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ABSTRACT

The Effects of Downstream Distributor Chains on Upstream Producer Entry: A Bargaining Perspective

by Suchan Chae and Paul Heidhues

This paper studies the effects of integration among downstream local distributors on the entry of upstream producers in a bargaining theoretic framework. We show that integration of downstream distributors may increase their bargaining power vis-à-vis upstream producers and thus lower incentives for entry in the upstream production industry. In order to explain price formation in such a market, we use a bargaining solution that generalizes the Nash solution.

ZUSAMMENFASSUNG

Die Auswirkungen von überregionalen Zusammenschlüssen zwischen Händlern auf den Eintritt von Inputproduzenten: Eine verhandlungstheoretische Analyse

Ausgehend von Industrien mit hohen Fixkosten und vernachlässigbaren Grenzkosten (z. B. Film- und Fernsehindustrie, Softwareindustrie, Pharmazeutische Industrie) wird untersucht wie sich überregionale Zusammenschlüsse zwischen "downstream distributors" (z. B. Kinos, Kabelbetreiber, Einzelhändler, Krankenhäuser bzw. Krankenkassen) auf die Angebotsvielfalt auswirken. Aus verhandlungstheoretischer Sicht werden dazu in diesem Beitrag die Auswirkungen von überregionalen Zusammenschlüssen zwischen lokalen "downstream distributors" auf den Eintritt von Inputpoduzenten untersucht . Es wird gezeigt wie überregionale Zusammenschlüsse von "distributors" deren Verhandlungsmacht gegenüber Inputproduzenten erhöhen können und damit die Anreize zum Eintritt in die Inputindustrie verringern können. Hierzu verwendet dieser Beitrag eine verallgemeinerte Nash-Verhandlungslösung, um die Preisbildung auf dem Inputmarkt zu analysieren.

1. Introduction

In this paper, we consider an input market in which multiple upstream firms sell their products to geographically separated downstream firms. In particular, we look at software-type markets in which the fixed costs of developing products incurred by upstream firms are substantial but the marginal costs of distributing them to downstream firms are negligible. We investigate, using a recently developed bargaining model, how the formation of downstream coalitions across geographically separated markets affects both the downstream firms' bargaining power and the number of varieties that upstream firms are willing to supply. What we have in mind is a situation in which the formation of coalitions (or mergers) is a long term decision, while upstream production decisions are short term decisions.

As an illustrative example, suppose that a movie-theater chain in Los Angeles wants to merge with a movie-theater chain in New York City. Should regulators be concerned about this merger? A casual answer may be no, since across-local-market mergers do not change the market structure in the local movie-theater markets. One may argue that local, not national, markets are the relevant markets. Consider the following legal case: After monopolizing the Las Vegas movie-theater market, Syufy enterprises was sued by the Department of Justice not for its behavior in the product market but for its alleged impact on the input market.[1] The government, however, lost its case. The judge's ruling explicitly mentions that Syufy was only a small regional entrepreneur even though this was not the main premises of the ruling.[2] We believe the case raises important ques-

1. US vs. Syufy enterprises and Raymond Syufy, 1990.
2. Testimony by one of Syufy's suppliers revealed that, in his mind, Syufy's bargaining power was severely limited by the fact that Syufy had only 1.3% of the national market share. See Waterman (1996) for a detailed discussion.

tions: Under what conditions do downstream mergers lead to excessive “market power” in the input market? How is the national size of a distributor chain related to its “input market power”?

In addition, regulators have been concerned about the *national* market size in other industries. For instance, the Cable Act of 1992 ordered the Federal Communications Commission to establish legal restrictions on the national size of the multiple cable system operators (MSOs).[3] Interestingly, this legislative action took pace despite the fact that local cable companies typically have nearly 100 percent market share on the output market.

Recently, the merger between AT&T and MediaOne lead to a debate as to whether these ownership rules are appropriate.[4] Proponents of the ownership restrictions, including consumer advocates, argue that they are necessary to ensure sufficient “variety” in the programing, especially as broadband cable allows for practically unlimited programming. Critics of the ownership constraints argued, among other things, that mergers in the cable industry increase not only cable companies’ efficiency in production but also enables cable companies to undertake the necessary infrastructure investments to connect customers to broadband cable. Our model examines the merits of both arguments and highlights the trade-off that policy makers face. Obviously, the results of this paper have implications for many other industries. The paper not only explains why distributor coalitions, such as hospital alliances in the market for pharmaceutical products, form but also predicts what consequences they might have.

To investigate the “market power” of distributor chains in the input market, one has to model how input prices are determined. In an equilibrium with free entry, one should expect upstream

3. See Congress of the United States (1992).
4. Broadcasting & Cable, May 1999, pp 10-11; New York Times, August 18, 1999, p 1; New York Times, September 10, 1999, p 1.

producers to earn zero profits. Thus the sum of the (not necessarily uniform) prices distributor chains pay should be equal to the fixed cost of developing the product. However, the question of *how* prices are determined in such a market remains an important theoretical issue.

Consider the movie market example again. We view the market for movies as one consisting of interconnected bilateral monopoly markets. If we look at each geographical market, a movie theater is a local monopolist. If we focus on each movie, a producer is a monopolist. Thus, in determining the price that a movie theater pays to gain the right to show a movie, the theater and producer both act as bilateral monopolists. Bargaining is a natural mechanism by which prices are formed in such a market.

The challenge lies, however, in extending the traditional bargaining theory to deal with the interactions of players between the local markets. In order to deal with such a situation, Chae and Heidhues (1999) generalized the well-known Nash solution in two separate directions: first to a situation where one party is a coalition of two players, and second to a situation where one party bargains with opponents on two fronts. Using the extended solution, they show that two theaters in two geographically separate local markets can increase their bargaining power by forming a coalition. Intuitively, the more concentrated the movie theater industry, the more important it is for a movie producer to resolve the bargaining problem with a movie-theater chain. This weakens the movie producer's position and thus it will concede more of the overall benefits. Thus large movie theater chains can affect market prices to their advantage. This in itself, however, has only distributional consequences. Even though the integration of the theaters may increase their market power, it does not affect aggregate welfare. It only leads to a redistribution of gains from cooperation within a local market from the unintegrated to the integrated players. Thus there is no justification, within the model Chae and Heidhues (1999), for restricting the national size of a theater chain.

In this paper, we endogenize movie producers' entry and show that mergers across local markets *can* have efficiency implications, justifying regulatory restrictions on such mergers. The intuition for this result is as follows: Integration across movie-theater chains increases their bargaining power. Potential movie producers anticipate the increased bargaining power of movie chains and thus expect to receive less for their movies. This reduces incentives to enter the movie production industry and therefore decreases the number of movies available. In our model, this leads to a decrease of welfare.[5]

Our treatment of firms and mergers differs from most of the related works in the literature in at least two substantial ways: First, we think of a firm's risk preferences as depending on its owners' risk preferences. In particular, we do not assume that firms are risk neutral.[6] Secondly, we regard two firms that merge (i.e., form a coalition) as simply sharing the ownership of all of their assets. In particular, we do not model the merger as a buy-out.[7] One may think of the owners as swapping stocks. The main reason why we do not consider buy-outs is that in our model a buy-out is always dominated by joint ownership, for we assume the homogeneity of agents and abstract from agency problems.

Our paper is closely related to the literature on input-market bargaining in the presence of oligopolistic product market competition such as Horn and Wolinsky (1988), Dobson and Waterson

5. From the theoretical point of view, there is no particular reason why mergers occur among downstream firms rather than among upstream firms. The model in this paper applies equally well to upstream mergers.
6. One interpretation of this feature can be that capital markets are imperfect.
7. This is in contrast to, for instance, Kamien and Zang (1990).

(1997), and von Ungern-Sternberg (1996). In the first stage of these two stage models, a single upstream supplier bargains with multiple downstream firms about the input market price. In the second stage, the downstream firms compete with each other, taking the input market price as given. The second stage competition thus determines the quantity of the input that each firm demands. Because, in these models, the bargaining parties only negotiate over linear transfer prices, the negotiated agreement leads to double marginalization.

