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ABSTRACT

Buyers’ Alliances for Bargaining Power

by Suchan Chae and Paul Heidhues

We provide a novel explanation as to why forming an alliance of buyers (or sellers) across separate markets can be advantageous when input prices are determined by bargaining. Our explanation helps to understand the prevalence of buyer cooperatives among small and medium sized firms.

Keywords: Nash bargaining solution, alternating-offer bargaining, bargaining power, buyer power, cooperatives, input markets.

JEL Classification: C78, L41, L96

ZUSAMMENFASSUNG

Verhandlungsmacht durch Käuferkooperationen

Dieses Papier entwickelt eine neue Erklärung dafür, warum Zusammenschlüsse zwischen Käufern (oder Verkäufern), die in unterschiedlichen Märkten aktiv sind, deren Verhandlungsmacht stärken können. Unser Ansatz kann unter anderem erklären, warum sich kleinere und mittlere Unternehmen oft zu Einkaufsgenossenschaften zusammenschließen.

1. Introduction

A large body of industrial organization literature investigates the extent to which coordinated activities through mergers or alliances lead to market power. It has also been noted that mergers may lead to considerable “buyer power” in oligopolistic input markets. This paper contributes to this literature by providing a novel explanation as to why large firms may have greater bargaining power in oligopolistic input markets than small firms. Our findings can also explain the prevalence of buyers’ cooperatives, through which small and medium sized firms conduct their supply negotiations.

Formally, we consider two independent markets. In each market, an input supplier negotiates with a downstream producer. If an agreement is reached in a market, a fixed benefit of cooperation is divided between the negotiating parties. Within this setup, we investigate the effect of forming an alliance between the buyers of the two markets using a variant of the standard two-person alternating-offer bargaining model. In our model, forming an alliance between the buyers amounts to delegating negotiations to one of its identical members with the common understanding that the spoils from bargaining are split equally among all members of the alliance.

We will show that forming a buyers’ alliance among risk-averse buyers can be advantageous in our model. There are two intuitive explanations for this. First, when an integrated party negotiates with each of the other parties, it takes the outcome of the bargaining with the other party as given. This increases the integrated party’s fall-back position as it is risking only part of its business opportunity in each negotiation. To the extent that this makes the integrated party bolder in bargaining, it increases the share it can capture. We call this the *fall-back wealth effect* of being involved in multiple negotiations. Second, when bargaining jointly, the two members of an alliance share the risk of a breakdown. When buyers prefer to risk half the amount twice rather than the full amount once, the split of the breakdown risk between the alliance members makes them bolder and thereby increases the alliance's share. We call this the *risk-sharing effect* of negotiating jointly.

We illustrate through some examples (Examples 1 and 2) that risk aversion per se does not imply the presence of either the fall-back wealth effect or the risk-sharing effect. However, we show that under certain conditions, namely that preferences can be represented by a HARA utility function (Example 3), risk aversion implies the presence of these two effects and that forming a coalition is profitable for risk averse buyers. Since risk aversion plays a key role in our results, we will devote the next section (Section 2) to the issue of the plausibility of this assumption on firms' attitudes toward risk.

Alliances of buyers (or sellers) across markets are found in many industries. For example, buyers' cooperatives through which farmers pool their resources to buy inputs such as seeds, fertilizers, petroleum products, farming equipment, heating oil, and hardware are common in the US agricultural industry. Similarly, farmers often form marketing cooperatives to sell farm products to wholesalers and retailers. According to the National Cooperative Business Association (www.ncba.coop), there are approximately 4100 agricultural cooperatives with 3.9 million memberships. The net business volume of agricultural cooperatives amounted to $105.5 billion in 1994.

In the US cable television market, the business press asserts that MSOs (multiple system operators) that consist of local companies operating in different cities fare better in input market negotiations with broadcasters than smaller local cable operating companies.[1] The Cable Act of 1992 ordered the Federal Communications Commission to establish legal restrictions on the *national* size of MSOs. This legislation took place despite the fact that local cable companies typically had a near 100% market share in the output market. One interpretation of this legislation is that Congress was concerned about excessive bargaining power of MSOs in input markets.

