. Regulating a Monopolist with Unknown Costs. *Econometrica*, 50(4):911–930, 1982.

J. Bulow and P. Klemperer. Auctions versus negotiations. *The American Economic Review*, 86(1):180–194, March 1996.

F. Chen. Auctioning supply contracts. *Management Science*, 53(10):1562–1576, 2007.

Z. Chen. Defining buyer power. *Antitrust Bull.*, 53:241, 2008.

G. S. Crawford, R. S. Lee, M. D. Whinston, and A. Yurukoglu. The Welfare Effects of Vertical Integration in Multichannel Television Markets. *Econometrica*, 86(3):891–954, 2018.

S. Dasgupta and D. F. Spulber. Managing procurement auctions. *Information Economics and Policy*, 4(1):5–29, 1989.

C. C. De Fontenay and J. S. Gans. Can vertical integration by a monopsonist harm consumer welfare? *International Journal of Industrial Organization*, 22(6):821–834, 2004.

I. Duenyas, B. Hu, and D. R. Beil. Simple auctions for supply contracts. *Management Science*, 59(10):2332–2342, 2013.

European Commission. Guidelines on the assessment of non-horizontal mergers under the Council Regulation on the control of concentrations between undertakings. (2008/C 265/07), 2008.

R. Gibbons. Four Formal(izable) Theories of the Firm? *Journal of Economic Behavior & Organization*, 58(2):200–245, 2005.

R. Gibbons and J. Roberts, editors. *The Handbook of Organizational Economics*. Princeton University Press, 2012.

J. Green and J.-J. Laffont. Non Verifiability, Costly Renegotiation and Efficiency. *Annales d'Économie et de Statistique*, (36):81–95, 1994.

J. R. Green and J.-J. Laffont. Renegotiation and the Form of Efficient Contracts. *Annales d'Économie et de Statistique*, (25/26):123–150, 1992.

O. Hart and J. Tirole. Vertical Integration and Market Foreclosure. *Brookings Papers on Economic Activity. Microeconomics*, 1990:205–276, 1990.

A. Hortaçsu and C. Syverson. Cementing Relationships: Vertical Integration, Foreclosure, Productivity, and Prices. *Journal of Political Economy*, 115(2):250–301, 2007.

B. Klein, R. G. Crawford, and A. A. Alchian. Vertical Integration, Appropriable Rents, and the Competitive Contracting Process. *Journal of Law & Economics*, 21(2):297–326, 1978.

J.-J. Laffont and J. Tirole. Auctioning Incentive Contracts. *Journal of Political Economy*, 95 (5):921–937, October 1987.

L. Linnemer. Backward integration by a dominant firm. *Journal of Economics & Management Strategy*, 12(2):231–259, 2003.

S. Loertscher and L. M. Marx. Merger Review for Markets with Buyer Power. *Journal of Political Economy*, 127(6):2967–3017, 2019a.

S. Loertscher and L. M. Marx. Merger Review with Intermediate Buyer Power. *International Journal of Industrial Organization*, 2019b.

S. Loertscher and M. Reisinger. Market structure and the competitive effects of vertical integration. *RAND Journal of Economics*, 45(3):471–494, 2014.

S. Loertscher and M. H. Riordan. Make and Buy: Outsourcing, Vertical Integration, and Cost Reduction. *American Economic Journal: Microeconomics*, 11(1):105–23, 2019.

R. P. McAfee and J. McMillan. Bidding for Contracts: A Principal-Agent Analysis. *RAND Journal of Economics*, 17(3):326–338, 1986.

R. P. McAfee and J. McMillan. Competition for Agency Contracts. *The RAND Journal of Economics*, 18(2):296–307, 1987.

R. B. Myerson. Optimal Auction Design. *Mathematics of Operations Research*, 6(1):58–73, February 1981.

J. A. Ordover, G. Saloner, and S. C. Salop. Equilibrium Vertical Foreclosure. *American Economic Review*, 80(1):127–142, 1990.

J. A. Ordover, G. Saloner, and S. C. Salop. Equilibrium Vertical Foreclosure: Reply. *American Economic Review*, 82(3):698–703, 1992.

D. Reiffen. Equilibrium Vertical Foreclosure: Comment. *American Economic Review*, 82(3): 694–697, 1992.

M. Reisinger and E. Tarantino. Vertical integration, foreclosure, and productive efficiency. *RAND Journal of Economics*, 46(3):461–479, 2015.

M. H. Riordan. Anticompetitive Vertical Integration by a Dominant Firm. *American Economic Review*, 88(5):1232–1248, 1998.

M. H. Riordan and D. E. M. Sappington. Awarding Monopoly Franchises. *American Economic Review*, 77(3):375–387, 1987.

S. C. Salop. Invigorating vertical merger enforcement. *Yale Law Journal*, 127:1962–1994, 2018.

S. C. Salop and D. P. Culley. Revising the US vertical merger guidelines: policy issues and an interim guide for practitioners. *Journal of Antitrust Enforcement*, 4(1):1–41, 2016.

J. J. Spengler. Vertical Integration and Antitrust Policy. *Journal of Political Economy*, 58(4): 347–352, 1950.

U.S. Department of Justice. Non-Horizontal Merger Guidelines. 1984.

O. E. Williamson. The Vertical Integration of Production: Market Failure Considerations. *American Economic Review*, 61(2):112–123, 1971.