Vertical bargaining and countervailing power

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We study a set of bilateral Nash bargaining problems between an upstream input supplier and several differentiated but competing retailers. If one bilateral bargain fails, the supplier can sell to the other retailers. We show that, in a disagreement, the other retailers' behavior has a dramatic impact on the supplier's outside options and, therefore, on input prices and welfare. We revisit the countervailing buyer power hypothesis and obtain results in stark contrast with previous findings, depending on the type of outside option. Our results apply, more generally, to the literature that incorporates negotiated input prices using bilateral Nash bargaining.

The question of how input prices (including wages) are set is subtle. In most retail markets, consumers are atomistic and, thus, reasonably modeled as price takers when patronizing a particular seller. It is less clear who sets the input price in vertically-related markets. In particular, in "tight" oligopolies with a few upstream and a few downstream firms, a framework of bilateral negotiations, with individually-negotiated input prices, seems appropriate.[1]

An extensive theoretical literature, both in Industrial Organization and in Labor Economics, has employed Nash axiomatic bargaining to model this setting. IO empirical work often uses structural models that are based on Nash bargaining. It is well known that, in a Nash bargain, the outside option impacts the bargained outcome. The same outside option, however, can be modeled in different ways, depending on the remaining players' behavior in the event of a disagreement. The purpose of this work is to study how the model of the outside option affects the outcome of the negotiation.

We make a general methodological point that applies to Nash bargaining in vertically-related markets with downstream competition, when one firm is engaged in multiple negotiations. The simplest setting would involve one upstream firm and two downstream competitors. Indeed, this is the setting analyzed by the seminal work of Horn and Wolinsky (1988, henceforth HW). They study whether

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[1] Bilateral relations are typically explained by investments in specialized assets made by both parties that lock them into the relationship.

downstream concentration can lead upstream firms to merge, using a Nash axiomatic approach to determine input prices.

HW themselves argue that there are at least two plausible specifications for modeling the behavior of downstream firms in disagreement. In a first scenario, the breakdown of the negotiation between a retailer and the input supplier is observed by the rival downstream firms; they react and make, in the downstream market, optimal choices that take into account that there is now one fewer competing firm. In the sequel, we will label this case *Observable* breakdowns. Alternatively, the rival firms may not observe the breakdown of the negotiation. Therefore, they keep making their optimal choices in the downstream market as if all competing firms were present. We will label this case *Unobservable* breakdowns, which is the case chosen by HW.

To show the relevance of the model of the outside option, we first revisit the countervailing buyer power hypothesis. Since the influential 1952 book of J. K. Galbraith, economists have disputed that consolidation in the downstream (retailing) sector may be beneficial to consumers, as fewer, more powerful, buyers could negotiate cheaper input prices with upstream suppliers, and final consumers could benefit to the extent that input price reductions were also passed through. We show that the model of the outside options changes – sometimes dramatically – the way in which the downstream market parameters affect the input price and the market equilibrium.

The main vehicle of our analysis is a simple linear model with a single upstream firm, and a varying number of competing and differentiated downstream firms. The input price is determined by bilateral negotiations, modeled using the Nash axiomatic approach, under the different hypotheses of *Observable* and *Unobservable* breakdowns. We also conduct the analysis for both Bertrand and Cournot downstream competition. In this context, we ask the following questions: Do downstream structural parameters affect the input price? If so, how? More importantly, how do the answers to these questions depend on the model of the behavior of the rival firms when there is disagreement? We find that countervailing power, interpreted as a more concentrated downstream market, may not keep input prices low, depending on market parameters, the nature of downstream competition and, crucially, the type of outside option. In our framework, more concentration downstream never pushes input prices down when downstream competition is in quantities. An increase in downstream concentration may lower the input prices with Bertrand competition: This, however, depends on the observability of breakdowns.[2]

The model of the outside option depends on the ability of rival retailers to take advantage of the breakdown, which, in turn, depends on whether rival retailers have already precommitted their quantities or prices. This is the reason why we

[2]The linear specification of the model has the advantage of simple closed-form solutions. It does not limit the generality of our results, as we are interested in deriving possibility results, showing that cases with divergent outcomes exist.

also distinguish between strategic complements and strategic substitutes in our analysis. We show that, under Cournot competition, the input price is always lower with *Unobservable* compared to *Observable* breakdowns, for any degree of product differentiation and for any number of firms. If other retail firms can observe and react to the disagreement of a rival, they will increase their quantities when they realize that there is one fewer rival, which, in turn, improves the value of the supplier's outside option and generates a higher input price in equilibrium. Under Bertrand competition the result is, instead, reversed: When remaining firms observe a disagreement, they react by increasing their prices, and this worsens the supplier's outside option, resulting in a lower input price.

We believe that there is not a superior or more realistic modeling disagreement choice; rather, it will depend on the circumstances. For instance, in the example of grocery stores and retailing, if negotiations fail, competing stores will probably not observe this immediately and may be sluggish in adjusting their choices (while customers will not find the product available on the shelves). One could also think of a catalog shop, such as Argos in the U.K., setting its prices, printing them in their catalog, and then finding that it cannot adjust them to take advantage of a rival's breakdown. In other circumstances, rivals would be able to react more quickly. With Internet retailing, for instance, we tend to think of prices as being very flexible and adjustable. A notable example is the setting of landing fees between airports and airline carriers: In disagreement, a flight will not be available, and since this is likely to be observable (because of the change in the timetable on the Internet, where bookings can be made), rival airlines will realize that they face less competition and respond accordingly.

We do not claim that *no* result is robust to different specifications of the outside option. We revisit HW's pioneering work in this area and show that their central result – that an upstream merger always increases the input price to downstream firms – is indeed robust, as it arises independently from the observability of breakdowns, the mode of downstream competition, the number of downstream firms and the degree of product differentiation.

The structure of the paper is as follows. In Section I, we review the relevant literature, presenting a distinction among the various alternatives used to model outside options. We then present the model in Section . In Section III, we derive the equilibrium input price and discuss countervailing power under the two hypotheses of *Observable* and *Unobservable* breakdowns, and for both downstream Cournot and Bertrand competition. In Section IV, we reassess HW in our generalized framework. In Section V, we check the robustness of our results to the possibility of renegotiating the remaining input prices when a breakdown occurs. Section VI concludes. All proofs are in an Appendix.

I. Related literature and contribution

The Nash solution to a bargaining problem involves the determination of payoffs for each party, together with a specification of the disagreement point if negotiations break down. The outside option is, of course, not an issue in every case in which the bargaining parties are *assumed* to be locked into a *single* bilateral relationship: If a negotiation breaks down, the two parties have no alternative and the outside option is zero (see, for instance, Correa-López, 2007; Correa-López and Naylor, 2004; Symeonidis, 2008 and 2010). In the case of input suppliers, this assumption is not palatable: When a negotiation between a supplier and a retailer breaks down, the former may still obtain positive profits by selling the input to other retailers. Determining these disagreement profits involves defining how the *other* downstream firms behave in a disagreement.[3]

The model of the outside options has not been studied systematically in the existing literature. The motivation may be attributed to HW themselves, who correctly state that whether breakdowns are *Observable* or *Unobservable* in case of disagreement "does not have any qualitative effects on the points that we make" (HW, p. 412). We will show that this statement cannot be generalized to many simple settings and that, on the contrary, the full consequences of the hypotheses used in subsequent analyses have not been fully comprehended.

This paper contributes directly to the understanding of countervailing buyer power, a phenomenon originally identified by Galbraith (1952). Formalizations are more recent, though, starting with von Ungern-Sternberg (1996) in a Cournot model with *Observable* breakdowns, and with Dobson and Waterson (1997), who study Bertrand competition with differentiated products and *Observable* breakdowns. We show that their results are sensitive to changes of either the competition mode or the observability of breakdowns.

However, due to the methodological implications of our analysis, our paper is related to a much larger literature studying – in the context of vertically-related industries – issues such as the incentives to merge, the effects of different bargaining structures, or the impact of input price discrimination. In fact, we can nest several previous studies and connect their results via their differing assumptions about the behavior of outsiders to a bargain. To give just a few examples, Milliou and Petrakis (2007) study the incentives for upstream mergers when firms can also choose the contract type (linear vs. two-part input prices) in a model in which the input price is set via Nash bargaining with *Observable* breakdowns. Both Marshall and Merlo (2004) and Dobson (1994) analyze pattern bargaining in linear wages using the case of *Observable* breakdowns. In a model with *Unobservable* breakdowns, Gal-Or and Dukes (2006) study merger incentives in the media industry, where media stations bargain with producers over (linear) advertising rates. Dukes, Gal-Or and Srinivasan (2006) show the effects of downstream cost reductions on upstream profits when linear transfer prices are bargained, with *Unobservable* breakdowns. Gal-Or (1997) studies the rationale for exclu-

[3]While, in this paper, we concentrate on IO applications, the use of a Nash axiomatic approach has also been widely used in Labor Economics to study the wage determination between oligopolistic firms and unions (see, e.g., Davidson, 1988; Dowrick, 1989). There, an industry-wide union corresponds to a single upstream firm in the IO applications, while firm-level unions are the counterpart to independent upstream firms.

sionary contracts when health insurance companies and hospitals bargain on the reimbursement rate, with *Observable* breakdowns. O'Brien (forthcoming) employs a bargaining framework to study the effects of price discrimination over the linear input sold to competing downstream firms. He analyzes the role of outside options, though they are taken as exogenous and unrelated to the type of competition played by the downstream firms. All these works generalize the seminal contribution of HW along several dimensions, often providing insufficient discussion of the role played by the model of the outside options. Some of these contributions contrast their findings directly with HW but solve the case with *Observable* breakdowns, which makes some comparisons unwarranted.