Similarly, it has been argued that bargaining power increases with the national size of a movie theater chain. For instance, after monopolizing the Las Vegas movie theater market, Syufy Enterprises was sued by the Department of Justice for the alleged impact of the merger in the input (rather than the product) market. 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% national market share.[2]

Gal-Or (1999a, 1999b) gives an account of the recent increase in the US health care industry concentration. She argues that an input bargaining model is appropriate for analyzing the health care industry.[3] Her theoretical models provide an interesting perspective for the reason why we

1. Gal-Or and Dukes (2002) investigate media mergers focusing on the effect of informative advertising. In their model, media merger affect the amount of advertising shown, which affects consumers' knowledge about available products, which in turn affects the intensity of competition for consumer goods and thereby the consumer-good firms' willingness to pay for advertising. Gal-Or and Dukes (2003) use a similar model to investigate under what conditions both media companies and advertisers would like to engage in exclusive dealing, which reduces the amount of advertising and product market competition in equilibrium and thereby increases the available rents to the firms.
2. See Waterman (1996) for a detailed discussion.
3. Gal-Or (1999b) also discusses why vertical mergers between hospitals and physician practices can increase their bargaining power vis-à-vis health insurance providers.

observe alliances between health insurance providers, between hospitals, and between physicians. Our paper is complementary to her papers in that we provide a new reason why such mergers can give rise to bargaining power.

Buyer cooperatives are common in other countries as well. In Germany, for example, the first modern farmers' cooperative was founded by Friedrich Wilhelm Raiffeisen in 1864. By the turn of the century, farmers' cooperatives (Genossenschaft) became widespread. While initially many cooperatives focused on financing, nowadays cooperatives are commonly used to buy inputs or to sell farm products (Raiffeisenwarengenossenschaften). Similarly, in many other traditional trades, small business owners conduct input negotiations jointly through cooperatives (Einkaufsgenossenschaften). For example, Edeka - a cooperative of about 5000 small retailers (and some larger retailers) - coordinates supply (and marketing) activities for its members.

Our model is related to the literature on input-market power. There have been various explanations as to why a larger downstream firm should get a better deal. One explanation is that a monopsonist who faces competitive input suppliers can reduce its input demand and thereby lower the input price. Empirically, this suggests that a concentrated downstream market structure should lead to a lower quantity traded. In most input markets, however, a few sellers face a few buyers and market power exists for both buyers and suppliers.[4] It is therefore natural to think of input market bargaining as determining the terms of trade.

4. See Waterson (1980), Salinger (1988), and Kuehn and Vives (1999) for two stage models of imperfectly competitive input markets in which the upstream firms compete as Stackelberg leaders in wholesale prices and the downstream firms compete with each other in the final goods market taking the input prices as given.

Under the assumption that input-market negotiations are efficient, Horn and Wolinsky (1988b) analyze mergers that increase bargaining power in oligopolistic input markets. They show that it can be profitable to form an alliance between suppliers (a workers' union) since, in equilibrium, each supplier negotiates on the margin taking it as given that the other negotiation is resolved. The bargaining parties thus split the incremental surplus of each input-market relation. If the suppliers are substitutes, twice the incremental surplus is less than the full surplus and a merger is profitable because the (incremental) surplus is always split equally between risk-neutral negotiating parties.[5] This idea has been generalized by Chipty and Snyder (1999) and Inderst and Wey (2003), who show in different cooperative models that a downstream merger is profitable if suppliers have a decreasing surplus function (or increasing net unit cost) because this implies that twice the incremental surplus is less than the entire surplus.[6] In our model, we abstract from these *incremental surplus effects*, rooted in the production technology and generated by production-related interactions between negotiations**.** Our bargaining effects rely solely on buyers' preferences relevant for bargaining.

If input-market bargaining is restricted to prices, the quantity traded is related to the agreed-upon input price. This yields an additional bargaining affect, for the bargaining frontier is not linear in this case even if agents are risk-neutral. Indeed, Horn and Wolinsky (1988a) showed that in

5. See also Jun (1989).
6. Chipty and Snyder (1999) assume that each negotiation is settled according to the Nash bargaining solution taking it as given that all other negotiations are resolved. Inderst and Wey (2003) use the Shapley value to calculate the benefits of a merger and justify this by showing also that the Shapley value can be obtained as an equilibrium of a noncooperative bargaining model with contingent offers. These papers assume independent downstream markets. Shaffer (2001) allows for competition between downstream firms. The written contract between the manufacturer and the retailer can specify any nonlinear pricing scheme. Within this model, industry profits are maximized only if there is a retail monopoly. Heidhues (2000) argues that efficient (rather than a nonlinear pricing) input-market negotiations with a single supplier preclude downstream competition between its buyers.

this case a merger to monopoly between firms that compete in strategic substitutes is not profitable as it has an adverse effect on input-market negotiations. To avoid this, in his view absurd, result, von Ungern-Sternberg (1996) imposes an additional assumption on the "generalized Nash solution" he uses to determine input prices. In effect, this assumption implies that he uses a proportional bargaining solution, i.e., a bargaining solution according to which the benefits are split Pareto-efficiently according to a fixed sharing rule α. As downstream monopolization increases the pie, it makes both parties better off. Horn and Wolinsky's result has been also qualified by Dobson and Waterson (1997), who assume that downstream firms compete in prices (i.e., strategic complements) rather than quantities. In their model, a downstream merger has two positive effects: First, due to the decrease in competition, the benefit that can be split between the downstream firm and the supplier increases. 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 supplier's bargaining power and makes downstream firms better off. The merging firms, however, lose market share to their competitors. They, however, do not provide conditions under which a merger is profitable.