In Horn and Wolinsky (1988)'s quantity-competition model, a downstream merger is unprofitable if firms produce substitutes.[8] In their model, downstream competition raises downstream firms' cost of making concessions in the input market bargaining. This changes the slope of the bargaining frontier and puts the downstream firms in a stronger bargaining position. Indeed, if firms produce substitutes then the positive bargaining effect of a downstream commitment to compete overcompensates the forgone benefits of monopolizing the product market.

Dobson and Waterson (1997) have a similar two stage setup in which downstream firms compete in prices rather than quantities. In their solution, the upstream supplier bargains with each downstream firm on the incremental benefit of reaching an agreement, assuming that the supplier reaches an agreement with each of the other downstream firms. In their model, a downstream merger has two effects: First, it increases the rent that a given downstream firm can extract from consumers, increasing the pie the players bargain over in the first stage. Second, the supplier has fewer alternative outlets available, which increases the incremental benefit of reaching an agreement with a given downstream firm. This reduces the suppliers' bargaining power and thus makes

8. To avoid this, in his view absurd, result, von Ungern-Sternberg (1996) requires that the "generalized Nash bargaining solution" he claims to use satisfies an additional assumption. This assumption, however, implies that von Ungern-Sternberg uses a proportional solution, i.e. a solution in which the bargaining parties' benefits are split Pareto-efficiently according to a fixed sharing rule α.

a given downstream firm better off. However, downstream firms that merge lose market share to their competitors. In fact, Dobson and Waterson do not show that a downstream merger can be profitable in their model.

In contrast to the above mentioned papers, mergers in our model do not change the level of competition in the downstream industry. Indeed, the major innovation of the bargaining approach used is that forming a coalition generates bargaining power in the absence of any substitutability between the merging parties. In addition, our paper allows for upstream entry. Thus we need to generalize the bargaining game to allow for multiple upstream suppliers.[9] This problem has been previously addressed in Waterman (1996). Our approach differs from his in that we show how mergers affect the firms' bargaining power rather than simply assert that the national size of a distributor chain is positively related to bargaining power.

Furthermore, in contrast to Waterman and the aforementioned literature, we do not restrict the bargaining agreement to linear transfer prices. Instead, we assume that each bilateral bargaining problem is resolved efficiently. Thus there is no double marginalization. In our model, downstream distributors buy the input, such as a movie, before selling it to as many consumers as is optimal. In other words, the input market price is a sunk cost when showing the movie and hence does not directly affect consumer prices. It may, however, determine how many movies are produced and thereby how many movies a movie theater wants to show, which in turn may affect consumer prices.

The model most closely related to our is perhaps Chipty and Snyder's (1999) bargaining model of the cable industry. In their model, a single producer bargains simultaneously with multi-

9. Among other things, this differentiates the current paper from Chae and Heidhues (1999).

ple downstream firms, each of which is a monopolist in its downstream market. In each bilateral bargaining between the supplier and a downstream firm, the players take as given that all other bargaining problems are resolved efficiently. The effective pie they bargain over is thus the incremental benefit of reaching an agreement given that all other bargaining problems are resolved. Each bargaining problem is solved using the Nash bargaining solution. Because firms are assumed to be risk neutral, the effective pie in any bargaining problem is split equally between the upstream supplier and the downstream firm. Thus, in contrast to our model, a downstream merger cannot affect the bargaining power of the cable operators, holding the size of the pie as given. It may, however, change the effective pie they bargain over. Based on their model and empirical data on upstream suppliers' advertising revenues, Chipty and Snyder maintain that, in the absence of any efficiency gains, mergers between cable operators would lower the effective pie over which the downstream firms bargain. Hence, mergers would lower the share that the integrating cable operators receive.

Why then do downstream mergers occur? The answer Chipty and Snyder provide is that mergers must lead to (non-specified) efficiency gains that can be divided between the bargaining parties. In contrast to our model, Chipty and Snyder's model predicts that upstream suppliers benefit from downstream mergers.[10] Their prediction, however, raises the question why broadcasters do not lobby in favor of relaxing the existing restrictions on the national size of MSOs.

The remainder of the paper is organized as follows: Section 2 introduces the model and its solution. Section 3 investigates the consequences of distributor integration. Section 4 provides the conclusion.

10. This suggests a simple empirical test to differentiate between the two models.

2. Model and solution

In this section, we first setup the basic model. Then, we introduce the bargaining solution and solve the game.

2.1. *Entry and bargaining*

We consider a two-stage game that determines the number of products developed and the payment producers collect from distributors. Let n_t be the number of local distributors that belong to a distributor chain *t*, and let *l* be the number of distributor chains. Then $m = \Sigma_{t=1}^{l} n_t$ is the total number of local distributors.[11] Each distributor is a local monopolist who faces a downward-sloping inverse demand curve $g(z)$, where *z*, an integer, is the number of inputs the local distributor sells. Let $R(z) = zg(z)$ denote the net revenue of a local distributor from selling *z* inputs, and let $\Delta R(z) = \{R(z) - R(z-1)\}$. Assume that $\Delta R(z)$ decreases in *z* and that there exists a unique $z*$ that maximizes $R(z)$.[12]

In the first stage, infinitely many independent producers decide whether or not to enter the upstream production industry. Each producer that decides to enter develops exactly one product incurring some fixed cost *f*. Denote by *h* the number of upstream producers that decide to enter.

11. For concreteness, one may think of inputs as movies, of local distributors as movie theaters, and of distributor chains as movie theater chains. Alternatively, one may think of inputs as TV-programming, of local distributors as cable operators, and of distributor chains as MSOs.
12. In some industries it may be natural to model upstream products as horizontally differentiated. As long as the incremental revenue of selling another upstream product in the final consumer market decreases in the number of products sold, which is a natural assumption, the positive predictions of our model are unchanged. As discussed below, however, the welfare conclusions may change.

In the second stage, producers $(p=1,\ldots,h)$ that entered sell their products to distributor chains $(t=1,\ldots,l)$. Each producer simultaneously negotiates with each distributor chain about the price that the distributor chain pays for the right to sell the product. Distributor chain t and producer p face a bargaining problem $\langle (t,p), \pi(t,p), (d_t^p, d_p^t)\rangle$, a situation where the bargaining parties (t,p) split the pie $\pi(t,p)$ if they come to an agreement and receive their breakdown payoffs (d_t^p, d_p^t) otherwise. In each bilateral bargaining problem, players are assumed to take the outcomes of all other bargaining problems as given. Thus, the producer's fall-back position, d_p^t, is the payment it receives from all other distributor chains minus the cost he incurred to develop the product, and the distributor chain's fallback position, d_t^p, is its payoff from settling all other bargaining problems.

The pie the bargaining parties are bargaining over, $\pi(p,t)$, is the benefit of an agreement between the two parties. Thus, in the case where $h \le z^*$ one has $\pi(p,t) = n_t \Delta R(h)$. That is, the pie the players are bargaining over is the incremental benefit of selling the product by all distributors that belong to the distributor chain, given that the distributor chain reached agreements with all other producers. In the case where $h > z^*$, one has $\pi(p,t) = 0$. That is, there is no added benefit for a distributor chain from reaching an agreement with the producer, given that it reached agreements in all other bargaining problems.

Formally, given that h producers have entered in the first stage, the second-stage subgame, $G(h)$, is the family of all bilateral bargaining problems between the producers and distributor chains, *i.e.*,

$$G(h) = \langle (t,p), \pi(t,p), (d_t^p, d_p^t) \rangle_{p = 1, \ldots, h; t = 1, \ldots, l}$$

Note that $G(h)$ is a combination of *interdependent* bargaining problems.

A *settlement* to $G(h)$ is an array $(x, y) = (x_t^p, y_p^t)_{p = 1, \ldots, h; t = 1, \ldots, l}$, where $x_t^p + y_p^t = \pi(t, p)$ for each (t, p). Here, x_t^p is the share of $\pi(t, p)$ that the distributor chain keeps from selling the product developed by *p*, and y_p^t is the payment the producer collects from distributor chain *t*.

2.2. *Preliminaries on bargaining solutions*

The solution we use to solve a second-stage bargaining game $G(h)$ is the simultaneous Zeuthen-Nash solution developed in Chae and Heidhues (1999).[13] The simultaneous Zeuthen-Nash solution extends the well-known Nash solution in two different directions. First, it extends the Nash solution to situations where a player bargains with multiple players simultaneously. In the second-stage bargaining game $G(h)$, for instance, a producer bargains with multiple distributor chains simultaneously. Second, the simultaneous Zeuthen-Nash solution extends the Nash solution to situations where a negotiating party is a coalition of agents. In the bargaining game $G(h)$, one type of negotiating party is a distributor chain, which is a coalition of local distributors.