Bilateral Nash bargaining models also play an increasing role in empirical work. Starting with Chipty and Snyder (1999), several papers have estimated models of input pricing for programs in the cable television industry. Crawford and Yurukoglu (2012) calibrate a Nash model with linear input prices to study what would happen if cable companies were to offer individual channels (*à la carte*) instead of bundles. They study a model with *Observable* breakdowns. Rennhoff and Serfes (2008) study a similar setting, though we could not retrieve the type of reaction they employ for disagreements.[4] Grennan (2013) estimates a Nash bargaining model between hospitals and medical equipment suppliers.[5] What is important in these works is that, typically, they first retrieve market parameters and then perform counterfactuals based on a particular assumption about what rivals do in a disagreement. It is legitimate to ask whether the results and policy implications they derive are robust to this assumption. We show that, at least, robustness is called into question when one looks at bargained input prices and the counterfactual involves changes in downstream structural parameters.

This paper concentrates mainly on input prices to show the dramatic impact that modeling reactions can have on equilibrium outcomes. Thus, we take as given several other key assumptions: We employ the Nash axiomatic approach; we assume that agreed-upon input contract terms are observed by all downstream firms when competing in the retail market; and we concentrate on linear input prices. These assumptions all correspond to the case of HW and most of the literature cited above. They have important implications, and we discuss each one in turn.

Nash axiomatic approach. It is well known that the unique subgame-perfect equilibrium of a non-cooperative bargaining model with outside options and a risk of breakdown converges to the asymmetric Nash bargaining solution, when the time period between offers and counteroffers becomes small. In fact, many of the papers with bilateral negotiations draw a connection with a non-cooperative bargaining, although the informational assumptions to make this connection are often difficult to map to reality. As a consequence of this approach, a bargaining

[4] In a related work, Chen, Rennhoff and Serfes (2011) consider *à la carte* pricing in a model with *Observable* breakdowns.

[5] In his model, patients cannot substitute across hospitals; hence, the issue of rivals' observability of breakdowns does not arise. See, also, Fong and Lee (2011) for hospital-insurance relationships.

pair cannot write contracts specifying different terms in the event of a breakdown in rivals' negotiations: This issue is investigated by Inderst and Wey (2003) and de Fontenay and Gans (2005), who study a sequence of bilateral negotiations.

Observable wholesale contracts. If wholesale contracts were not observable to downstream competitors, then commitment problems would arise, as the supplier's contract terms with one firm would not affect the downstream rivals' retail choices (McAfee and Schwartz, 1994; Rey and Tirole, 2007).[6] The supplier's opportunism problem in each bilateral contract would turn the supplier into his worst competitor, and the input price would be set at cost under "passive beliefs". Downstream structural parameters would essentially play no role, and one could not address the question of countervailing power in a meaningful way. The assumption of observability of input contracts is appealing when studying the union-firm wage bargaining problem, as unions typically announce their deals with employers as soon as they are concluded. Instead, this is less likely to be so in the presence of hidden terms of trade between manufacturers and retailers.

Linear wholesale prices. These are easier to justify when dealing with wage bargaining, though they can be found in many industries. A desirable property of linear input prices is that downstream (and, where present, upstream) conditions can affect input prices.[7] This assumption allows shifts in bargaining surplus to affect downstream prices, also allowing for the possibility that an increase in downstream bargaining power ultimately shows up in lower retail prices. Linear contracting is, nevertheless, a restrictive assumption. However, we should note that if observable non-linear contracts were set by a single upstream supplier, then they would completely eliminate intrabrand competition and always achieve the full monopoly outcome. If, instead, competing retailers make simultaneous take-it-or-leave-it offers to the same manufacturer, Marx and Shaffer (2007) find that upfront payments lead to exclusive dealing provisions, with only one retailer selling in equilibrium. In both cases, the question of countervailing power would again not be very meaningful. The case of Nash axiomatic bargaining when contracts are observable and nonlinear has yet to be examined fully in the literature.[8]

II. The model

We consider an industry in which a single upstream supplier sells an intermediate good to $N \geq 2$ downstream firms. Downstream firms use this input to

[6] Observability here refers to contractual terms at the time of market competition, not to be confused with observability of breakdowns.

[7] Inderst and Valletti (2009) argue that linear prices should be employed when preferential terms enhance a buyer's competitive position in the downstream markets, which would typically not be the case with two-part tariffs.

[8] Bargaining over observable nonlinear input prices is studied by, among others, O'Brien and Shaffer (2005), Antelo and Bru (2006), Milliou and Petrakis (2007), and Symeonidis (2008 and 2010). The opportunism problem is reintroduced when the supplier negotiates separately with a "non-orchestrated" number of retailers, and these bilateral negotiations result in binding contracts. These results depend delicately on the fact that contracts cannot be made contingent on market structure. See Miklós-Thal, Rey and Vergé (2011).

produce differentiated goods and sell them to final consumers. The ratio of input to output is identical for all downstream firms, and is normalized to one. Each downstream firm i pays a linear input price w_i to the upstream supplier and does not incur any other cost. The costs of the single upstream supplier are normalized to zero.

We assume a linear aggregate demand structure for the final good, which is widely used in IO. The inverse demand for the generic downstream firm i, given its own output q_i and output q_j of each of its rivals, is given by

$$p_i = 1 - \frac{q_i N + \mu \sum_{j=1}^{N} q_j}{1+\mu} \qquad \text{for } i = 1, \ldots, N, \tag{1}$$

whenever this is positive (Shubik and Levitan, 1980). The parameter μ describes the degree of homogeneity among the goods produced by downstream firms: When $\mu = 0$, we have independent goods, while goods tend to become homogeneous as μ approaches infinity. Hence, when $\mu \to \infty$, the model nests a standard homogeneous Cournot market with linear demand. This inverse demand function is derived from the quasi-linear quadratic utility function of a representative consumer

$$U = \sum_{i=1}^{N} q_i - \frac{N}{2(1+\mu)} \left[\sum_{i=1}^{N} q_i^2 + \frac{\mu}{N} \left(\sum_{i=1}^{N} q_i \right)^2 \right] + I, \tag{2}$$

where I is the consumption of other goods.

Inverting (1), it is also possible to obtain the system of linear direct demand functions. With N goods sold in the final market, the demand for the generic firm i is given by

$$q_i = \frac{1 - p_i - \mu \left(p_i - \frac{\sum_{j=1}^{N} p_j}{N} \right)}{N} \qquad \text{for } i = 1, \ldots, N. \tag{3}$$

As is well known (Motta, 2004), this demand system has two particularly attractive features for our purposes. First, aggregate demand does not depend upon the degree of substitution between products. Second, in a symmetric equilibrium, aggregate demand does not change with the number N of products in the market since (1) simplifies to $q_i = \frac{1-p}{N}$ when $p_i = p$ for all p_is, and, thus, $\sum_{i=1}^{N} q_i = 1 - p$.[9]

[9] Of course, N still has an impact on the equilibrium level of p. In a previous version of this paper (Iozzi and Valletti, 2010), the analysis was carried out using a demand system as in Singh and Vives (1984), where aggregate demand varies with the market parameters. This is the demand system used in the more-closely-related literature, thus allowing for perfect comparability between extant results and ours. However, it does not allow to disentangle the direct effects of changes in the market parameters on the nature of the bargaining, from those derived from the induced change in aggregate demand.

Competition in the industry is described by a two-stage game, as follows. At stage 1, the upstream firm negotiates the linear input price w_i with each downstream firm i individually; these bargains are further discussed in the next section. At stage 2, the downstream firms observe the outcomes of stage 1 and compete against each other, either in prices or in quantities, given the values of w_is from stage 1. We derive the symmetric pure strategy equilibrium of this game.

Within this setup, we first test the countervailing power hypothesis by looking at how the equilibrium input price varies as the downstream industry becomes more concentrated (lower N), and as products become more homogeneous (lower μ).[10] Then, we amend our model to allow for more firms upstream and revisit HW's investigation of an upstream merger, extending their findings in several respects. Before carrying out these analyses, we discuss the structure of the negotiations.

A. *Bargaining*

The N first-stage negotiations are conducted simultaneously so that, while bargaining, the firms' negotiators treat the other input prices as given.[11] Each bargain is obtained using the two-person Nash solution. Thus, the outcome is a set of input prices that are a Nash equilibrium in the Nash bargains.

More formally, denote by $\pi_i^D(w_i, \mathbf{w}_{-i})$ the profit in the last stage of downstream firm i and, by $\pi^M(w_i, \mathbf{w}_{-i})$, the profit of the upstream monopoly firm, where w_i is the input price to firm i and $\mathbf{w}_{-i}$ is the $(N-1)$-dimensional vector of input prices to all the other downstream firms. Also, let $\overline{\pi}^M$ be the disagreement payoff for the upstream firm. Since each downstream firm i has no alternative supplier, its disagreement payoff is simply zero. At stage 1, the upstream supplier and each downstream firm i form a separate bargaining unit and set w_i to maximize the following Nash product:

$$\max_{w_i} \Omega_i = [\pi^M(w_i, \mathbf{w}_{-i}) - \overline{\pi}^M]^\beta [\pi_i^D(w_i, \mathbf{w}_{-i})]^{1-\beta} \text{ for } i = 1, \dots, N, \tag{4}$$

where $\beta \in (0, 1)$ denotes the bargaining power of the upstream firm relative to that of the downstream firm. The FOC of this problem can be written as

$$\frac{\beta}{1-\beta} \frac{\pi_i^D(w_i, \mathbf{w}_{-i})}{\pi^M(w_i, \mathbf{w}_{-i}) - \overline{\pi}^M} = -\frac{\partial \pi_i^D(w_i, \mathbf{w}_{-i})/\partial w_i}{\partial \pi^M(w_i, \mathbf{w}_{-i})/\partial w_i} \text{ for } i = 1, \dots, N. \tag{5}$$

The equilibrium is found as the Nash solution to the N separate bargaining prob-

Therefore, we believe that the current formulation is much better suited to an analysis of countervailing buyer power, which depends on comparative statics with respect to these parameters.