Our paper differs from the above papers in that we assume away any interrelation between merging parties based on market demand or technology. Thus we identify pure bargaining effects of merging two independent parties. Our bargaining effect does not appear in *any* of the previous models because they all assume that bargaining parties are risk neutral. Relaxing this assumption, our paper *provides conditions* under which a merger enhances the bargaining power of the merging parties.

One interesting issue is what welfare consequences the increased bargaining power of an alliance has. Indeed, there has been a growing concern on the consequences of buyer power among antitrust authorities in the US and Europe.[7] In the main model of this paper (in Section 3), input-market bargaining is efficient and thus buyer power has only distributive consequences. We provide, however, a simple example (Example 4 in Section 4) that shows that there can be welfare consequences of the increased buyer power due to alliance. In this example, we add an initial (long term) investment decision with contractual incompleteness. Thus the investing firms face a hold-up problem as the investment benefits will partially be shared through bargaining with their negotiating partners. In such an environment, alliance has an effect on investment incentives and industry development.

Viewed as a contribution to bargaining theory, this paper investigates a noncooperative bargaining model in which an alliance (that is, its representative) negotiates sequentially with two bargaining partners. Each negotiation is modeled as an alternating-offer bargaining with an exogenously given breakdown probability. There is a fixed (monetary) benefit from cooperation that can be divided in each of the two negotiations independent of whether the other negotiation is resolved. The ability of an alliance to share its payoff leads to the risk-sharing effect. The effect of what an alliance receives in one negotiation on the other negotiation leads to the fall-back wealth effect.

In a sequential setting, it is not difficult to see that the outcome of the first negotiation can positively affect the amount the integrated party receives in the second negotiation. (Proposition

7. In the US, buyer power explicitly enters the merger control guidelines as an efficiency defense (see the 1992 Horizontal Merger Guidelines, with revision on Section 4 on efficiencies in 1997). Similarly, the buyer power defense enters the 1998 Competition Act of the UK.

1). There is, however, a feedback effect of the second negotiation on the first negotiation, for the result of the second negotiation is anticipated in the first negotiation. Suppose that as the alliance gets more in the first negotiation, it gets more in the second negotiation. Then the alliance is effectively facing a negative tax or subsidy on what it receives in the first negotiation. This subsidy increases the amount of pie to be divided in the first negotiation. Thus the alliance's opponent in the first bargaining will demand more. The overall implication of this feedback is not entirely clear. For instance, Chae (2002) shows that under certain conditions, the subsidy can hurt the subsidized party in bargaining. We show, however, that in the presence of the risk sharing effect and the fall-back wealth effect, the members of an alliance receive more after integration than before (Proposition 2).

From the modeling point of view, we can demonstrate our qualitative conclusion regarding the advantage of forming an alliance in an alternative model where two negotiations are carried out simultaneously rather than sequentially. In a simultaneous bargaining model, each bargaining problem is resolved according to the Nash bargaining solution taking as given the solution to all other bargaining problems. We used this simultaneous bargaining approach in a previous version of this paper.[8] One advantage of the sequential approach of the current model is that it is a noncooperative bargaining model with a *unique* subgame perfect equilibrium, which facilitates the comparison between bargaining outcomes for integrated and independent bargainers. In contrast, no such noncooperative foundation is available for the simultaneous bargaining solutions used in the literature.

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8. Chae and Heidhues (1999a).

In Section 2, we explain why it is natural to assume in our bargaining model that firms' objective functions are concave in profits. In Section 3, we characterize conditions under which forming an alliance among buyers (or sellers) increases their bargaining power. In Section 4, we provide an example where the increased buyer power through alliance can have welfare consequences. Section 5 contains concluding remarks. Some technical proofs are relegated to the Appendix.