13. Harsanyi (1956) shows the equivalence of Zeuthen's (1930) and Nash's (1950) solutions.

For the purpose of setting up the basic structure that is used to generalize the Nash solution, we will here introduce the players' preferences, a two-person bargaining problem, the Zeuthen-Nash solution, and some of its properties.

Assumption 1. *Players' preferences can be represented by a smooth and increasing von Neumann-Morgenstern utility function,* $v(x)$.[14]

During a bargaining process, a player is typically viewed as facing a gamble in which with probability q, he receives payoff $x_a + d_a$ and with probability $1 - q$, the negotiation breaks down and he receives payoff d_a. Let $s_a(q, x_a + d_a, d_a)$ be the certainty equivalent of such a gamble, i.e.,

$$s_a(q, x_a + d_a, d_a) = v_a^{-1}[qv_a(x_a + d_a) + (1 - q)v_a(d_a)] .$$

A player's *risk concession,*

$$c_a(q, x_a + d_a, d_a) = x_a + d_a - s_a(q, x_a + d_a, d_a) ,$$

is the amount he is willing to concede in order to avoid the chance of a breakdown.

Definition 1. The *marginal risk concession of a player* is defined as

$$\lim_{q \to 1} \frac{c_a(q, x_a + d_a, d_a)}{(1 - q)} .$$

It will be denoted $\mu_a(x_a, d_a)$.[15]

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14. A smooth function is one that is n times differentiable for any n.

The marginal risk concession is the rate of change in the risk concession as the probability of a breakdown approaches zero. The Zeuthen-Nash solution, introduced below, equalizes the marginal risk concessions across players. It thus captures the notion that, while negotiations never break down in equilibrium, it is the fear of a breakdown that restrains players' demands so the bargaining problem can be resolved. It is easy to check that

$$\mu_a(x_a, d_a) = \frac{v_a(x_a + d_a) - v_a(d_a)}{v_a'(x_a + d_a)}. \qquad (1)$$

Note in particular that one has $\mu_a(0, d_a) = 0$. We make the following two assumptions:

Assumption 2. $\mu_a(x_a, d_a)$ *is decreasing in* d_a *for all* $x_a > 0$.

Assumption 3. $\mu_a(x_a, d_a)$ *is increasing and convex in* x_a.

Assumption 2 ensures that the marginal risk concession of a player is decreasing in his fall-back position, which is his wealth in the event that the bargaining breaks down. Because the Zeuthen-Nash solution equalizes the players' marginal risk concessions, Assumption 2 implies that the better the fall-back position of an individual player is, the stronger a negotiator he becomes.

To assume that the marginal risk concession is increasing in x_a is natural and indeed satisfied by a broad class of preferences. This class includes all risk averse preferences and all preferences

15. Aumann and Kurz (1977) call this the "fear of ruin". They also show that for the kind of bargaining problems considered in this paper, the Nash solution equalizes the fear of ruin or marginal risk concession across players.

that can be represented by utility functions with constant relative risk aversion.[16] The convexity of an individual's marginal risk concession with respect to x_a implies that for any positive integer n,

$$\mu_a(x_a, d_a) \geq n\mu_a\left(\frac{x_a}{n}, d_a\right).$$

The inequality states that the sum of marginal risk concessions for evenly split parts of a certain amount x_a is not higher than the marginal risk concession of the full amount. The importance and intuitive appeal of Assumption 3 will become apparent once we introduce the marginal risk concession of a coalition.

It turns out that Assumptions 2 and 3 are satisfied by all risk averse preferences that can be represented by von Neumann-Morgenstern utility functions with constant hyperbolic risk aversion (HARA).[17] Note that Assumption 2 rules out risk neutrality. Here we think of a firm's risk preference as reflecting its owner(s)'s risk preferences. If, instead, one follows the standard assumption that firms are risk neutral, then the outcome of our model would be independent of the downstream market structure.

A *two-person bargaining problem* $\langle (a, b), \pi, (d_a, d_b)\rangle$ is a situation where two agents (a, b) split a pie of size π if they can agree on their shares, and receive payoffs (d_a, d_b) otherwise. The *Zeuthen-Nash solution* of the two-person bargaining problem is a vector $(x_a + d_a, x_b + d_b)$ such that $x_a + x_b = \pi$ and[18]

16. In particular, the concavity of a utility function is not a necessary condition.
17. This class includes all utility functions with constant relative risk aversion. See Chae and Heidhues (1999).

$$\mu_a(x_a, d_a) = \mu_b(x_b, d_b) .$$

Since $\mu_a(x_a, d_a)$ is increasing in x_a by Assumption 3, there exists a unique Zeuthen-Nash solution for any two-person bargaining problem.

Following the approach of Chae and Heidhues (1999), we submit that the equalization of the marginal risk concession is the defining characteristic of the Nash solution that is generalizable to bargaining situations involving coalitions. The solution to any bargaining problem should equalize, across parties, the amount a party is willing to concede in order to avoid the breakdown of negotiations. The amount is measured in our framework by the marginal risk concession of the negotiating party. In our model, a party can be either an individual or a coalition of individuals. We thus need to define the marginal risk concession of a coalition.

Definition 2. The *marginal risk concession of a coalition* with n_t identical members is denoted and defined as

$$\mu_t(x_t, d_t) = n_t \mu_a\left(\frac{x_t}{n_t}, \frac{d_t}{n_t}\right) ,$$

where *a* denotes the representative member of the coalition.

Here the marginal risk concession of a coalition is defined as the sum of the marginal risk concessions of its members. It is quite natural to presume that the amount the coalition is willing to concede in order to avoid the chance of a breakdown is the sum of what its members are willing to concede.

18. Technically, for the bargaining problem introduced above, the following equation is equivalent to the first order condition of the Nash maximization.

Regarding the split of a payoff within a coalition, note that the members of a coalition split not only the equilibrium payoff but also the breakdown payoff. Thus we do not allow the members of a coalition to write a binding contract regarding the split of a pie available in the future.

As a strategic motivation for Definition 2, consider a Rubinstein-type (1982) alternating-offer model in which a coalition member is delegated to bargain on behalf of the coalition with an outsider, knowing that the coalition's share is split equally between all of its members. There is an exogenously given probability of a break down after an offer is rejected. There exists a unique subgame perfect equilibrium for this game. As the break-down probability approaches zero, the marginal risk concession of the coalition as defined above is what is equalized with the marginal risk concession of the outsider in the solution to the above strategic game.[19]

Given Definition 2, Assumption 3 implies that sharing the risk of a breakdown between multiple agents (weakly) decreases their marginal risk concession. Thus, if a coalition of agents negotiates jointly and splits the risk of a breakdown across its members, the coalition will be in a stronger bargaining position.

Technically, it should also be noted that the marginal risk concession of a coalition is smooth, increasing in x_t, and decreasing in d_t. Thus, whenever two coalitions face each other in a single bargaining problem, there exists a unique solution which equalizes the coalitions' marginal risk concessions.

Below we interpret a coalition as the outcome of some merger process. Definition 2, thus, implies that firms that merge simply share the ownership of all of their assets. For concreteness,

19. See Chae and Heidhues (1999).

one may think of entrepreneurs swapping stocks or exchanging ownership rights. Alternatively, a coalition can be understood as a joint venture in which firms are committed to negotiate jointly with suppliers. Definition 2, however, rules out a merger in which one player buys the other out. The main reason why we do not consider buy-outs is that a buy-out is always dominated by joint ownership in our model. The benefits of joint ownership are twofold: First, the players can share the risk of a break down in negotiations, which makes them (weakly) stronger negotiators. Second, a buy-out is costly, thereby lowering a firm's breakdown point, which weakens its bargaining position. If, however, forming coalitions is exogenously ruled out, then even with homogeneous agents one can show that buy-outs are profitable under certain conditions.