[10] One could also accommodate downstream asymmetries in this model in order to distinguish between "large" and "small" retailers, but this would come at the cost of extra notational burden.

[11] For the upstream monopolist, this means that N separate negotiators are sent to conduct independent negotiations with each downstream firm.

lems. We concentrate only on symmetric equilibria.

The disagreement payoff of the upstream firm in (4) and (5) is crucial to our analysis and warrants further discussion. In the event of an unsuccessful negotiation between the upstream supplier and firm i, the upstream firm can still sell to the remaining $N-1$ downstream firms. Thus, it has an outside option equal to $\overline{\pi}^M = \sum_{j \neq i} w_j \overline{q}_j$, where w_j is the anticipated equilibrium level of the input price resulting from the negotiation, and $\overline{q}_j$ is the quantity that each downstream firm j different from i sells in the event case of a disagreement.[12]

The breakdown of the negotiation between the upstream supplier and firm i makes the latter unable to produce its good and sell it in the final market. This has two immediate consequences. First, consumers are unable to buy good i, which has to be removed from the consumer choice set. While this readjustment at the consumer level is uncontroversial, the other consequence of the breakdown depends on the way that firm i's downstream rivals react to the disagreement, which, in turn, hinges on their possibility of observing the negotiation breakdown. We study two possible scenarios:

- ***Unobservable breakdowns:*** The breakdown of the negotiation between firm i and the input supplier *is not observed* by the rival downstream firms. Therefore, they are not able to adjust their behavior to the absence of firm i in the downstream market. All the rival downstream firms stick to their optimal strategic behavior (in prices or quantities) as if all N firms were present in the downstream market. Formally, in the case of downstream Cournot competition, the outside option of the upstream firm is obtained by noting that $\overline{q}_j = \widehat{q}_j^N(\mathbf{w}^*)$, where $\widehat{q}_j^N(\mathbf{w}^*)$s are the last-stage anticipated quantities in a N-firm equilibrium, calculated at the anticipated equilibrium input prices, and which are, therefore, independent of the currently negotiated w_i. In the case of Bertrand competition, $\overline{q}_j$s are the quantities bought (after the consumer readjust her optimally-purchased basket) when firms still play the anticipated last-stage retail prices in a N-firm equilibrium, as a function of the equilibrium input prices.

- ***Observable breakdowns:*** The breakdown of the negotiation between firm i and the input supplier *is observed* by the rival downstream firms. They react by adopting an optimal choice (in prices or quantities) that takes into account that only $N-1$ firms operate in the downstream market. The upstream provider's outside option profits have to be calculated accordingly. Formally, in the case of Cournot competition downstream, $\overline{q}_j = \widehat{q}_j^{N-1}(\mathbf{w}^*)$, where $\widehat{q}_j^{N-1}(\mathbf{w}^*)$s are the last-stage equilibrium quantities (at the anticipated input prices) when $N-1$ firms compete.[13] Under price competition,

[12]Note that we do not allow for renegotiations of input prices. The robustness of our analysis to this assumption is discussed in Section V.

[13]In disagreement, firm i does not produce anything, and the vector of equilibrium input prices $\mathbf{w}^*$ for the rivals does not include w_i^*. In the literature, this case is sometimes referred to by setting w_i to

$\overline{q}_j$s are the quantities bought (after the consumer readjusts her optimally-purchased basket) in a $(N-1)$-firm Bertrand equilibrium in the final stage of the game, as a function of the negotiated input prices.

Although we frame our distinction in terms of *Observable/Unobservable* breakdowns, what differs between the two cases is not only the possibility that rivals observe the breakdown of a negotiation, but also that they are able to take advantage of it. This implies being able to redetermine their choices in the downstream market in a timely manner, which, in turn, depends on the extent to which output or price are predetermined and not adjustable. In a Cournot world, output can be predetermined – e.g., by capacity constraints or other complementary raw materials that cannot be ordered at short notice – so that it is not feasible to increase supply and take advantage of a rival's inability to conclude a deal. This is the case that HW consider. However, one can imagine that, while still competing in strategic substitutes, this condition does not hold, and firms can step up production and place more goods on the market when they hear of a rival's breakdown. In the case of Bertrand, HW's assumption sounds less plausible, as prices are typically flexible, so it is difficult to pre-commit to them in the way a firm can pre-commit to output levels. However, significant menu costs may exist due, for instance, to price promises or printed (catalog) prices.

III. Countervailing buyer power

In the following sections, we characterize the equilibrium of our market game and show that the existence of countervailing buyer power depends on the two different hypotheses of *Observable* and *Unobservable* breakdowns when determining outside options, as well as on the mode of competition (Cournot vs. Bertrand) and on market characteristics, such as the degree of product differentiation and market concentration.

A. *Cournot competition*

We start the analysis with the case of downstream Cournot competition. Each retailer sets its final quantity to maximize $\pi_i^D = (p_i - w_i)q_i$, where p_i is given by (1). In the case of N firms operating in the downstream industry, by solving the system of FOCs of these problems, we obtain the second-stage subgame equilibrium quantities

$$\widehat{q}_i^N(w_i, \mathbf{w}_{-i}) = \frac{(1+\mu)[2N(1-w_i) + \mu(1 - Nw_i + \sum_{j\neq i} w_j)]}{(2N+\mu)(2N+N\mu+\mu)}, \tag{6}$$

for $i, j = 1, \ldots, N$.

infinity. We abuse the notation slightly by using $\mathbf{w}^*$ also in this case.

These quantities determine the agreement payoffs of the downstream retailers and of the upstream supplier in the first stage of the game, which are given, respectively, by $\pi_i^D(w_i, \mathbf{w}_{-i}) = \frac{N+\mu}{1+\mu}\left[\widehat{q}_i^N(w_i, \mathbf{w}_{-i})\right]^2$ and $\pi^M(w_i, \mathbf{w}_{-i}) = \sum_i w_i \widehat{q}_i^N(w_i, \mathbf{w}_{-i})$.

Unobservable breakdowns. — In the case of disagreement, retailer i cannot sell anything – thus, $\overline{q}_i = 0$ – but the other retailers do not readjust their Nash-Cournot quantities. Hence, the other $N-1$ firms would still be selling $\overline{q}_j = \widehat{q}_j^N(\mathbf{w}^*)$, which denotes the second-stage anticipated equilibrium quantity when the input prices are set at their anticipated equilibrium level. The outside option for the upstream monopolist is then $\overline{\pi}^M = \sum_{j\neq i} w_j \widehat{q}_j^N(\mathbf{w}^*)$.

The following Proposition characterizes the input price:

PROPOSITION 1: *When downstream firms compete in quantities, and negotiation breakdowns are Unobservable, the input price is given by*

$$w_C^U = \frac{1}{2}\frac{\beta}{1 + \frac{\mu(1-\beta)(N-1)}{2N+\mu}}, \tag{7}$$

and it is decreasing both in N and in μ, for all values of β.

Therefore, in the current case with downstream Cournot competition, we do *not* support the idea that higher concentration downstream exerts countervailing buyer power and pushes down the input price. On the contrary, for any degree of bargaining power and product differentiation, the input price is lower the higher the number of downstream firms.

Observable breakdowns. — When negotiation breakdowns are observable, with successful bargains, the payoffs of both the upstream and the downstream firms are identical to those in the previous case. The difference concerns the quantities sold by the remaining firms when the upstream monopolist disagrees with firm i, and its resulting payoffs. Clearly, also in this case, $\overline{q}_i = 0$, but the other firms now readjust their quantities in the downstream market, as they anticipate that firm i produces nothing. In particular, the quantities $\overline{q}_j$ they would be selling are the second-stage equilibrium quantities in an industry with only $N-1$ firms; that is,

$$\widehat{q}_j^{N-1}(\mathbf{w}^*) = \frac{(1+\mu)\{[2N(1-w_j^*) + \mu[1-(N-1)w_j^* + \sum_{k\neq j} w_k^*]\}}{N(2+\mu)(2N+\mu)}, \tag{8}$$

for $j, k = 1, \ldots, N$ and $j, k \neq i$.

In a symmetric equilibrium, we have the following Proposition:

PROPOSITION 2: *When downstream firms compete in quantities, and negotiation breakdowns are Observable, the input price is given by*

$$w_C^O = \frac{\beta}{2}, \tag{9}$$

and it is independent of N and μ, for all values of β.

In other words, this price depends only on bargaining power β, while downstream structural parameters, such as the number of firms or the degree of product differentiation, play no role.[14]

Our finding is in stark contrast with the result of von Ungern-Sternberg (1996), derived with homogeneous goods in a setting similar to the one in this section. In his paper, the equilibrium input price is increasing in the number of downstream firms. His result is obtained using equation (5), but setting the RHS equal to -1, as would be the case in a negotiation between the upstream firm and only *one* retailer. However, this hypothesis is inconsistent with having also assumed the existence of an outside option for the upstream firm. This inconsistency results in an equilibrium input price that is, curiously, equal to 1 when all the bargaining power is with the upstream firm ($\beta = 1$). This input price would choke off demand completely, and no quantity would be sold. In our model, instead, with a fully-specified game, when $\beta = 1$, the input price is equal to $\frac{1}{2}$ – i.e., the (linear) monopoly input price.