2. Firms' Objective Functions

It is often assumed that firms are risk neutral, that is, their objective functions are linear in profits. However, the impact of risk aversion on industry outcomes has also been studied in many standard models of competition. Sandmo (1971) studies the theory of competitive firms under risk aversion. Appelbaum and Katz (1986) investigate the impact of risk aversion on comparative statics in competitive industries. Asplund (2002) determines equilibrium outcomes in standard oligopoly models with risk averse firms. Spagnolo (1999) points out that if firms are risk averse, multi-market contact facilitates collusion, and Spagnolo (2002) argues that the concavity of the objective function helps to sustain collusive agreements.[9]

The assumption that firms are risk neutral in decision making is typically justified on the grounds that financial markets are perfect and owners' portfolios are well diversified. In reality, however, owners' portfolios are not always well diversified. For instance, think of small businesses managed by their owners. The owners of such small firms often invest a large share of their wealth in their own firms and hence their financial wealth is largely determined by the success of their firms. This implies that business decisions will be influenced by the owners' risk-aversion. Within a von Neumann-Morgenstern framework, it is thus natural to assume that these owner-managed firms behave as if they had concave objective functions. Moreover, it is hard to imagine that a firm can insure itself against not coming to an agreement in negotiations with one of its suppliers. Therefore, it is natural to assume that the negotiation risk falls on the owner of a small

9. Discussions in this section benefited from the discussions in Spagnolo (1999) but expand them.

businesses. In fact, many of the examples we considered in the previous section involve buyers'alliances between small businesses.

While the assumption of risk aversion can be taken literally in the case of buyers'alliances between small businesses, there is also overwhelming evidence that large firms behave *as if* they were risk averse. For example, there is a large body of empirical evidence suggesting that top managers manipulate accounts and tune production decisions in order to decrease the variability of profits over time.[10] This income smoothing is indicative of the fact that firms have strictly concave objective functions. Also, firms invest considerable resources in order to hedge through various kinds of derivatives. Since firms with linear objective functions have no reason to hedge, this is further evidence that real-world firms behave as if they were risk averse. This strong evidence is reflected by a large theoretical literature that explains why firms might behave as if they were risk averse.

One reason given in the theoretical literature as to why firms have strictly concave objective functions is the tax code.[11] Items such as tax credits generate convexity in firms' tax liabilities since the present value of unused credits diminishes during carry forward to future periods. This convexity in tax liabilities gives rise to firms' concave objective functions. Indeed, the nonlinearity of the tax code is one of the standard arguments explaining why hedging is desirable.

Another reason for why firms may pursue concave objective functions lies in financial market imperfections. Past works suggest that due to information asymmetries in capital markets, a

10. See, for example, Degeorge et al (1999), Greenawalt and Sinkey (1988), Kasanen et al (1996), and Ronen and Sadan (1981).
11. For early papers in finance, see Smith and Schulz (1985) and Myers and Majluf (1984).

firm's cost of external finance is strictly convex.[12] This implies that firms prefer smooth earnings paths to ensure that internal funds are always available and suboptimal investment policies can be avoided.[13] Indeed, the convex cost of external finance is a common explanation as to why firms should and do hedge.[14] Furthermore, it has been argued that investors value assets with smooth returns higher. Some institutional investors face regulations that induce them to prefer assets with stable returns.[15] Small investors, on the other hand, face transaction costs when selling or buying assets and hence may prefer smooth returns for consumption reasons. Equity holders potentially gain from reduced variance in earnings through improvement in portfolio optimization decisions.

So far we have argued that owners or investors have reasons for wanting their firms to follow concave objective functions, i.e., to behave as if the firms were risk averse. There is also a large body of literature explaining why managers want to maximize a concave objective function even if the owners would have linear objective functions. Fudenberg and Tirole (1995) develop an optimal contract model in which owners cannot commit to long-term contracts. In their model, incumbent managers earn rents and new performance measures are better signals than old ones. In equilibrium, shareholders may find it optimal to replace a manager in low profit periods even if these low profit periods follow high profit periods. Since managers earn rents while being employed, they are willing to incur positive costs in order to smooth reported profits and divi-

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12. See, for example, Hubbard et al (1993).
13. See Froot et al (1993).
14. Note also that the literature on the "credit channel of monetary policy" is based on the idea of an external finance premium, i.e., the idea that external financing (issuing equity or debt) is more costly than internal financing (retained earnings). For a survey of this literature, see Bernanke and Gertler (1995)
15. For an empirical analysis of this question in a debt dominated country, see Kasanen et al (1996).

dends and thereby reduce the chance of being fired. The managerial incentives thus induce the managers to behave as if they had strictly concave objective functions.[16]

Another standard explanation for income smoothing and hedging is that managers are financially constrained and risk averse.[17] Indeed, in the large body of literature that views the relationship between shareholders and managers as a principle-agent problem, the well-known trade-off between incentives and risk sharing follows from the assumption that managers are more risk averse than owners.