2.3. Solution to the game

We will now introduce a solution to the two-stage game introduced earlier. For simplicity, assume that all distributors have identical preferences and that all producers have identical preferences. Specifically, all distributors (not distributor chains) have the same marginal risk concession $\mu_a(\ ,\ )$ and all producers have the same marginal risk concession $\mu_p(\ ,\ )$.

Definition 3. A *simultaneous Zeuthen-Nash solution* is a settlement (x, y) to $G(h)$ such that for any (t, p),

$$\mu_p(y_p^t, d_p^t) = \mu_t(x_t^p, d_t^p) , \tag{2}$$

$$d_t^p = \sum_{k \neq n} x_t^k + n_t R(h-1) \text{ for } h \leq z^* \text{ and } d_t^p = n_t R(z^*) \text{ otherwise,} \tag{3}$$

$$d_p^t = \left(\sum_{k \neq t} y_p^k \right) - f . \tag{4}$$

Equation (2) states that a simultaneous Zeuthen-Nash solution to $G(h)$ equalizes the marginal risk concessions of the bargaining parties in each bargaining problem $\langle (t, p), \pi(t, p), (d_t^p, d_p^t) \rangle$. Equation (3) states that the breakdown point of a distributor chain in bargaining with a producer is the amount it receives if all but the bargaining with the producer are resolved. Likewise, equation (4) states that a producer's breakdown point in bargaining with a distributor chain is the payment it receives from all other distributor chains minus the cost f it incurred to produce the movie. Note that there can be multiple simultaneous Zeuthen-Nash solutions to $G(h)$.

For any settlement (x, y) of $G(h)$, one can represent the overall payoffs for the distributor chains and producers by a vector $(X_1, \ldots, X_l, Y_1, \ldots, Y_h)$ such that

$$X_t = \Sigma_p x_t^p + n_t R(h-1) \text{ if } h \le z^* \text{ and } X_t = n_t R(z^*) \text{ otherwise.} \tag{5}$$

$$Y_p = \sum_t y_p^t, \tag{6}$$

Equation (5) states that the overall payoff a distributor chain receives is equal to the revenue with one less producer plus the shares of the pies it receives through bargaining. Equation (6) states that the overall payoff a producer receives is the sum of the payments it receives from all distributor chains.

A simultaneous Zeuthen-Nash solution (x, y) will be called *symmetric* if it satisfies

$$(y_p^1, \ldots, y_p^l) = (y_{p'}^1, \ldots, y_{p'}^l) \text{ for any } p, p'. \tag{7}$$

Equation (7) imposes symmetry across the identical upstream producers.

Definition 4. *An array* (h, x, y) is a *symmetric sequential solution* to the two-stage game if (x, y) is a symmetric simultaneous Zeuthen-Nash solution to $G(h)$ such that

$$Y_p - f \geq 0 \quad \text{for the representative producer } p, \tag{8}$$

and if *for some* symmetric simultaneous Zeuthen-Nash solution $(\tilde{x}, \tilde{y})$ to $G(h + 1)$, one has

$$\tilde{Y}_p - f < 0 \quad \text{for the representative producer } p. \tag{9}$$

Equations (8) and (9) are similar to the standard "zero-profit" condition under free entry. They require that upstream producers enter the market until it is unprofitable to do so, correctly anticipating the solutions to the subsequent cooperative subgames $G(h)$ and $G(h + 1)$ in making their entry decisions. We thus require the analog of Selten's (1965) subgame perfection for our two-stage game, which includes "cooperative" subgames.

One can think of an alternative solution concept for our two-stage game:

Definition 4´. *An array* (h, x, y) is a *symmetric forward-induction solution* to the two-stage game if (x, y) is a symmetric simultaneous Zeuthen-Nash solution to $G(h)$ such that

$$Y_p - f \geq 0 \quad \text{for the representative producer } p, \tag{10}$$

and if *for any* symmetric simultaneous Zeuthen-Nash solution $(\tilde{x}, \tilde{y})$ to $G(h + 1)$, one has

$$\tilde{Y}_p - f < 0 \quad \text{for the representative producer } p. \tag{11}$$

The latter definition uses the analog of the forward-induction principle inherent in Kohlberg and Mertens's (1986) stable sets. Producers signal by entry that they expect to coordinate on a second-stage bargaining solution in which they receive non-negative profits. Thus, a solution cannot be sustained if there exists a second-stage solution in which an additional movie producer can make profits. Since the solution concept in Definition 4´ is a rather strong one, our analyses will be based on Definition 4.

2.4. *Existence of solution*

In order to establish the existence of a symmetric sequential solution to the two-stage game, it will be sufficient to prove the existence of a solution to every subgame $G(h)$.

Theorem 1. *There exists a symmetric solution to any subgame* $G(h)$.

We will prove the theorem below. It is easy to check that

Lemma 1. *If* $h > z^*$*, then* $X_t = n_t R(z^*)$ *and* $Y_p = 0$.

To establish the existence of a solution for any subgame $G(h)$ with $h \leq z^*$, it will be useful to reduce some of the equations defining the solution into a simple relation. In order to do this, we observe from equations (2), (3), and (4) that the share of a distributor chain *t* from bargaining with a representative producer, x_t^p, is connected to other distributor chains' bargaining problems only through the producer's fall-back position, d_p^t. Using of this observation, we first look for a solution to the set of bargaining problems involving distributor chain *t* while holding the representative producer's fall-back position, d_p^t ($= d_1^t = \dots = d_h^t$), fixed. Then we establish the existence of a solution where the producer's fall-back position in bargaining with distributor chain *t* is determined from the producer's bargaining with all other distributor chains.

To characterize the solution set in relation to the symmetric breakdown point, d_p^t, we define

Definition 5. For $h \le z^*$, the *feedback correspondence* Φ_t is defined by

$$\Phi_t(d_p^t) = \Big\{ y_p^t \in [0, n_t \Delta R(h)]; \text{ there exists some } x_t^p \text{ such that } x_t^p + y_p^t = n_t \Delta R(h), \; \mu_p(y_p^t, d_p^t) = \mu_t(x_t^p, n_t R(h-1) + (h-1)x_t^p) \Big\}.$$

The feedback correspondence maps the solution payment the representative producer receives in all other local markets into the set of solution payments it receives from distributor chain *t*. It is easy to check that $\Phi_t(d_p^t)$ is upper hemi continuous. Thus $\Phi_t(d_p^t)$ has a closed graph and therefore its maximum and minimum elements exist. Furthermore, we show the following in the Appendix:

Lemma 2. *Suppose* $h \le z^*$. *Both the maximum and minimum elements of* $\Phi_t(d_p^t)$ *are increasing in* d_p^t.

To establish the existence of a solution to all cooperative subgames in which $h \le z^*$, we will establish the existence of a solution that is best from a producer's point of view. Let $\phi_t(d_p^t)$ denote the maximum element of $\Phi_t(d_p^t)$.

Proof of Theorem 1. The solution to any subgame for which $h > z^*$ has been specified in Lemma 1. Consider a subgame in which $h \le z^*$. Note that $\phi_t(d_p^t)$ is increasing by Lemma 2 for such a subgame. Thus, $\phi(y_p^1, \ldots, y_p^l) = (\phi_1(d_p^1), \ldots, \phi_l(d_p^l))$, where $d_p^t = (\Sigma_{k \ne t} y_p) - f$, defines an increasing mapping from $[0, n_1 \Delta\pi(h)] \times \ldots \times [0, n_l \Delta\pi(h)]$ to itself. Hence, the mapping has a fixed point by Tarski's fixed point theorem.[20] Each y_p^t is a symmetric solution to the set of bargaining problems involving theater chain *t. Q.E.D.*

We believe that bargaining is a natural mechanism to determine prices in interconnected bilateral monopoly markets. Using the demand function in the product market to model substitutability between movie producers, we identified the core and the simultaneous Zeuthen-Nash solution for the input-market bargaining problem. Theorem 1 ensures the existence of a bargaining solution. We cannot, however, establish the uniqueness of such a solution in general.