B. Bertrand competition

We follow the same framework introduced above, with the only difference that now downstream firms compete in prices. In the second stage of the game, each retailer sets its final price to maximize $\pi_i^D = (p_i - w_i)q_i$, where q_i is given by (3). For all N firms operating in the downstream market, after solving the system of FOCs with respect to prices, we obtain

$$\begin{aligned} \widehat{p}_i^N(w_i, \mathbf{w}_{-i}) &= \\ &= \frac{N(2N + 2N\mu - \mu) + (N + N\mu - \mu)[N(2+\mu)w_i + \mu \sum_{j \neq i} w_j]}{(2N + 2N\mu - \mu)(2N + N\mu - \mu)}, \end{aligned} \tag{10}$$

for $i, j = 1, \ldots, N$. Let $\widehat{\mathbf{p}}^N(w_i, \mathbf{w}_{-i})$ be the N-dimensional vector of such equilibrium prices. The resulting quantities that are demanded downstream and eventually supplied by the upstream firm are obtained by substituting all $\widehat{p}_i(.)$s back

[14] An input price independent of the degree of product differentiation and the number of downstream firms is not a novelty in the literature (see, e.g., Dowrick, 1989) and depends entirely on the linearity of our model. Our result extends to the case of a bargain over the input price, the finding that the input price set unilaterally by the upstream firm is invariant to the downstream market structure when the final demand function shows constant elasticity of slope (Greenhut and Ohta, 1976).

into (3), so that the output of the generic firm i is given by $q_i(\widehat{\mathbf{p}}^N(w_i, \mathbf{w}_{-i}))$. The agreement payoffs of the upstream monopoly supplier and downstream firm i can be determined, respectively, as $\pi^M(w_i, \mathbf{w}_{-i}) = \sum_i w_i q_i(\widehat{\mathbf{p}}^N(w_i, \mathbf{w}_{-i}))$ and $\pi_i^D(w_i, \mathbf{w}_{-i}) = [\widehat{p}_i^N(w_i, \mathbf{w}_{-i}) - w_i] q_i(\widehat{\mathbf{p}}^N(w_i, \mathbf{w}_{-i}))$.

When disagreement occurs between one retailer i and the upstream supplier, only $N-1$ remaining firms operate in the final market. Therefore, the system of demand functions is not (3) anymore, but the one derived from the maximization of the consumer utility defined only over the $N-1$ remaining goods, as it is $q_i = 0$. Formally, this is given by[15]

$$(11) \qquad q_j = \frac{(1+\mu)\left(1 - p_j - \frac{\mu\left(N-1-\sum_{k\neq i} p_k\right)}{N+(N-1)\mu}\right)}{N}, \quad \text{for } j,k = 1,\ldots,N; j,k \neq i.$$

Unobservable breakdowns. — In disagreement, $\overline{q}_i = 0$, and the other firms do not readjust their expected Nash-Bertrand prices of the last stage. The outside option of the upstream supplier can then be calculated plugging into (11) the Bertrand equilibrium prices $\widehat{\mathbf{p}}^N(.)$, as in (10), calculated at the anticipated equilibrium input prices $\mathbf{w}^*$. The input price is obtained as the outcome of the bargaining problem as in (5), giving the following result:

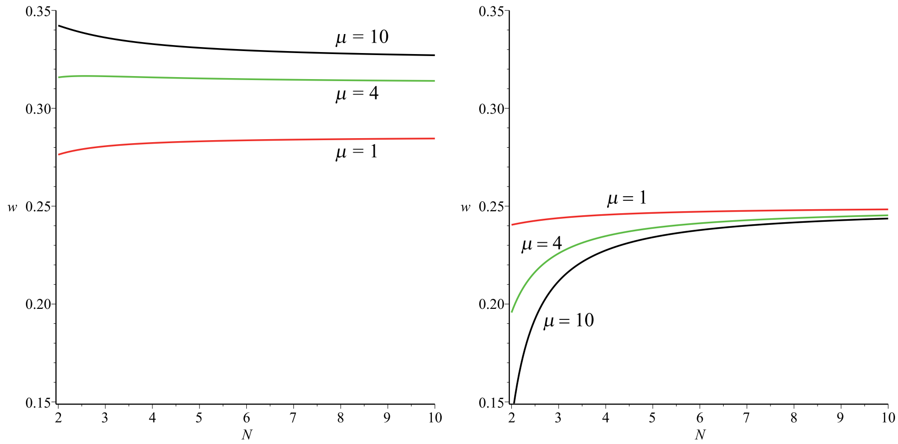
PROPOSITION 3: *When downstream firms compete in prices, and negotiation breakdowns are Unobservable, the input price is given by*

$$(12) \qquad w_B^U = \frac{1}{2}\frac{\beta}{1 - \frac{\mu(1+\mu)(1-\beta)N(N-1)}{(2N+2N\mu-\mu)(N+N\mu-\mu)}},$$

and it is increasing in μ and decreasing/increasing/non monotonic in N, depending on μ, for all values of β.

Proposition 3 illustrates that the behavior of the input price with respect to the product differentiation parameter is monotonic, as it always increases when products become closer substitutes. The relationship of the input price with the number of downstream competitors is more involved. In particular, we have that, for low (high) enough values of μ, the input price is always increasing (decreasing) in N. When μ is in a mid-range, the input price is first increasing and then decreasing in the number of downstream firms. This is depicted in panel (a) of Figure 1, where the equilibrium input price is plotted against the number of downstream firms, for different values of μ. As the Figure clearly shows, the role of downstream concentration to exert countervailing buyer power is limited to

[15] As this is sometimes misunderstood, it is worth noting that the consumer preferences are still as in (2), but now with $q_i = 0$. Thus, the parameter N still enters the utility function. This is why (11) does *not* correspond to (3), after simply changing N to $N-1$.



(a) *Unobservable* breakdowns (b) *Observable* breakdowns

FIGURE 1. EQUILIBRIUM INPUT PRICE WITH BERTRAND COMPETITION WHEN $\beta = \frac{1}{2}$.

the case of downstream markets in which retailers already enjoy sufficiently high market power because products are sufficiently differentiated and competitors are relatively few.

OBSERVABLE BREAKDOWNS. — The payoffs of both the upstream and downstream firms that make successful bargains are identical to those of the previous case. Therefore, it remains only to discuss what happens in disagreement. The remaining $N-1$ downstream firms take into account the presence of one less competitor and choose their equilibrium prices, facing demand as given in (11). These prices in a disagreement can be computed as

$$(13)\quad \widehat{p}_j^{N-1}(\mathbf{w}^*) = \frac{N(2N+2N\mu-3\mu)+(N+N\mu-2\mu)\left[(N(2+\mu)-\mu)w_j^* + \mu\sum_{k\neq j} w_k^*\right]}{(2N+2N\mu-3\mu)(2N+N\mu-2\mu)},$$

for $j, k = 1, \ldots, N$ and $j, k \neq i$. We can state the following Proposition:

PROPOSITION 4: *When downstream firms compete in prices, and negotiation breakdowns are Observable, the input price is given by*

$$(14)\qquad w_B^O = \frac{1}{2}\frac{\beta}{1+\frac{\mu^2(1+\mu)(1-\beta)N(N-1)(2N+N\mu-\mu)}{(2N+2N\mu-\mu)(2N-2\mu+N\mu)(N+N\mu-\mu)^2}},$$

and it is increasing in N and decreasing in μ, for all values of β.

Less product differentiation now always reduces the input price; the same effect results from a reduction in the number of firms. Both effects are illustrated in panel (b) of Figure 1. These results differ from those in the classical paper of Dobson and Waterson (1997). The authors use a setup analogous to ours, but they find that it is only when products are sufficiently homogenous, or when firms are relatively numerous, that a reduction in the number of downstream firms reduces the input price.[16] These diverging results are due mainly to the different demand system we use. Our demand system ensures that a change in market parameters does not affect the level of aggregate demand. This is not the case in Dobson and Waterson, where, instead, aggregate demand varies with both the number of firms and the degree of product differentiation. Therefore, any change of the market parameters confounds their direct effect with those related to the change in market size.

C. Discussion

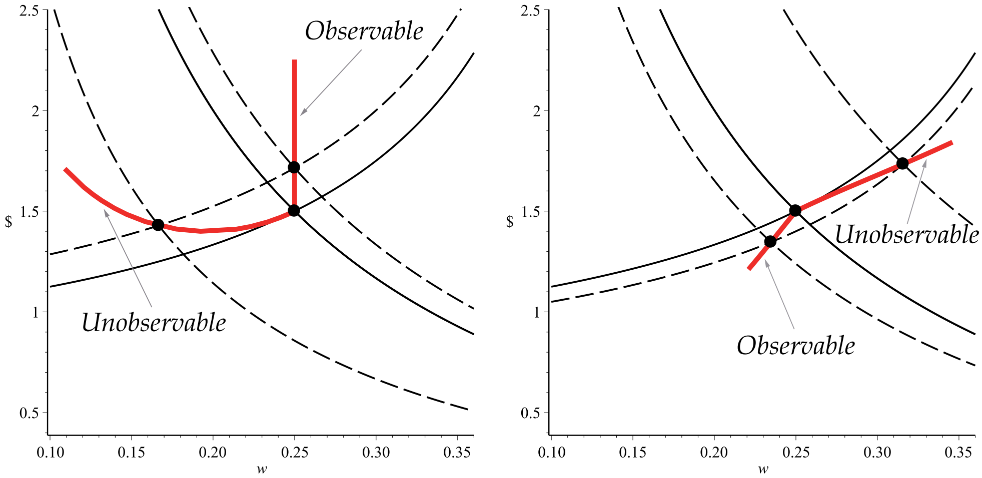
Having obtained all the expressions for the input price under different modes of downstream competition and different observability of breakdowns, we now sum up and discuss our findings.