Joskow and Rose (1994) report evidence that corporate boards tend to cap managers' bonuses, thereby supporting an earlier observation made by Healy (1985).[18] This gives managers an incentive to transfer wealth from periods in which they are above the cap to periods to which they are below the cap, i.e., to engage in income smoothing, providing another reason for why firms behave as if they had concave objective functions.

Following the seminal paper by Jensen and Meckling (1976), it is often assumed that managers want to invest into pet projects or follow other pursuits such as the firms' growth and power. This implies that managers may invest even if the pecuniary return from investing is negative. For these type of investments, the managers are financially constrained. Thus managers prefer to have some free cashflow every period and this makes them averse to variations in firms' profits.

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16. See also DeFond and Park (1997), who provide some empirical support for this argument.
17. See Stulz (1984).
18. See also Holthausen et al (1995).

Debt financing gives rise to the risk of bankruptcy. Managers are strongly averse to the risk of bankruptcy because it ruins their future earnings opportunity. Bondholders also have an incentive to reduce the variability of earnings to minimize the probability of financial distress and its associated bankruptcy costs.[19] In the presence of stochastic shocks, this keeps managers from maximizing expected profits and leads them to avoid bankruptcy.[20] Managers thus behave as if they had strictly concave objective functions.[21]

19. For more details, see Smith and Stulz (1985).
20. A complementary argument is that if bondholders can observe neither the firm's ability to smooth income nor the underlying variance of the firm's earnings, then managers have an incentive to smooth reported income in order to lower claim holders' perception of the variance of the underlying earnings and thus the risk of bankruptcy. The reason is that this decreases the firm's cost of borrowing. See Trueman and Titman (1988).
21. The above arguments lead Greenwald and Stiglitz (1993) to state that "because of financial market imperfections... firms act in a risk averse manner."

3. Buyer Power through Alliance

There are two parallel markets. In each market, a seller and a buyer bargain over the price of a good.[22] The value of the good to a buyer is π, while it has zero value to a seller if unsold. The two sellers have identical preferences and the two buyers have identical preferences. The buyers in markets 1 and 2 are called buyer 1 and buyer 2, respectively, and the sellers in markets 1 and 2 are called seller 1 and seller 2, respectively.

Suppose the two buyers form an alliance. The alliance delegates bargaining to one player. Since the two buyers have identical preferences, it does not matter to whom bargaining is delegated. The buyer to whom bargaining is delegated will be simply called "the buyer". When bargaining with the sellers is completed, the two buyers split the spoils.

The buyer first bargains with seller 1 in a Rubinstein-type (1982) alternating-offer protocol. After each rejection, there exists a fixed probability of breakdown. If the bargaining ends with an acceptance or if the bargaining breaks down, the buyer immediately starts bargaining with seller 2 in the same alternating-offer protocol, possibly with a different breakdown probability.

Denote the von-Neumann Morgenstern (vN-M) utility function of an individual by u_i ($i = b, s$). We assume that u_i is smooth, $u_i(0) = 0$, $u_i' > 0$, and

$$(d/dx)^2 \log(u_i(x) - u_i(d)) < 0 \text{ for any } x > d \geq 0. \quad (1)$$

22. This paper was originally motivated by bargaining between a cable operator and a broadcaster in a television market. See Chae (1998) for a policy analysis in this market using a bargaining model.

The last condition implies that the log of utility gain is strictly concave. It is satisfied if players are weakly risk averse or risk neutral, i.e., $u_i'' \leq 0$. But it is also satisfied by some risk-loving preferences. For instance, it is always satisfied if players' preferences can be represented by vN-M utility functions with constant relative risk aversion, $u_i(x) = x^{1-r}$, where $\infty < r < 1$.[23]

Given a payoff x, a breakdown payoff d, and breakdown probability $1-p$, define an individual's certainty equivalent $c_i(p, x, d)$ as the payoff y such that $pu_i(x) + (1-p)u_i(d) = u_i(y)$. The amount an individual is willing to pay in order to avoid an infinitesimal chance of breakdown will be called the *marginal risk concession*. It is formally defined and denoted as

$$\mu_i(x, d) \equiv \lim_{p \to 1} \frac{x - c_i(p, x, d)}{1-p} = \frac{\partial}{\partial p} c_i(1, x, d) = \frac{u_i(x) - u_i(d)}{u_i'(x)}.$$