3. Distributor integration

3.1. *Effects on the market*

We want to analyze how integration between distributor chains affects the input market price and quantity in equilibrium. Before we tackle this problem head-on, we will first look at a closely

20. See Tarski (1955).

related problem. The question is whether larger distributor chains can in some sense shift input costs to smaller ones.[21] Since the producers' profits are driven down toward zero under free entry, input costs are entirely borne by the distributors as a whole. Thus the question can be formally put forward as asking whether a larger distributor chain pays a lower per-local market price. The answer to this question will be yes if the following condition is satisfied:

Week Feedback Condition. $\mu_a(x, R(h-1) + (h-1)x)$ *is increasing in x.*

Note that in the one-producer case the Week Feedback Condition trivially follows from Assumption 3. In the *n*-producer case, the above condition states that the direct effect of receiving another unit in the bargaining problem at hand dominates the feedback effect of receiving another unit in all other bargaining problems. If the above condition is satisfied, a larger distributor chain pays a lower price per local market. In the Appendix, we prove that

Proposition 1. *Let the Week Feedback Condition be satisfied. Then in any symmetric simultaneous Zeuthen-Nash solution to* $G(h)$, $n_i > n_j$ *implies* $x_i^p / n_i > x_j^p / n_j$.

We now analyze how integration between distributor chains can affect input market prices. Recall that the second-stage solution may not be unique. Thus, in the comparative statics that follow, we work with the supremum and infimum of the solution set as suggested by Milgrom and Roberts (1994). We find a sufficient condition under which integration between two distributor chains leads to a decrease of the set of second-stage solution payments to the producers. That is,

21. Waterman (1996) argues that large distributor chains may force their input price below the producer's average cost, thus "free riding" on the level of product variety supported by other distributors.

for a fixed number of producers, integration between distributor chains lowers the input market price they have to pay. Integration increases the bargaining power not only of the integrating distributor chains but also of all other distributor chains.

Consider two distributor chains *i* and *j* that may or may not be integrated. As will be shown in Theorem 2, their integration increases the set of their solution payoffs (and thus decreases the payments to producers) if the following condition is satisfied:

Integration Condition.

$$(n_i + n_j)\mu_a\left(\frac{x_i^p + x_j^p}{n_i + n_j}, R(h-1) + (h-1)\frac{x_i^p + x_j^p}{n_i + n_j}\right)$$
$$\leq n_i\mu_a\left(\frac{x_i^p}{n_i}, R(h-1) + (h-1)\frac{x_i^p}{n_i}\right) + n_j\mu_a\left(\frac{x_j^p}{n_j}, R(h-1) + (h-1)\frac{x_j^p}{n_j}\right).$$

That the above condition is satisfied in the one producer case is shown in the Appendix. The condition is also satisfied if $x_i^p/n_i = x_j^p/n_j$, that is, if the distributor chains that may integrate pay the same price per local market when they do not integrate. In this case, one has $x_i^p/n_i = x_j^p/n_j = (x_i^p + x_j^p)/(n_i + n_j)$, which implies that the amount at stake and the breakdown point on the left hand side of the Integration Condition is equal to the amount at stake and the breakdown points on the right hand side.

In general, integrating theater chains may result in different breakdown points for distributors. We cannot, however, predict how redistribution of the breakdown payments affects a coalition's marginal risk concession. The Integration Condition is an aggregation condition which ensures that such a redistribution does not increase the marginal risk concession of the coalition.

Theorem 2. *If the Integration Condition is satisfied and if* $h \leq z^*$ *, then any integration between distributor chains reduces both the supremum and infimum of the set of symmetric second-stage solution payments to producers*.

We will prove the theorem below. We need to specify possible reactions in all other markets in order to understand the effect of integration between two distributor chains. To do this, we partition the set of distributor chains into distributor chains 1 to *k* and distributor chains *k*+1 to *l*. We use the fact mentioned earlier that the bargaining problems involving the distributor chains 1 to *k* interact with the bargaining problems involving the distributor chains *k*+1 to *l* through the producers fall-back positions only. Hence, we can summarize markets *k*+1 to *l* by the (symmetric) amount $w \in [0, \Sigma_{j=k+1}^{l} n_t \Delta\pi(h)]$ that a representative producer receives in those markets.

Before we examine how second-stage payments to producers are affected by the market structure in the distributor industry, we first establish how the set of solutions in markets 1 to *k* depends on *w*. For expositional simplicity, we will focus on the supremum of the solution set.

Definition 6. Let *K* be a group of distributor chains. For $h \leq z^*$, the *feedback correspondence* for group *K* as a correspondence $\Phi^K:[0, \Sigma_{t=k+1}^{l} n_t \Delta R(h)] \to [0, \Sigma_{t=1}^{k} n_t \Delta R(h)]$ such that

$\Sigma_{t=1}^{k} y_p^t \in \Phi^K(w)$ if $(y_p^1, \ldots, y_p^k)$ is a solution to the simultaneous equation system

$$(y_p^1, \ldots, y_p^k) = \left(\phi_1\left(w + \sum_{t=2}^{k} y_p^t\right), \ldots, \phi_k\left(w + \sum_{t=1}^{k-1} y_p^t\right)\right).$$

Note that $\Phi^K(w)$ is well defined, since for any given *s*, $\phi(y_p^1, \ldots, y_p^k) = (\phi_1(w + \Sigma_{t=2}^k y_p^t), \ldots, \phi_k(w + \Sigma_{t=1}^{k-1} y_p^t))$ is a monotonically increasing mapping from a nonempty, compact, and convex set $[0, \Sigma_{j=1}^k n_t \Delta R(h)]$ of the Euclidean space into itself. Hence, for any given *w*, there exists a solution to this system of equations by Tarski's fixed point theorem.

Definition 7. For $h \leq z^*$, the *supremum payment* to a producer in bargaining with the distributor chains in *K*, for a given payment *w* from all other distributor chains, is defined as $\phi^K(w) = \sup \Phi^K(w)$.

The following proposition formalizes the notion that a producer becomes a tougher negotiator in market 1 to *k* if it receives a higher payment in the remaining markets.

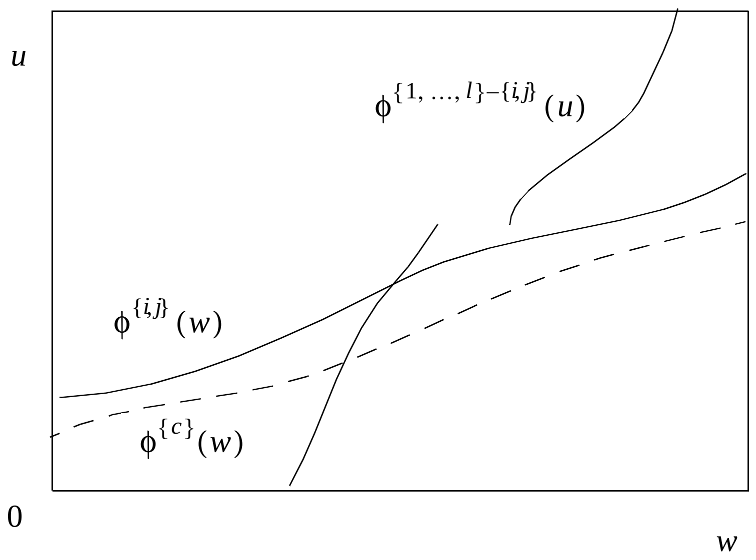
Lemma 3. $\phi^K(w)$ *is increasing in* w.

The proof is relegated to the Appendix. When distributor chains *i* and *j* are integrated, we will denote the integrated distributor chain by *c*. In the Appendix we show that

Lemma 4. *Let* $h \leq z^*$ *and suppose that the Integration Condition is satisfied. Then, for any given payment w from all other distributor chains, the producer's solution payment is lower if it faces an integrated party, i.e.,* $\phi^{\{c\}}(w) < \inf \Phi^{\{i,j\}}(w)$.

This enables us to establish Theorem 2. The formal proof of Theorem 2 is delegated to the Appendix. We illustrate the proof in Figure 1. Both functions in Figure 1 that are represented by

Figure 1



the solid lines, are increasing by Lemma 3. The supremum payment a producer receives in this cooperative subgame is represented by the sum of the coordinates *w*, *u* at the crossing point furthest to the North East in Figure 1. By Lemma 4, one has $\phi^{\{c\}}(w) < \phi^{\{i,j\}}(w)$ for all *w*, which implies that the supremum solution payment to producers decreases whenever two distributor chains integrate.

Let Γ denote the set of all partitions of the set of all distributors, and let γ, γ' denote elements of Γ. For our model, Γ is the set of all possible market structures in the distributor industry.