We first provide a graphical illustration of the results by plotting the values of the LHS and the RHS of (5), whose intersection determines the equilibrium input price. It is important to recall that the bargaining solution has the property that a party becomes relatively stronger the higher the value of its outside option and the more costly its concessions. The LHS of (5) is the ratio between the profit *levels* of the two bargaining parties, net of the value of the outside option, whenever it exists. In all cases, this ratio is always decreasing in the equilibrium input price, w^*, because the downstream (upstream) net agreement profits are decreasing (increasing) in w^*. Note that, for a given mode of downstream competition, the LHS of (5) changes with *Observable* or *Unobservable* breakdowns, as the supplier's profit in disagreement, $\overline{\pi}^M$, differs under the two hypotheses.

The RHS of (5) is the ratio of the *marginal effects* of a change in w_i on the firms' profits or, in other words, the ratio of *concession costs*. For the buyer, a concession (an agreement to pay a higher input price) increases its costs and weakens its competitive position in the downstream market relative to rivals. For the seller, a concession is an agreement to accept a lower price. The behavior of this ratio with respect to w^* reflects the rather general property that the concession cost for a downstream firm relative to that of the seller is higher the higher the level of input prices w^*. The RHS does not change with the observability of the breakdowns but only with the mode of competition.

We first focus on panel (a) of Figure 2, which illustrates the case of downstream quantity competition. We keep the number of firms fixed and plot the LHS and

[16]Dobson and Waterson (1997) discuss only the effect of changes in downstream concentration on the final prices. For an explicit discussion of the effects of a change in concentration on the input price, see Section 4.2 of Iozzi and Valletti (2010), which replicates their analysis.



(a) Cournot competition (b) Bertrand competition

FIGURE 2. EQUILIBRIUM INPUT PRICES WHEN $\beta = \frac{1}{2}$ AND $N = 4$. THE CURVES REPRESENT THE LHS (DOWNWARD CURVES) AND THE RHS (UPWARD CURVES) OF (5) WHEN $\mu = 0$ (SOLID LINES) AND $\mu = 4$ (DASHED LINES). THEIR INTERSECTION DETERMINES THE EQUILIBRIUM INPUT PRICE, ON THE HORIZONTAL AXIS. THE BOLD RED CURVES ARE THE LOCUS OF THE INTERSECTIONS AS μ VARIES, WITH *Observable* AND *Unobservable* BREAKDOWNS.

the RHS of (5) for the two cases of *Observable* and *Unobservable* breakdowns, and for different values of μ. The downward-sloping lines are the LHS of (5) in the cases of *Observable* and *Unobservable* breakdowns, drawn for different values of μ. The upward-sloping lines are the RHS of (5), always identical with or without observability of breakdowns for a given value of μ. The intersections of the relevant lines for the same value of μ determine the equilibrium value of the input price. We plot (in bold red) the locus of the intersections of the two curves, indicating the equilibrium for all possible values of μ.

To interpret the figure, start from the downward-sloping solid line: The LHS of (5) when $\mu = 0$. There is no case distinction between *Observable* and *Unobservable* breakdowns, as each downstream firm is a monopolist. When we allow μ to vary (downward-sloping dashed lines), the plots of the LHS of (5) depend on the observability of disagreements because of the different disagreement profits obtained by the upstream firm. These are higher when breakdowns are *Observable* because the remaining downstream firms observe that there is one less downstream competitor and offer a quantity larger than when breakdowns are *Unobservable*. This larger aggregate quantity benefits the upstream firm, which, in disagreement, makes a higher profit for a given level of the input price. Therefore, for each strictly positive value of μ, the LHS of (5) with *Observable* breakdowns always lies above the corresponding line when there are *Unobservable* breakdowns.

Also note that the LHS when $\mu > 0$ always lies below (above) the LHS when

$\mu = 0$ in the case of *Unobservable* (*Observable*) breakdowns. Under *Unobservable* breakdowns, the LHS of (5) simplifies to $\frac{\pi_i^D(\mathbf{w})}{\pi^M(\mathbf{w})-\overline{\pi}^M} = \frac{\frac{N+\mu}{1+\mu}\left[\widehat{q}_i^N(\mathbf{w})\right]^2}{w\widehat{q}_i^N(\mathbf{w})} = \frac{\frac{N+\mu}{1+\mu}\widehat{q}_i^N(\mathbf{w})}{w}$, which is definitely decreasing in μ; hence, as products become more homogeneous, the dashed curves shift down, compared to downstream monopoly (solid curve when $\mu = 0$). With *Observable* breakdowns, the numerator $\pi_i^D(\mathbf{w})$ is unchanged. The denominator $\pi^M(\mathbf{w})-\overline{\pi}^M$ is now, different from before, decreasing in μ: This is due to the fact that the value of the outside option increases when $\mu > 0$ since the supplier benefits from the expanded output of the other rival downstream firms. This latter effect dominates and gives the upstream supplier a stronger position, pushing the LHS up when $\mu > 0$, compared to $\mu = 0$.

In the same graph, we also plot the RHS of (5): The solid line is for $\mu = 0$ and the dashed line, lying northwest of the former, is for $\mu = 4$. These positions depend mainly on the concession cost of the downstream firm, which increases with μ: Under Cournot competition (and, more generally, with strategic substitutes), an increase in the input price has a negative direct effect on profits (due to the higher cost) and also an equally negative strategic effect, in that it worsens the competitive position of the firm relative to its rival. This latter strategic effect is stronger the more homogeneous the products are.

Panel (a) of Figure 2 allows us to study how the equilibrium input price varies with μ. With *Unobservable* breakdowns, w^* clearly always decreases as μ increases. However, with *Observable* breakdowns, any change in μ induces an equal upward shift on the LHS and RHS of (5): The ratio of the levels and of the marginal effects is equally affected by the differentiation parameter, and, therefore, w^* is independent with respect to μ.

The case of Bertrand competition is shown in panel (b). Note again that, for $\mu = 0$, each downstream firm is a local monopolist, and the mode of downstream competition does not affect the equilibrium. This implies that the solid lines are the same in the two panels (a) and (b). The two panels, however, show two remarkable differences. First, the LHS of (5) with *Unobservable* breakdowns always lies *above* the corresponding line in the event of *Observable* breakdowns for each strictly positive value of μ. This occurs because the supplier's profits in a disagreement are always lower when breakdowns are *Observable*; the remaining downstream firms observe that there is one less downstream competitor and set a price higher than in the case of *Unobservable* breakdowns. Even after the consumers' readjustment, these higher prices result in lower aggregate quantity, which reduces the value of the upstream firm's outside option for a given level of input prices.[17] The second difference is that now the RHS of (5) when μ is positive lies southeast to the same line when $\mu = 0$. Again, this is driven by the concessions costs for the downstream firm – i.e., the numerator of the RHS of (5). Contrary to Cournot, the negative direct effect on profits of an increase

[17]An argument similar (but opposite) to the one used in the Cournot case explains why, when $\mu > 0$, the LHS with *Observable* (*Unobservable*) breakdowns lies below (above) the benchmark case of $\mu = 0$.

in w^* is now compensated by a positive strategic effect due to the softening of competition as firms compete in strategic complements. As products become more homogeneous, these marginal effects on downstream profits decrease (until, in the limit, they are zero for $\mu \to \infty$). Overall, this Panel shows clearly that, when breakdowns are *Observable*, w^* decreases with μ, while the opposite occurs when breakdowns are *Unobservable*.

We now turn to a more formal pair-wise comparison of the equilibrium input prices. We compare them in two ways: For a given mode of competition, according to whether or not breakdowns are observable; and for the same hypothesis regarding the observability of disagreements, across the different modes of downstream competition. This is illustrated in the following Proposition:

PROPOSITION 5: *For all strictly positive values of β and μ, and for all values of $N \geq 2$, we have that*

- $w_C^U < w_C^O$ *and* $w_B^O < w_B^U$;
- $w_B^O < w_C^O$ *and* $w_C^U < w_B^U$.

It is possible to interpret the first line of inequalities in Proposition 5 again by looking at Figure 2. As discussed above, with quantity competition (panel (a)), the LHS when breakdowns are *Observable* always lies above its counterpart in *Unobservable* breakdowns, while the RHS is the same. Clearly, this motivates the ranking of the equilibrium input prices, with and without observability of breakdowns. A mirror case justifies the opposite result under price competition (panel (b)).

A similar argument explains the second line of inequalities in Proposition 5. First, we re-emphasize that both supplier's and retailers' profits are identical under quantity and price competition when $\mu = 0$. Therefore, the solid lines when $\mu = 0$ are identical in both panels, and the equilibrium input prices are identical under Bertrand and Cournot competition: $w^*|_{\mu=0} \equiv w^{mon} = 0.25$. As the bold red lines in Figure 2 show, with *Unobservable* breakdowns, w^* decreases below w^{mon} as μ increases under Cournot competition (panel (a)), while the opposite holds in the case of Bertrand competition (panel (b)). An equal but opposite argument holds for the case of *Observable* breakdowns, with the only difference that under Cournot, the input price is always equal to w^{mon}, while under Bertrand, $w^* < w^{mon}$.

Although we concentrate our analysis on input prices, we can also derive the following welfare result almost immediately:

PROPOSITION 6: *Let W_m^b be the value taken by welfare at equilibrium, where $m = \{B = Bertrand, C = Cournot\}$ is the mode of competition and $b = \{O = Observable, U = Unobservable\}$ relates to the observability of breakdowns. For all strictly positive values of β and μ, and for all values of $N \geq 2$, we have that*

- $W_C^O < W_C^U$ *and* $W_B^U < W_B^O$*;*
- $W_C^O < W_B^O$ *and* $W_B^U < W_C^U$*.*

Identical results hold for consumer surplus.