Observe that (1) is equivalent to

$$\frac{\partial}{\partial x} \mu_i(x, d) > 0 \text{ for any } x > d \geq 0.$$

We can analyze the model backward starting from the bargaining between the buyer and seller 2. This part of the model is similar to a standard two-person Rubinstein bargaining game. Let x^1 denote what the buyer (that is, the alliance) received from bargaining with seller 1. Also, let x^2 denote what the buyer receives from bargaining with seller 2. Both x^1 and x^2 are split equally between buyer 1 and buyer 2. Given x^1, the feasible utility set and the disagreement point are, respectively,

23. See Chae and Heidhues (1999a).

$$S^2(x^1) = \left\{\left(u_b\left(\frac{x^2}{2}+\frac{x^1}{2}\right), u_s(\pi - x^2)\right) : 0 \le x^2 \le \pi\right\},$$

$$d^2(x^1) = \left(\frac{x^1}{2}, 0\right).$$

Since this game is a standard two-person bargaining game, it is well known that there exists a unique subgame perfect equilibrium. In the equilibrium, bargaining ends immediately and in each subgame a proposing player's offer ensures that the receiver is indifferent between accepting the offer and facing the risk of a breakdown in order to become a proposer himself. The equilibrium payoff vector $(x^2, \pi - x^2)$ can be obtained as follows: Let (y_b, z_s) be the equilibrium payoff vector when the buyer is the initial proposer, and let (z_b, y_s) the equilibrium payoff vector when the seller is the initial proposer. If the breakdown probability is $1-p$, then

$$u_b\left(\frac{z_b}{2}+\frac{x^1}{2}\right) = pu_b\left(\frac{y_b}{2}+\frac{x^1}{2}\right) + (1-p)u_b\left(\frac{x^1}{2}\right),$$

$$u_s(z_s) = pu_s(y_s).$$

That is,

$$z_b = 2\left\{c_b\left(p, \frac{y_b}{2}+\frac{x^1}{2}, \frac{x^1}{2}\right) - \frac{x^1}{2}\right\}, \tag{2}$$

$$z_s = c_s(p, y_s, 0). \tag{3}$$

The solution can be obtained by combining these with the feasibility conditions

$$y_b + z_s = \pi, \tag{4}$$

$$z_b + y_s = \pi. \quad (5)$$

For convenience, let us assume that the buyer is the initial proposer in bargaining with a seller, and let $x^2 = \phi^p(x^1) \equiv y_b$. We will now determine x^1 in the bargaining between the buyer and seller 1. For this problem, the feasible utility set and the disagreement point are, respectively,

$$S^1 = \left\{\left(u_b\left(\frac{x^1}{2} + \frac{\phi^p(x^1)}{2}\right), u_s(\pi - x^1)\right): 0 \le x^1 \le \pi\right\},$$

$$d^1 = \left(\frac{\phi^p(0)}{2}, 0\right).$$

Put $v_b(x_1) \equiv u_b((x^1/2) + \{\phi^p(x^1)/2\})$ and assume that the function v_b satisfies the strict log-concavity condition (1), which was assumed of u_b. Then there exists a unique subgame perfect equilibrium for the bargaining game between the buyer and seller 1. The assumption that v_b satisfies (1) is equivalent to

$$\frac{\partial}{\partial x}\left[\frac{\mu_b((x^1/2) + \{\phi^p(x^1)/2\}, \phi^p(0)/2)}{1 + \phi^{p\prime}(x^1)}\right] > 0. \quad (6)$$

Since $(x^1/2) + \{\phi^p(x^1)/2\}$ is an increasing function of x^1 and $(\partial/\partial x)(\mu_b(x, d)) > 0$ for any x, d, a sufficient condition for (6) is

$$\phi^{p\prime\prime}(x^1) \le 0 \text{ for any } x^1.$$

For instance, if the buyer's preferences exhibit constant absolute risk aversion, then, as will be seen in Example 2 below, $\phi^p(x^1) = 0$ for any x^1 and thus (6) is satisfied.

From now on, we will study the limit solution as the breakdown probabilities go to zero.[24] Let $\phi(x^1) \equiv \lim_{p \to 1} \phi^p(x^1)$. Then, as will be shown in the Appendix, $x^2 = \phi(x^1)$ is the solution to

$$2\mu_b\left(\frac{x^2}{2} + \frac{x^1}{2}, \frac{x^1}{2}\right) = \mu_s(\pi - x^2, 0). \tag{7}$$

Similarly, as will be also shown in the Appendix, given the function $\phi(x^1)$, one can obtain the buyer's equilibrium payoff in his bargaining with seller 1 as

$$\frac{2}{1 + \phi'(x^1)} \cdot \mu_b\left(\frac{x^1}{2} + \frac{\phi(x^1)}{2}, \frac{\phi(0)}{2}\right) = \mu_s(\pi - x^1, 0). \tag{8}$$

Denote the solution to the above equation as $\hat{x}^1$, and let $\hat{x}^2 \equiv \phi(\hat{x}^1)$.