Definition 8. γ *is more concentrated than* γ' if γ can be obtained from γ' by forming unions of elements of γ'.

The relation "is more concentrated than" induces a partial ordering on Γ. Theorem 2 implies the first main result of this paper.

Proposition 2. *For any fixed number producers for which $h \leq z^*$, any increase in concentration decreases the set of solution payments to the producers.*

The proposition formalizes the notion that the price for the right to sell the product in each local market falls if the national distributor industry is more concentrated. That is, across-local-market integration results in increased market power in the input market. However, the free entry conditions, equations (8) and (9), ensure that the producers' profits are close to zero in any solution. Thus, as the market power of the distributor chain industry increases, the number of upstream products developed falls. This is formalized in

Proposition 3. *Both the maximum and minimum number of products developed in a symmetric sequential solution to the two-stage game are (weakly) decreasing in the distributors industry's concentration.*

Proposition 3 reveals that distributor chains contemplating whether or not to merge must compare two effects. The direct effect that a merger tends to increase their bargaining power versus the indirect effect that a merger reduces the upstream variety available to them. Furthermore, Proposition 3 reveals that the remaining downstream firms' profits may fall through the reduced variety available to them. The effects of a downstream merger on consumer surplus and welfare are discussed below.

3.2. *Effects on welfare*

In our model, any concentration in the distributor industry that reduces the number of products developed decreases welfare. To show this, we first establish that in any solution, the number of products that are actually developed is less than the socially optimal number.

From the inverse demand curve in each local market, it follows that the total surplus within a local market is $\Sigma_{z=1}^{h} g(z)$. Thus, if all local distributors decide to show h movies, the national consumer surplus is $m\{\Sigma_{z=1}^{h} g(z)\}$.

Proposition 4. *In a symmetric sequential solution to the two-stage game, the actual entry is less than (or equal to) the socially optimal entry.*

Proof: The social optimality requires entry as long as the increase in the consumer surplus and the net revenue from selling the product is greater than the cost of producing the movie. The overall benefit of adding an extra movie is $mg(h)$. Thus, the socially optimal level of entry h^* is the maximum integer h such that

$$mg(h) \geq f\ ,$$

where $g(h)$ is a decreasing function. However, in any symmetric sequential equilibrium, one has

$$mg(h) > m\Delta R(h) > Y_p \geq f\ ,$$

and thus $h \leq h^*$. *Q.E.D.*

Suppose, for instance, that the demand function is linear: $g(z) = a - bz$. Then the socially optimal entry h^* satisfies

$$m(a - bh^*) \geq f \text{ and } m\{a - b(h^* + 1)\} < f\ .$$

On the other hand, in a symmetric sequential equilibrium, one has

$$m\Delta R(h) = m(a + b - 2bh) > f\ .$$

Thus, whenever $h^* > 1$, one has $h < h^*$.

In our model the market thus provides less than the optimal product variety. Thus, the following welfare result is very intuitive. It would, however, be reversed if one had a setup with excessive product proliferation such as Salop's circular city model.

Proposition 5. *Both the highest and the lowest levels of welfare in a symmetric sequential solution to the two-stage game are (weakly) decreasing in the distributor industry's concentration.*

Proof: By Proposition 3, the maximum and minimum number of movies produced in a symmetric sequential solution to the two-stage game are (weakly) decreasing in the theater industry's concentration. Using Proposition 4, it is easy to check that this lowers the highest and lowest levels of welfare.

Q.E.D.

4. Conclusion

In this paper, we modeled both price formation and the entry of upstream producers in an input market. Using a bargaining framework, we showed that a higher degree of concentration among downstream distributors reduces incentives to enter the upstream production industry. The reason is that higher concentration among downstream distributors reduces the bargaining power of upstream producers.

The result provides some rationale for restrictions on the national size of distributor chains, such as movie theater chains or multiple cable television system operators (MSOs). Our results have implications for many other industries in which a retailer has some local monopoly power in the output market and purchases products from multiple monopolistic producers.

One maintained assumption in our approach was that there was no new entry of downstream firms. If new downstream firms could enter after incurring some fixed costs, the extent of entry would depend on their bargaining power. Thus, the ability to form distributor chains would affect the number of distributors. In such circumstances, policies toward distributor chains should be formulated considering their effects on the entry of both the producers and distributors. Another maintained assumption was that there were no merger activities among the producers. This assumption can also be relaxed with the obvious result that producers' bargaining power will increase. The important point is that the framework developed in this paper can be fruitfully employed to analyze any of these alternative scenarios.

We believe our model is useful in highlighting the trade-off policy makers face in various industries. Consider for instance the recent merger between AT&T and MediaOne mentioned in the Introduction of this paper. Roughly speaking, the FCC was faced with the question of whether it should force AT&T to divest cable operators or relax existing national ownership restrictions. Lobbyists on behalf of AT&T argued that the merger would enable them to connect consumers to broadband cable more quickly. First, take these long term decisions as given. Then our model predicts that this merger will increase AT&T’s bargaining power vis-a-vis program suppliers, thereby increasing the returns on the long term investments. However, the merger will also, according to our model, tend to reduce programming variety and thereby lower the returns on the long term investment. Interpreting AT&T’s argument within our model, the first effect must dominate the second. If so, the FCC decision to substantially relax national ownership restrictions can be viewed as encouraging AT&T’s investment in broadband cable while discouraging the development of new independent programming and thereby the investment of other cable operators.

This policy application also highlights the importance of investigating the effects of vertical integration between downstream distributors and upstream producers. It would be interesting to see if our model could be extended to investigate the effects of integration between a group of movie producers and a group of movie theaters.

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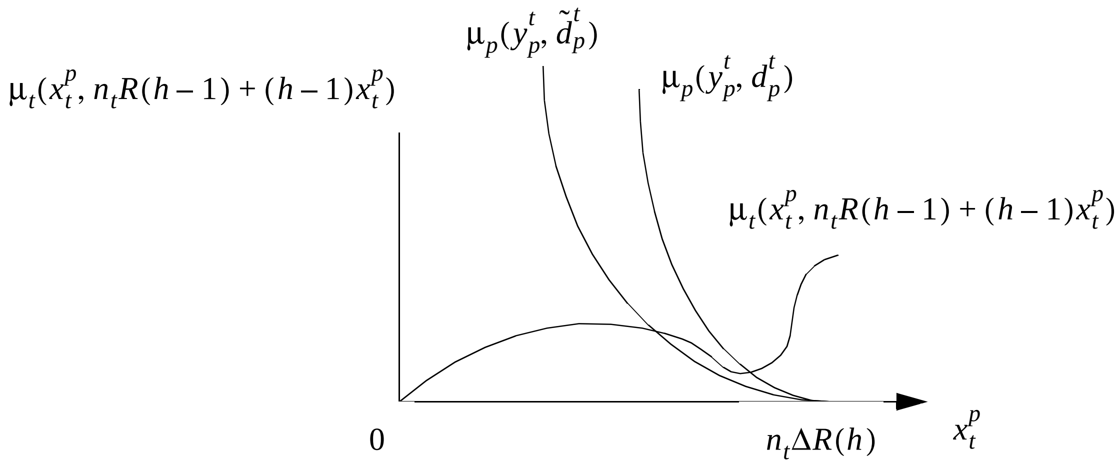
Appendix A.

Proof of Lemma 2

By Definition 5 any element of $\Phi_t(d_p^t)$ has to satisfy

$\mu_p(y_p^t, d_p^t) = \mu_t(x_t^p, n_t R(h-1) + (h-1)x_t^p)$. Recall that, $\mu_t(x_t^p, n_t \pi(h-1) + (h-1)x_t^p)$ is a smooth function, which is positive for all $x_t^p > 0$. Also, recall that, by Assumption 2, $\mu_p(y_p^t, d_p^t)$ is increasing and convex in y_p^t, and, by Assumption 2, $\mu_p(y_p^t, d_p^t)$ is decreasing in d_p^t. The above lemma is illustrated in Figure A1, for $\tilde{d}_p^t > d_p^t$.