Proposition 6 is the counterpart of Proposition 5. It shows that the ranking between the different cases analyzed, presented in Proposition 5 in terms of input prices, can be applied immediately to a welfare ranking. For the sake of brevity, Proposition 6 does not provide additional comparative statics exercises on CS and W with respect to the structural parameters N and μ. We merely note that these additional comparative statics do not necessarily derive from those on w^*, as the structural parameters also directly enter the expressions for W and CS.

IV. Input prices and upstream mergers

In this section, we revisit HW's main result – that an upstream merger always increases the input price to downstream firms. HW specifically analyze the case of two downstream Cournot firms and two upstream firms that may merge. Without an upstream merger, each upstream firm can supply only one specific downstream firm; with an upstream merger, the outside option of the upstream firm in disagreement is modeled as in the case of *Unobservable* breakdowns.

We extend their findings to a general number of firms, Bertrand competition, and different observability of disagreements. In the absence of an upstream merger, we maintain HW's hypothesis that each downstream firm deals with an independent upstream firm. Thus, we modify our analysis to allow for the existence of N independent upstream firms. For both types of downstream competition, we first characterize the input prices in the case of N independent suppliers.[18] We then compare them with those obtained in the case of an upstream merger: When there is a single upstream supplier, the analysis corresponds to the one conducted in Sections III.A and III.B.[19]

Let us start with downstream Cournot competition and N independent input suppliers. The second stage is the same as the one described in Section III.A. In the first stage, each firm is in a bilateral monopoly relationship with an independent supplier, and the Nash bargaining problem with zero outside options gives

$$w_C^I = \frac{1}{2}\frac{\beta}{1+\frac{(2-\beta)\mu(N-1)}{4N+2\mu}}, \tag{15}$$

[18] As a downstream firm and its upstream supplier are locked into bilateral relations when they bargain, their outside options are zero, and in this case, we should not worry about the type of reaction to disagreements.

[19] As in HW, we consider an upstream merger to monopoly. While this may be rarely observed in practice, it can be a more realistic assumption in international mergers when upstream suppliers belong to geographically different markets, or when describing a union-firm wage bargaining problem.

where the superscript I is a mnemonic for 'independent' upstream firms. When, in the downstream industry, competition is in prices, the second stage is the same as the one studied in Section III.B. In the first stage, with N independent upstream firms, the Nash bargaining problem with zero outside options gives

$$w_B^I = \frac{1}{2}\frac{\beta}{1+\frac{\mu(2-\beta)(N-1)(N+N\mu-\mu)}{2N(2N+2\mu-\mu)}}. \tag{16}$$

Comparing these results with the input prices obtained with a single merged upstream firm in the previous sections, we can state the following Proposition:

PROPOSITION 7: *For all strictly positive values of β and μ, and for all values of $N \geq 2$, an upstream merger to monopoly always increases the input price to downstream firms, independent from the type of downstream competition (Cournot vs. Bertrand) and from the observability of breakdowns (Observable vs. Unobservable breakdowns). That is,*

$$w_C^I < w_C^U \quad \textit{and} \quad w_C^I < w_C^O;$$
$$w_B^I < w_B^U \quad \textit{and} \quad w_B^I < w_B^O.$$

Thus, we have confirmed the robustness of the central result of HW, which was obtained for the special case of $N = 2$, $\beta = \frac{1}{2}$, Cournot competition downstream, and *Unobservable* breakdowns. Indeed, their finding arises independently from the observability of breakdowns, from the mode of competition, or from the number of competing firms.

V. Renegotiation

As is typical of Nash axiomatic models, in our analysis, we assumed that input prices are committed to in the first stage, and not subject to renegotiation in the case of disagreement. Thus, the remaining players' outside options are evaluated at the anticipated equilibrium input prices. In this section, we check the robustness of our results to this assumption.

Once one opens to the possibility of renegotiations, many permutations are doable. Here, we consider two that are natural candidates. First, we look at unilateral deviations between *one* pair of up/downstream firms in a disagreement. Secondly, we take *all* the other agreements between the upstream supplier and the remaining downstream firms to be non-binding in a disagreement, so that, when a breakdown occurs, there is a full renegotiation of the input prices between the upstream monopolist and the remaining downstream firms. We discuss the main findings and relegate all technical details to the Appendix.

Regarding unilateral deviations, we find that all our equilibria are renegotiation-proof. Intuitively, the downstream firm would agree to renegotiate only discounts, but the upstream firm would like to do exactly the opposite. This result is actually quite strong, as it generally depends on symmetric equilibrium input prices, rather than on the level of these prices at equilibrium (as long as they are below the unconstrained monopoly input price). Hence, a nice property of using linear input prices, when justifiable, is that there would be no Pareto gains in a disagreement from increasing/decreasing the wholesale price, something that is much trickier under non-linear input tariffs.

With respect to the case of full renegotiation, we follow the spirit of Stole and Zwiebel (1996) and again confirm the robustness of our main results. First, the equilibrium input price under non-binding agreements and quantity competition is identical to that in the case of *Observable* breakdowns but fully binding agreements on the input price. Second, under price competition, again with non-binding agreements, our results are similar in nature to those with *Observable* breakdowns and binding agreements: Non-binding agreements generally push prices down, but the input price is still always increasing in N and decreasing in μ, as in Proposition 4. Finally, an immediate consequence of all these results is that the generalization of HW's result contained in Section IV also carries over to the case of non-binding agreements.

VI. Conclusions

The impact of policy, regulation, or intervention in industries where both upstream and downstream firms possess market power and engage in bilateral bargaining depends on how input prices respond. This paper highlights the sensitivity of predictions to the specification of outside options in these settings, particularly as the use of the Nash bargaining solution has grown more pervasive in applied work. The primary point was to show that, upon the disagreement of a downstream firm, the possibility for the other downstream rivals to observe the disagreement and respond to it at the retail level influences how negotiated input prices vary with changes in downstream concentration and product differentiation.

In our main application, we reassessed Galbraith's (1952) original idea that countervailing power could keep input prices low. It turns out this is not a general result, as it depends not only on the nature of downstream competition, but also on what is assumed about outside options. In our framework, countervailing power is a robust finding only when breakdowns are observed by rivals competing in strategic complements.

We are not, however, arguing that one should not expect robust results to arise, simply by changing the mode of competition or the type of retail observability of breakdowns. The answer depends on the particular question asked. We have also revisited HW's pioneering work in this area and showed that their central result is, indeed, very robust, as it arises independently from what it is assumed about the observability of breakdowns when determining the outside options. In fact, several further questions could be re-assessed using our methodological approach.

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Appendix

In this Appendix, we first provide all the proofs of the paper. We then derive the formal results behind our discussion of the renegotiation of input prices in Section V.

Proof of Propositions 1-4. We start by noting that all equilibrium input prices in Propositions 1-4 come from a simple, direct application of (5) and the use of the symmetry assumption. All input prices can be rewritten as

$$w_m^b = \frac{1}{2}\frac{\beta}{1+k_m^b},$$

where b denotes the possibility of observing the breakdowns, $b = \{O = Observable, U = Unobservable\}$, and m the mode of competition downstream, $m = \{B = Bertrand, C = Cournot\}$, so that

$$k_C^O = 0; \tag{A-1}$$

$$k_C^U = \frac{\mu(1-\beta)(N-1)}{2N+\mu}; \tag{A-2}$$

$$k_B^O = \frac{\mu^2(1+\mu)(1-\beta)N(N-1)(2N+N\mu-\mu)}{(2N+2N\mu-\mu)(2N-2\mu+N\mu)(N+N\mu-\mu)^2}; \tag{A-3}$$

$$k_B^U = -\frac{\mu(1+\mu)(1-\beta)N(N-1)}{(2N+2N\mu-\mu)(N+N\mu-\mu)}. \tag{A-4}$$

The proofs then establish the results in terms of the ks above.

Comparative statics in Propositions 1-4 follow from differentiating the ks in

(A-1)-(A-4) with respect to μ and N, obtaining

$$\text{(A-5)} \qquad \frac{\partial k_C^U}{\partial \mu} = \frac{2(1-\beta)(N-1)N}{(2N+\mu)^2} > 0;$$

$$\text{(A-6)} \qquad \frac{\partial k_C^U}{\partial N} = \frac{(1-\beta)\mu(\mu+2)}{(2N+\mu)^2} > 0;$$

$$\text{(A-7)} \qquad \frac{\partial k_B^O}{\partial \mu} = \frac{\mu N(N-1)(1-\beta)z_1}{(2N+\mu(2N-1))^2(2N+\mu(N-2))^2(N+\mu(N-1))^3} > 0;$$

$$\text{(A-8)} \qquad \frac{\partial k_B^O}{\partial N} = \frac{2\mu^2(1+\mu)(1-\beta)z_2}{(2N+\mu(2N-1))^2(2N+\mu(N-2))^2(N+\mu(N-1))^3} < 0;$$

$$\text{(A-9)} \qquad \frac{\partial k_B^U}{\partial \mu} = -\frac{(1-\beta)(N-1)N(2N^2+4N^2\mu+\mu^2(2N^2-1))}{(2N+\mu(2N-1))^2(N+\mu(N-1))^2} < 0;$$

$$\text{(A-10)} \qquad \frac{\partial k_B^U}{\partial N} = \frac{\mu(1-\beta)(1+\mu)((1+N(N-2))\mu^2-N^2\mu-2N^2)}{(2N+\mu(2N-1))^2(N+\mu(N-1))^2} \gtreqless 0;$$

where $z_1 \equiv (4N^4-9N^3+4N^2+3N-2)\mu^4 + N(24N^3-41N^2+9N+6)\mu^3 + 4N^2(13N^2-14N+1)\mu^2+24N^3(2N-1)\mu+16N^4$ and $z_2 \equiv -(N^5-3N^4+2N^3+2N^2-3N+1)\mu^4 - 3N(2N^4-5N^3+3N^2+N-1)\mu^3 - N^2(13N^3-28N^2+18N-2)\mu^2 - 12(N^5-2N^4+N^3)\mu - 4N^4(N-2)$. The sign of (A-5), (A-6) and (A-9) is immediately established. Also, the sign of (A-7) and (A-8) is also immediately established, after noting that $z_1 > 0$ and $z_2 < 0$. Finally, the sign of (A-10) depends on the last term of the numerator, which is positive when $\mu > \frac{\left(N-\sqrt{9N^2+8-16N}\right)N}{2(1+N^2-2N)}$.