Now we will compare a buyer's payoff obtained above to his payoff when the two buyers do not form an alliance. Without alliance, a buyer and a seller bargain in each market according to the standard alternating-offer procedure with a fixed probability of breakdown after each rejection. As is well known, as the breakdown probability goes to zero, the unique subgame perfect equilibrium outcome $(x, \pi - x)$ approaches the Nash (1950) bargaining solution that maximizes $u_b(x) \cdot u_s(\pi - x)$. Denote a buyer's equilibrium payoff at the Nash bargaining solution by x^N. Then it satisfies

$$\mu_b(x^N, 0) = \mu_s(\pi - x^N, 0). \tag{9}$$

24. The breakdown probability of the bargaining between the buyer and seller 2 can be in principle different from the breakdown probability for the bargaining between the buyer and seller 1.

Observe that in the special case in which all players are risk-neutral, $\mu(x+d, d) = x$ and hence a buyer receives $\pi/2$.

We will now show that under the two conditions below, forming an alliance benefits the buyers, i.e., $(\hat{x}^1 + \hat{x}^2)/2 > x_N$.

Strong Fall-back Wealth Effect (SF): $\mu_i(x+d, d) < \mu_i(x+d', d')$ for $x > 0$, $d > d'$.

Weak Risk-sharing (WR): $\mu_i(2x, 0) \geq 2\mu_i(x, 0)$.

Alternatively, one may require the following two conditions, weakening SF and strengthening WR.

Weak Fall-back Wealth Effect (WF): $\mu_i(x+d, d) \leq \mu_i(x+d', d')$ for $x > 0$, $d > d'$.

Strong Risk-sharing (SR): $\mu_i(2x, 0) > 2\mu_i(x, 0)$.

SF says that the marginal risk concession of a player is decreasing in one's fall-back position. WF relaxes SF to a weak inequality. WR requires that, for a zero breakdown point, doubling the amount of stake at least doubles the marginal risk concession of a player. In other words, WR says that when the breakdown point is equal to zero, the marginal risk concession is convex in x.

Example 1. Suppose that an individual is risk averse and the individual's preferences can be represented by vN-M utility functions with constant relative risk aversion (CRRA), i.e.,

$u_i(x) = x^{1-r}$ where $0 < r < 1$. Then

$$\mu_i(x+d, d) = \frac{1}{1-r}\{(x+d) - d^{1-r}(x+d)^r\}$$

Differentiating the right hand side with respect to d, one obtains

$$\frac{1}{1-r}\left[1 - \left\{(1-r)\left(\frac{x+d}{d}\right)^r + r\left(\frac{x+d}{d}\right)^{-(1-r)}\right\}\right] < 0 .$$

(The last inequality holds, for if we let $f(y) = (1-r)y^r + ry^{-(1-r)}$ then $f(1) = 1$, $f'(y) > 0$ for $y > 1$ if $0 < r < 1$.) Thus SF holds. Since $\mu_i(x, 0) = x/(1-r)$, one has $\mu_i(2x, 0) = 2\mu_i(x, 0)$. Thus WR holds, but SR is violated.

Example 2. Suppose that an individual is risk averse and the individual's preferences can be represented by vN-M utility functions with constant absolute risk aversion (CARA), i.e., $u_i(x) = (1 - e^{-\alpha x})/(1 - e^{-\alpha})$, where $\alpha > 0$. Then $\mu_i(x+d, d) = (e^{\alpha x} - 1)/\alpha$.

Thus WF and SR hold, while SF is not satisfied.

Example 3. Suppose an individual's preferences can be represented by vN-M utility functions with hyperbolic absolute risk aversion (HARA), i.e.,

$$u_i(x) = \frac{1-\gamma}{\gamma}\left(\frac{ax}{1-\gamma} + b\right)^{\gamma}$$

with the parameter restrictions $-\infty < \gamma < 1$, $a > 0$, and $b > 0$. This is a broad class of utility functions such that the CRRA ($b = 0$) and CARA ($\gamma = -\infty$ and $b = 1$) utility functions are limiting cases. The restriction $\gamma < 1$ ensure that agents are risk averse. We will show in the Appendix that both SF and SR hold for this class of utility functions.