Figure A1



A solution is any crossing point of μ_p and μ_t. Because, by Assumption 2, $\mu_p(y_p^t, d_p^t) > \mu_p(y_p^t, \tilde{d}_p^t)$ the minimum and maximum x_t^p satisfying equation

$\mu_p(y_p^t, d_p^t) = \mu_t(x_t^p, n_t\pi(h-1) + (h-1)x_t^p)$ must be decreasing in d_p^t, as illustrated above.

Thus, the minimum and maximum y_p^t is increasing in d_p^t.

Q.E.D.

Proof of Proposition 1

Suppose not. Then there exist a $n_i > n_j$ for which $x_i^p/n_i \le x_j^p/n_j$. Substituting the marginal risk concession of its members for the marginal risk concession of the coalition into Definition 3 and rewriting, one has

$$\frac{1}{n_i}\mu_p\left(n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p + \sum_{k \ne i, j} y_p^k - f\right) = \mu_a\left(\frac{x_i^p}{n_i}, R(h-1) + (h-1)\frac{x_i^p}{n_i}\right), \qquad (12)$$

$$\frac{1}{n_j}\mu_p\left(n_j\Delta R(h) - x_j^p, n_i\Delta R(h) - x_i^p + \sum_{k \ne i, j} y_p^k - f\right) = \mu_a\left(\frac{x_j^p}{n_j}, R(h-1) + (h-1)\frac{x_j^p}{n_j}\right). \qquad (13)$$

The Week Feedback Condition implies

$$\mu_a\left(\frac{x_i^p}{n_i}, R(h-1) + (h-1)\frac{x_i^p}{n_i}\right) \le \mu_a\left(\frac{x_j^p}{n_j}, R(h-1) + (h-1)\frac{x_j^p}{n_j}\right),$$

and thus equations (12) and (13) imply that

$$\frac{n_j}{n_i}\mu_p\left(n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p + \sum_{k \ne i, j} y_p^k - f\right) \qquad (14)$$
$$\le \mu_p\left(n_j\Delta R(h) - x_j^p, n_i\Delta R(h) - x_i^p + \sum_{k \ne i, j} y_p^k - f\right).$$

However, Assumptions 2 and 3 imply that

$$\frac{n_j}{n_i}\mu_p\left(n_i\left(\Delta R(h)-\frac{x_i^p}{n_i}\right), n_j\Delta R(h)-x_j^p+\sum\nolimits_{k\neq i,j}y_p^k-f\right)$$
$$\geq \mu_p\left(n_j\left(\Delta R(h)-\frac{x_i^p}{n_i}\right), n_j\Delta R(h)-x_j^p+\sum\nolimits_{k\neq i,j}y_p^k-f\right)$$
$$> \mu_p\left(n_j\left(\Delta R(h)-\frac{x_j^p}{n_j}\right), n_j\Delta R(h)-x_j^p+\sum\nolimits_{k\neq i,j}y_p^k-f\right)$$
$$> \mu_p\left(n_j\left(\Delta R(h)-\frac{x_j^p}{n_j}\right), n_i\Delta R(h)-x_i^p+\sum\nolimits_{k\neq i,j}y_p^k-f\right),$$

contradicting equation (14).

Q.E.D.

Proof of the Integration Condition in the one producer case

In the one-producer case, the Integration Condition becomes

$$(n_i+n_j)\mu_a\left(\frac{x_i^p+x_j^p}{n_i+n_j}, 0\right)\leq n_i\mu_a\left(\frac{x_i^p}{n_i}, 0\right)+n_j\mu_a\left(\frac{x_j^p}{n_j}, 0\right) .$$

This follows trivially if $x_i^p/n_i \geq x_j^p/n_j \geq (x_i^p+x_j^p)/(n_i+n_j)$. Note that if $x_i^p/n_i \geq x_j^p/n_j$ then $x_i^p/n_i \geq (x_i^p+x_j^p)/(n_i+n_j) \geq x_j^p/n_j$. Thus $x_i^p/n_i \geq x_j^p/n_j \geq (x_i^p+x_j^p)/(n_i+n_j)$ implies $x_i^p/n_i = x_j^p/n_j = (x_i^p+x_j^p)/(n_i+n_j)$. Now we consider the case where $x_i^p/n_i < (x_i^p+x_j^p)/(n_i+n_j) < x_j^p/n_j$. In this case, the convexity of μ_i with respect to its first argument implies that

$$\mu_i\left(\frac{x_i^p+x_j^p}{n_i+n_j}, 0\right)\leq \frac{n_i}{n_i+n_j}\mu_i\left(\frac{x_i^p}{n_i}, 0\right)+\frac{n_j}{n_i+n_j}\mu_j\left(\frac{x_j^p}{n_j}, 0\right) .$$

Q.E.D.

Proof of Lemma 3

To prove Lemma 3 we will use the following two lemmas:

Lemma A.1. *For any* $\Sigma_{t=1}^{k} y_p^t$ *and* $\Sigma_{t=1}^{k} (y_p^t)'$ *that are element of* $\Phi^K(w)$*, one has* $\Sigma_{t=1}^{k} y_p^t > \Sigma_{t=1}^{k} (y_p^t)'$ *if and only if* $y_p^t > (y_p^t)'$ *for any* $t = 1, \ldots, k$.

Proof: Without loss of generality, let $y_p^t = y_p^1$. Definition 6 implies that

$$y_p^1 = \phi_1\left(w + \sum_{j=2}^{K} y_p^j\right),$$

$$(y_p^1)' = \phi_1\left(w + \sum_{j=2}^{K} (y_p^j)'\right).$$

Because ϕ_1 is increasing, one has $y_p^1 > (y_p^1)'$ if and only if $\Sigma_{j=2}^{k} y_p^j > \Sigma_{j=2}^{k} (y_p^j)'$. Thus, one has $y_p^1 > (y_p^1)'$ if and only if $\Sigma_{t=1}^{k} y_p^t > \Sigma_{t=1}^{k} (y_p^t)'$. *Q.E.D.*

In the following, we will denote $\phi^{\{1, \ldots, k\}}$ simply by ϕ^k.

Lemma A.2. *If* $\phi^{k-1}(w)$ *is increasing, then* $(y_p^1, \ldots, y_p^k)$ *such that* $\Sigma_{j=1}^{k} y_p^j = \phi^k(w)$ *satisfies*

$$y_p^k = \phi_k(w + \phi^{k-1}(w + y_p^k)).$$

Proof: Suppose $y_p^k \neq \phi_k(w + \phi^{k-1}(w + y_p^k))$. By Definition 6, $y_p^k = \phi_k(w + \Sigma_{i=1}^{k-1} y_p^i)$. However, by Definition 6, one also has

$$\sum_{i=1}^{k-1} y_p^i \in \Phi^{k-1}(w + y_p^k) .$$

Thus $\Sigma_{j=1}^{k} y_p^j < \phi^{k-1}(w + y_p^k)$. Construct a sequence $\left\{(y_p^k)^n\right\}$ by $(y_p^k)^1 = y_p^k$ and

$$(y_p^k)^n = \phi_k(w + \phi^{k-1}(s + (y_p^k)^{n-1})) .$$

Since both ϕ_k and ϕ^{k-1} are increasing, the sequence $\left\{(y_p^k)^n\right\}$ is monotonically increasing.

Because each $(y_p^k)^n \in [0, n_k \Delta R(h)]$, the sequence $\left\{(y_p^k)^n\right\}$ converges to some $\tilde{y}_p^k$. This $\tilde{y}_p^k$ $(> y_p^k)$ satisfies

$$\tilde{y}_p^k = \phi_k(w + \phi^{k-1}(w + \tilde{y}_p^k)) ,$$

which contradicts the fact that there is no $(\tilde{y}_p^1, \ldots, \tilde{y}_p^k)$ with $\tilde{y}_p^k > y_p^k$ that satisfies $\Sigma_{j=1}^{k} \tilde{y}_p^j \in \Phi^k(w)$. *Q.E.D.*

Now we will prove Lemma 3. We will proceed by induction. Lemma 2 implies that $\phi^1(w)$ is increasing in *w*, since $\phi^1(w) = \phi_1(w)$. Assume that $\phi^k(w)$ is increasing. We will show that $\phi^{k+1}(w)$ is increasing.