Proof of Proposition 5. Using (A-1)-(A-4), the proof is immediate, noting that

$$k_C^O - k_C^U = -\frac{(1-\beta)\mu(N-1)}{2N+\mu} < 0;$$

$$k_B^O - k_B^U = \frac{N\mu(1-\beta)(1+\mu)(N-1)(\mu^2(1-2N+N^2)+\mu(3N-2)N+2N^2)}{(2N+\mu(2N-1))(2N+\mu(N-2))(N+\mu(N-1))^2} > 0;$$

$$k_C^O - k_B^O = -\frac{\mu^2 N(1+\mu)(N-1)(2N+\mu(N-1))(1-\beta)}{(2N+\mu(2N-1))(2N+\mu(N-2))(N+\mu(N-1))^2} < 0;$$

$$k_C^U - k_B^U = \frac{(1-\beta)\mu(N-1)(\mu^2(2N^2-2N+1)+\mu(6N-2)N+4N^2)}{(2N+\mu)(2N+\mu(2N-1))(N+\mu(N-1))} > 0.$$

Proof of Proposition 6. In a symmetric equilibrium, when q^* denotes the equilibrium quantity sold by each downstream firm in the final market and p^* its equilibrium price, using (1) and (2), we can simplify consumer surplus and total welfare as

$$\begin{aligned} CS(q^*) &= U(q^*) - Np^*q^* = \frac{(Nq^*)^2}{2}; \\ W(q^*) &= U(q^*) - Np^*q^* + N(p^* - w^*)q^* + Nw^*q^* \\ &= \frac{1}{2}(2 - Nq^*)Nq^*. \end{aligned}$$

Since $CS(q^*)$ and $W(q^*)$ are both increasing in q^* in the relevant range, and q^* is decreasing in w^*, our claim follows directly from Proposition 5.

Proof of Proposition 7. We note that the input prices with dispersed upstream ownership can be written as $w_m^I = \frac{1}{2}\frac{\beta}{1+k_m^I}$, where m denotes the mode of competition downstream, $m = \{B = Bertrand, C = Cournot\}$. Thus, from (15) and (16), we define

$$\begin{aligned} k_C^I \equiv& \frac{(2-\beta)\mu(N-1)}{4N+2\mu}; \\ k_B^I \equiv& \frac{\mu(2-\beta)(N-1)(N+N\mu-\mu)}{2N(2N+2\mu-\mu)}. \end{aligned}$$

Comparing these with (A-1)-(A-4), we find

(A-11) $k_C^O - k_C^I = \dfrac{\beta\mu(2-\beta)(N-1)}{2\mu(N(2-\beta)+\beta)+4N} > 0;$

(A-12) $k_C^U - k_C^I = \dfrac{\beta^2(\mu+2N)\mu(N-1)}{2[\mu(N(1-\beta)+\beta)+2N][\mu(N(2-\beta)+\beta)+4N]} > 0;$

(A-13) $k_B^O - k_B^I =$

$$= \frac{\beta\mu(N-1)(2\mu N - \mu + 2N)h_1}{2h_2((N^2-2N+1)(2-\beta)\mu^2 + ((6-\beta)N - 4 + \beta)\mu N + 4N^2)} > 0;$$

(A-14) $k_B^U - k_B^I =$

$$= \frac{\beta\mu(N-1)(2\mu N - \mu + 2N)h_3}{2([(N^2-2N+1)(2-\beta)]\mu^2 + [(6-\beta)N - 4 + \beta]\mu N + 4N^2)h_4} > 0;$$

where $h_1 \equiv [(N^4 - 5N^3 + 9N^2 - 7N + 2)(2-\beta)]\mu^4 + [5(2-\beta)N^3 - 2(19 - 10\beta)N^2 + (44 - 23\beta)N - 8(2-\beta)]\mu^3 N + [9(2-\beta)N^2 - 3(16 - 9\beta)N + 2(13 - 7\beta)]\mu^2 N^2 + [7(2-\beta)N - 20 + 12\beta]\mu N^3 + 2(2-\beta)N^4$, $h_2 \equiv [2N^4 - (8+\beta)N^3 + 2(6+\beta)N^2 - (8+\beta)N + 2]\mu^4 + [10N^3 - (29 + 3\beta)N^2 + (28 + 4\beta)N - \beta - 9]\mu^3 N + [18N^2 - (35 + 2\beta)N + 16 + 2\beta]\mu^2 N^2 + 14(N-1)\mu N^3 + 4N^4$, $h_3 \equiv [(N^2 - 2N + 1)(2-\beta)]\mu^2 + [2((3-2\beta)N - (2-\beta))]\mu N + (4 - 3\beta)N^2$ and $h_4 \equiv$

$[\beta N(N-1)+1+N(N-2)]\mu^2+[3N-2+\beta(N-1)]\mu N+2N^2$. After noting that $h_i>0$ for all is, the sign of (A-11)-(A-14) is immediately established.

We now provide the analysis supporting our robustness analysis contained in Section V.

A1. Bilateral renegotiation

We evaluate the players' outside options at the anticipated equilibrium input price and check whether the upstream and one randomly-chosen among the remaining downstream firms had a mutual gain from renegotiating it. Specifically, we compute the impact of a change in w_j on the disagreement profits of the upstream firm and of downstream firm j, respectively, $\overline{\pi}^M$ and $\overline{\pi}_j^D$. In what follows, we describe our computations for the different modes of competition and nature of the breakdowns. We show that two marginal effects are always opposite in sign, and, thus, the input price is renegotiation-proof.

Observable breakdowns and downstream quantity competition. — From Section III.A, when a disagreement occurs between the upstream supplier and downstream firm i, the profits obtained by the upstream monopolist are given by $\overline{\pi}^M=\sum_{k\neq i}w_k^*\widehat{q}_k^{N-1}(\mathbf{w}^*)$, where $\widehat{q}_k^{N-1}(\mathbf{w}^*)$s are the quantities that the remaining $N-1$ firms would offer in the last stage of the game, after having readjusted their choices because of the missing rival firm, as in (8), evaluated at the anticipated input price. Similarly, the profits obtained by each of the $N-1$ downstream firms are given by $\overline{\pi}_j^D=[p_j(\widehat{\mathbf{q}}^{N-1}(\mathbf{w}^*))-w_j^*]\widehat{q}_j^{N-1}(\mathbf{w}^*)$, where

$$p_j(.)=1-\frac{q_jN+\mu\sum_{k\neq i}q_k}{1+\mu}$$

is the inverse demand function faced by firm j when only $N-1$ products are on offer.

Next, we differentiate with respect to the input price the profits of the upstream monopolist and of firm j, and we evaluate the derivatives at a symmetric equilibrium, where $w_j^*=w_k^*=w^*$ for all j and k. Notice that, since the negotiated input prices are always observable, we allow for the marginal change in w_j to affect the quantities chosen by the $N-2$ rival firms. For the upstream monopolist, we obtain $\left.\frac{\partial\overline{\pi}^M}{\partial w_j}\right|_{w_j=w^*}=\gamma_C(1-2w^*)$, where $\gamma_C\equiv\frac{(1+\mu)}{N(\mu+2)}>0$. This marginal effect is positive for all values w^* below the monopoly price $(\frac{1}{2})$. For the downstream firm, we obtain $\left.\frac{\partial\overline{\pi}_j^D}{\partial w_j}\right|_{w_j=w^*}=-\delta_C^O(1-w^*)$, where $\delta_C^O\equiv\frac{2(1+\mu)(N+\mu)(\mu N+2N-\mu)}{N^2(\mu+2)^2(\mu+2N)}>0$.

Observable breakdowns and downstream price competition. — From Section III.B, the upstream monopolist profits in the case of breakdown are given by $\overline{\pi}^M = \sum_{k \neq i} w_k^* q_k(\widehat{\mathbf{p}}^{N-1}(\mathbf{w}^*))$, where $q_k(.)$ is the demand function to firm k when only $N-1$ products are on offer, as in (11), and $\widehat{\mathbf{p}}^{N-1}(\mathbf{w}^*)$ is the vector of equilibrium prices that the remaining $N-1$ firms would set in the last stage of the game, after having readjusted their choices because of the missing firm i. Similarly, each downstream firm obtains profits given by $\overline{\pi}_j^D = [\widehat{p}_j^{N-1}(\mathbf{w}^*) - w_j^*] q_j(\widehat{\mathbf{p}}^{N-1}(\mathbf{w}^*))$.

Then, we differentiate with respect to the input price the expressions for profits of the upstream monopolist and of the firm j, and we evaluate the derivatives at a symmetric equilibrium. As before, we allow for the marginal change in w_j to affect the prices chosen by the $N-2$ rival firms. We obtain $\left.\frac{\partial \overline{\pi}^M}{\partial w_j}\right|_{w_j = w^*} = \gamma_B(1-2w^*)$, where $\gamma_B \equiv \frac{[N+(N-2)\mu)](1+\mu)}{[N+(N-1)\mu][2N+(N-2)\mu]} > 0$, and $\left.\frac{\partial \overline{\pi}_j^D}{\partial w_j}\right|_{w_j = w^*} = -\delta_B^O(1-w^*)$, where $\delta_B^O \equiv \frac{2[N+\mu(N-2)][(N^2-4N+4)\mu^2+(3N-5)\mu N+2N^2](1+\mu)}{[N+\mu(N-1)][2N+\mu(N-2)]^2[2N+\mu(2N-3)]} > 0$.

Unobservable breakdowns and downstream quantity competition. — From Section III.A, when a disagreement occurs between the upstream supplier and downstream firm i, the upstream monopolist's profits are given by $\overline{\pi}^M = \sum_{k \neq i} w_k^* \widehat{q}_k^N(\mathbf{w}^*)$, where $\widehat{q}_k^N(\mathbf{w}^*)$s are the quantities that the remaining $N-1$ firms would offer in the last stage of the game, without the readjustment due to the missing rival firm (see (6)), evaluated at the anticipated input price. More subtle is the definition of profits for the downstream firm, which is unaware of the breakdown of the negotiation and of the fact that firm i's product is not available. Then, firm j not only keeps offering the optimal quantity as if N firms were in the market, but also believes that the consumers are making their choices as if all goods were available, so that the demand function is the one with N goods available. Its "perceived" profits are then $\overline{\pi}_j^D = [p_j(\widehat{\mathbf{q}}^N(\mathbf{w}^*)) - w_j^*]\widehat{q}_j^N(\mathbf{w}^*)$, where $p_j(.)$ is as in (1).

Next, we differentiate with respect to the input price the profits of the upstream monopolist and of firm j and evaluate the derivative at the symmetric equilibrium. For the downstream firm, we obtain $\left.\frac{\partial \overline{\pi}_j^D}{\partial w_j}\right|_{w_j = w^*} = -\delta_C^U(1-w^*)$, where $\delta_C^U \equiv \frac{2(2+\mu)(N+\mu)N(1+\mu)}{(\mu+2N)(2N+\mu N+\mu)^2} > 0$. For the upstream firm, we obtain $\left.\frac{\partial \overline{\pi}^M}{\partial w_j}\right|_{w_j = w^*} = -\frac{(1+\mu)(3\mu w^* - \mu + 4Nw^* - 2N)}{(\mu+2N)(2N+\mu N+\mu)}$, which is always positive when evaluated at the equilibrium input price $w^* = w_C^U$.

Unobservable breakdowns and downstream price competition. — As in the previous case, the definition of the players' profits is affected by the fact that the remaining downstream firms do not observe the breakdown of the negotiation between firm i and the upstream monopolist, which is, of course, aware of the disagreement.

From Section III.B, when a disagreement occurs between the upstream supplier and downstream firm i, the profits obtained by the upstream monopolist are given by $\overline{\pi}^M = \sum_{k \neq i} w_k^* q_k(\widehat{\mathbf{p}}^N(\mathbf{w}^*))$, where $q_k(.)$ is the demand function of firm k when only $N-1$ products are on offer, as in (11), and $\widehat{\mathbf{p}}^N(\mathbf{w}^*)$ is the vector of equilibrium Bertrand prices that the remaining $N-1$ firms would set in the last stage of the game without the readjustment due to the missing rival firm, as in (10), evaluated at the anticipated input price. As to the downstream firm, its "perceived "profits are then $\overline{\pi}_j^D = [\widehat{p}_j^N(\mathbf{w}^*) - w_j^*] q_j(\widehat{\mathbf{p}}^N(\mathbf{w}^*))$, where $q_j(.)$ is the demand function to firm k when all N products are on offer, as in (3).

Taking the derivatives of these profits and evaluating them at the symmetric input price, we have that $\left.\frac{\partial \overline{\pi}_j^D}{\partial w_j}\right|_{w_j = w^*} = -\delta_B^U(1 - w^*)$, where $\delta_B^U \equiv 2(N + \mu N - \mu)\frac{(3\mu N^2 - 2N\mu^2 + N^2\mu^2 - 2\mu N + 2N^2 + \mu^2)}{N(2N + \mu N - \mu)^2(2N + 2\mu N - \mu)} > 0$; we also find that $\left.\frac{\partial \overline{\pi}^M}{\partial w_j}\right|_{w_j = w^*} = \frac{(2N - 4\mu N w^* + 3\mu w^* - \mu + 2\mu N - 4N w^*)(1 + \mu)}{(2N + 2\mu N - \mu)(2N + \mu N - \mu)}$, which is always positive for any $w^* < \frac{1}{2}$.

A2. Full renegotiation

We now consider that, when a breakdown occurs, a full renegotiation of the input price takes place between the upstream monopolist and the remaining downstream firms. The latter then make their choices in the final market based on the renegotiated input price. We borrow the idea of non-binding agreements in a negotiation breakdown directly from Stole and Zwiebel (1996). To make our results fully comparable with those derived earlier in the paper and to maintain our focus on the effect of the specification of the outside option on the equilibrium input price, we do not employ their sequential game but, instead, keep the same game structure used in the previous sections.[20]

If a negotiation breaks down, all other agreements are not binding, the outside option is the equilibrium outcome of a new negotiation with one less downstream firm. Therefore, we encounter a recursive structure. Formally, the outside option of the upstream monopolist is $\overline{\pi}^M = \sum_{\substack{j=1 \\ j \neq i}}^{N} w_j^{N-1} \overline{q}_j$. In case of quantity competition, for all js, $\overline{q}_j = \widehat{q}_j^{N-1}$, as in (8), after substituting $w_j = w_k = w^{N-1}$. With price competition, $\overline{q}_j$s are obtained by setting $w_j = w_k = w^{N-1}$ in the second-stage equilibrium prices, as in (13), and then substituting them into the inverse demand functions given in (11). After solving for the symmetric equilibrium input

[20] Stole and Zwiebel (1996) deal with a labor market that is modeled as an extensive form game in which bargaining proceeds as a finite sequence of pairwise negotiations between one (of N) employee and the firm. In each negotiation, if the parties reach an agreement, they split-the-difference; in a disagreement, the worker exits the game forever, and a new set of negotiations starts with the remaining $N-1$ workers. They show that the unique subgame perfect equilibrium of this game is stable, in the sense that neither party can improve its payoff in a pairwise negotiation with the other party.

price using (5), for both $m = \{B = Bertrand, C = Cournot\}$, one gets

$$w_m^N\left(w_m^{N-1}\right) = \frac{a_m + \sqrt{c_m\left(w_m^{N-1}\right)^2 + c_m w_m^{N-1} + d_m}}{4b_m}, \tag{A-15}$$

where we use

$$\begin{aligned}
a_C \equiv& -2x' - 3x'';\\
b_C \equiv& -x' - x'';\\
c_C \equiv& -16(1-\beta)(N-1)(2N + N\mu + \mu)b_C;\\
d_C \equiv&(2x' + x'')^2;\\
a_B \equiv&[2y'(1-\beta) - 10N\mu\beta + 4N\mu - 6\beta N + 3\beta\mu]\, y'';\\
b_B \equiv&[y'(1-\beta) - 2\beta N + \beta\mu - 4N\mu\beta + 2N\mu]\, y'';\\
c_B \equiv&16(1-\beta)(1+\mu)(N-1)(y' + 2N\mu)[(y' + 2N\mu)(1-\beta) + \beta\mu - 2N\beta(1+\mu)]\, y''';\\
d_B \equiv&[(2y'(1-\beta) - 2\beta N + \beta\mu - 6N\mu\beta + 4N\mu)\, y''^2;
\end{aligned}$$

where $x' \equiv (2+\mu)(1-\beta)$, $x'' \equiv \beta(2N+\mu)$, $y' \equiv (-N^2+2N-1)\mu^2 - (3\mu+2)N^2$, $y'' \equiv (N+N\mu-\mu)(2N+N\mu-2\mu)$ and $y''' \equiv (2N+N\mu-2\mu)(2N+N\mu-\mu)(N+N\mu-2\mu)$.

In the case of downstream Cournot competition, from the initial condition $w = \frac{\beta}{2}$ when $N = 1$ and using iterative methods, it is immediate to establish that $w_C^N = \frac{\beta}{2}$ for any N. That is, we obtain the same result as (9) under *Observable* breakdowns and no renegotiations. When downstream competition is in prices, using the same techniques, we can also solve (A-15) for explicit values of N, β and μ. In the illustration in Figure A-1, the dots give the equilibrium input price for different values of N. For comparison, the Figure also features the equilibrium input price with *Observable* breakdowns, already illustrated in Panel (b) of Figure 1.

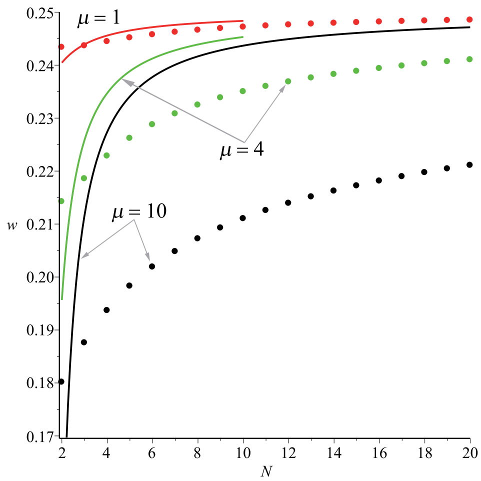

FIGURE A-1. EQUILIBRIUM INPUT PRICE WITH BERTRAND COMPETITION WHEN $\beta = \frac{1}{2}$. THE DOTS ILLUSTRATE THE CASE OF FULL RENEGOTIATION, WHILE THE SOLID LINES GIVE THE CASE OF *Observable* BREAKDOWNS.