Since $\phi^k(w)$ is increasing, Lemma A.2 implies that $(y_p^1, \ldots, y_p^{k+1})$ such that $\Sigma_{j=1}^{k+1} y_p^j = \phi^{k+1}(w)$ satisfies

$$y_p^{k+1} = \phi_{k+1}(w + \phi^k(w + y_p^{k+1})) . \tag{15}$$

Thus, by Lemma A.1, one has $\phi^{k+1}(w) = y_p^{k+1} + \phi^k(w + y_p^{k+1})$. To prove that $\phi^{k+1}(w)$ is increasing in *w*, let $\tilde{w} > w$ and construct a sequence $\left\{(y_p^{k+1})^n\right\}$ by $(y_p^{k+1})^1 = y_p^{k+1}$ and

$$(y_p^{k+1})^n = \phi_{k+1}(w' + \phi^k(\tilde{w} + (y_p^{k+1})^{n-1})) .$$

Since both ϕ_{k+1} and ϕ^k are increasing, the sequence $\left\{(y_p^{k+1})^n\right\}$ is monotonically increasing.

Because each $(y_p^{k+1})^n \in [0, n_{k+1}\Delta R(h)]$, the sequence $\left\{(y_p^{k+1})^n\right\}$ converges to some $\tilde{y}_p^{k+1} > (y_p^{k+1})^1$. Thus, one has

$$\tilde{y}_p^{k+1} + \phi^k(\tilde{w} + \tilde{y}_p^{k+1}) > y_p^{k+1} + \phi^k(w + y_p^{k+1}) .$$

Hence, $\phi^{k+1}(\tilde{w}) > \phi^{k+1}(w)$.

Q.E.D.

Proof of Lemma 4

Consider first the situation where the distributor chains *i*, *j* are not integrated. For a given payment *w* from all other distributor chains, Definitions 5 and 7 imply that

$$\mu_p(y_p^t, d_p^t) = \mu_t(x_t^p, n_t R(h-1) + (h-1)x_t^p) , \tag{16}$$

for $t = i, j$. Substituting the marginal risk concession of its members for the marginal risk concession of the coalition into equation (16) and rewriting, one has

$$\mu_p(n_i \Delta R(h) - x_i^p, n_j \Delta R(h) - x_j^p + w - f) = n_i \mu_a\left(\frac{x_i^p}{n_i}, R(h-1) + \frac{(h-1)x_i^p}{n_i}\right), \tag{17}$$

$$\mu_p(n_j \Delta R(h) - x_j^p, n_i \Delta R(h) - x_i^p + w - f) = n_j \mu_a\left(\frac{x_j^p}{n_j}, R(h-1) + \frac{(h-1)x_j^p}{n_j}\right). \tag{18}$$

Let x_c^p denote the solution share of the integrated coalition. Suppose $x_c^p \le x_i^p + x_j^p$. We will show later that if $x_c^p \le x_i^p + x_j^p$ then

$$\begin{aligned} &\mu_p((n_i + n_j)\Delta R(h) - x_c^p, w - f) \\ &> \mu_p(n_i \Delta R(h) - x_i^p, n_j \Delta R(h) - x_j^p + w - f) + \mu_p(n_j \Delta R(h) - x_j^p, n_i \Delta R(h) - x_i^p + w - f). \end{aligned} \tag{19}$$

Applying equations (19), (17), (18), and the Integration Condition yields:

$$\begin{aligned} &\mu_p((n_i + n_j)\Delta R(h) - x_c^p, w - f) \\ &> \mu_p(n_i \Delta R(h) - x_i^p, n_j \Delta R(h) - x_j^p + w - f) + \mu_p(n_j \Delta R(h) - x_j^p, n_i \Delta R(h) - x_i^p + w - f) \\ &= n_i \mu_a\left(\frac{x_i^p}{n_i}, R(h-1) + \frac{(h-1)x_i^p}{n_i}\right) + n_j \mu_a\left(\frac{x_j^p}{n_j}, R(h-1) + \frac{(h-1)x_j^p}{n_j}\right) \\ &\ge (n_i + n_j)\mu_a\left(\frac{x_c^p}{(n_i + n_j)}, R(h-1) + \frac{(h-1)x_c^p}{(n_i + n_j)}\right). \end{aligned}$$

Hence,

$$\mu_p((n_i + n_j)\Delta R(h) - x_c^p, w - f) > (n_i + n_j)\mu_a\left(\frac{x_c^p}{(n_i + n_j)}, R(h-1) + \frac{(h-1)x_c^p}{(n_i + n_j)}\right), \tag{20}$$

which contradicts Definition 5. Thus, $x_c^p > x_i^p + x_j^p$. Hence Definition 5 implies that

$\phi^{\{c\}}(w) < \inf \Phi^{\{i,j\}}(w)$ for all *w*.

We will now show that if $x_c^p \le x_i^p + x_j^p$ then equation (19) holds. One has

$$\begin{aligned}
&\mu_p((n_i + n_j)\Delta R(h) - x_c^p, w - f) \\
&> \mu_p((n_i + n_j)\Delta R(h) - x_c^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f),
\end{aligned}$$

for the left hand side breakdown point of the above equation is smaller than the right hand side breakdown point and thus Assumption 2 implies that the left hand side is greater than the right hand side. Since $x_c^p \le x_i^p + x_j^p$, Assumption 3 implies that

$$\begin{aligned}
&\mu_p((n_i + n_j)\Delta R(h) - x_c^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f) \\
&> \mu_p(n_i\Delta R(h) - x_i^p + n_j\Delta R(h) - x_j^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f).
\end{aligned}$$

Assumption 3 and Assumption 2 imply that

$$\begin{aligned}
&\mu_p(n_i\Delta R(h) - x_i^p + n_j\Delta R(h) - x_j^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f) \\
&\ge \mu_p(n_i\Delta R(h) - x_i^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f) \\
&+ \mu_p(n_j\Delta R(h) - x_j^p, \min\{n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p\} + w - f) \\
&\ge \mu_p(n_i\Delta R(h) - x_i^p, n_j\Delta R(h) - x_j^p + w - f) + \mu_p(n_j\Delta R(h) - x_j^p, n_i\Delta R(h) - x_i^p + w - f).
\end{aligned}$$

Q.E.D.

Proof of Theorem 2

By definition, the supremum solution payment to a producer in the non-integrated case is

$$\sup\ \{\Phi^{\{1,\ldots,l\}-\{i,j\}}(u) + \Phi^{\{i,j\}}(w)\}\ \text{ s.t. } u = \Phi^{\{i,j\}}(w) \text{ and } w = \Phi^{\{1,\ldots,l\}-\{i,j\}}(u), \quad (21)$$

and that in the integrated case is

$$\sup\ \{\Phi^{\{1,\ldots,l\}-\{i,j\}}(u) + \Phi^{\{c\}}(w)\}\ \text{ s.t. } u = \Phi^{\{c\}}(w) \text{ and } w = \Phi^{\{1,\ldots,l\}-\{i,j\}}(u). \quad (22)$$

Lemma A.1 implies that $(\bar{w}, \bar{u})$ satisfying (21) also satisfies

$$\bar{w} = \sup\{\Phi^{\{1,\,\ldots,\,l\}-\{i,\,j\}}(\Phi^{\{i,j\}}(\bar{w}))\}\,,$$

and that $(\hat{w}, \hat{u})$ satisfying (22) also satisfies

$$\hat{w} = \sup\{\Phi^{\{1,\,\ldots,\,l\}-\{i,\,j\}}(\Phi^{c}(\hat{w}))\}\,.$$

To prove $\hat{w} < \bar{w}$, construct a sequence $\{w^n\}$ by $w^1 = \hat{w}$ and

$$w^n = \{\phi^{\{1,\,\ldots,\,l\}-\{i,\,j\}}(\phi^{\{i,j\}}(w^{n-1}))\}\,.$$

By Lemmas 3 and 4, this sequence is monotonically increasing. Since each $w^n \in [0, \Sigma_{l=1}^{k} n_l \Delta R(h)]$, the sequence converges to some $\tilde{w} > \hat{w}$ satisfying

$$\tilde{w} = \{\phi^{\{1,\,\ldots,\,l\}-\{i,\,j\}}(\phi^{\{i,j\}}(\tilde{w}))\}\,.$$

Because $\bar{w} \geq \tilde{w}$ by definition, one has $\hat{w} < \bar{w}$. The proof that the infimum is also decreasing with integration is similar.

Q.E.D.

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