Theorem 1. *Suppose that the buyer's preferences satisfy* [SF *and* WR] *or* [WF *and* SR]. *Then forming an alliance is profitable, i.e.* $(\hat{x}^1 + \hat{x}^2)/2 > x_N$.

The theorem will be proved by the following two propositions:

Proposition 1. *Suppose that the buyer's preferences satisfy* [SF *and* WR] *or* [WF *and* SR]. *Then a buyer representing an alliance receives a larger share of the benefit than an independent buyer in market two, i.e.* $\hat{x}^2 > x^N$.

Proof. If the buyer's preferences satisfy SF and WR, one has

$$2\mu_b\left(\frac{x^2}{2} + \frac{x^1}{2}, \frac{x^1}{2}\right) < 2\mu_b\left(\frac{x^2}{2}, 0\right) \leq \mu_b(x^2, 0) \tag{10}$$

since $x^1, x^2 > 0$. If the buyer's preferences satisfy WF and SR instead, the weak and strict inequalities in (10) are exchanged. Thus, in either case, one has, by (7), $\mu_s(\pi - \hat{x}^2, 0) < \mu_b(\hat{x}^2, 0)$. If one compares this with (9), one can see that $\hat{x}^2 > x^N$. *Q.E.D.*

The proof of the above proposition shows how [SF and WR] or [WF and SR] work together to the buyer's advantage. Depending on which pair of conditions is used, the role of one property is more conspicuous than the other.

The fall-back wealth effect can be intuitively explained as follows: When bargaining with seller 2, the buyer's breakdown payoff is what he receives from the bargaining with seller 1. Thus, if the bargaining with seller 2 breaks down, the buyer still receives some payoff from the earlier bargaining with seller 1. Due to SF (or WF), this lowers the buyer's marginal risk concession and thus the buyer can credibly demand a larger share of the pie.

The risk-sharing effect can be intuitively explained as follows: The two members of the alliance share the spoils from bargaining. Due to SR (or WR), dividing a given payoff between two individuals leads to a lower marginal risk concession than giving the undivided payoff to one individual. This increases the bargaining power of the alliance.

It is interesting to note that when players with constant relative risk aversion (CRRA) form an alliance, there is positive fall-back wealth effect but zero risk-sharing, while when players with constant absolute risk aversion (CARA) form an alliance, there is positive risk-sharing but zero fall-back wealth effect.

We will now analyze the outcome of the bargaining between the buyer and seller 1. In this bargaining, both sides understand that if the buyer receives more in the current round, he will be able to extract more from his opponent in the next round. It is as if the buyer is subsidized on what he receives in the current round.[25] This effect favors the buyer. The reason is that in order to increase the “perceived” pie, more should be given to the buyer. But, once the pie is increased in this way, the seller 1 may demand more from the increased pie. The overall effect is not clear *a priori*. Nevertheless, we establish

Proposition 2. *Suppose that the buyer's preferences satisfy* [SF *and* WR] *or* [WF *and* SR]. *Then a buyer representing an alliance receives a larger share of the benefit then an independent buyer in market one, i.e.* $\hat{x}^1 > x^N$.

Proof. Suppose to the contrary that $\hat{x}^1 \le x^N$. Then by Proposition 1, one has $\hat{x}^1 < \hat{x}^2$ and thus

$$\mu_s(\pi - \hat{x}^1, 0) > \mu_s(\pi - \hat{x}^2, 0)\,. \tag{11}$$

From (8), (7), and (11), it follows that

$$\frac{2}{1+\phi'(\hat{x}^1)} \cdot \mu_b\!\left(\frac{\hat{x}^1}{2} + \frac{\hat{x}^2}{2}, \frac{\phi(0)}{2}\right) \;=\; \mu_s(\pi - \hat{x}^1, 0) > \mu_s(\pi - \hat{x}^2, 0) \;=\; 2\mu_b\!\left(\frac{\hat{x}^2}{2} + \frac{\hat{x}^1}{2}, \frac{\hat{x}^1}{2}\right)$$

i.e.,

$$\frac{1}{1+\phi'(\hat{x}^1)}\left\{u_b\!\left(\frac{\hat{x}^1}{2} + \frac{\hat{x}^2}{2}\right) - u_b\!\left(\frac{\phi(0)}{2}\right)\right\} > u_b\!\left(\frac{\hat{x}^1}{2} + \frac{\hat{x}^2}{2}\right) - u_b\!\left(\frac{\hat{x}^1}{2}\right).$$

Thus, one has

25. See Chae (2002) for an analysis of tax incidence with bargaining.

$$u_b\left(\frac{\hat{x}^1}{2}+\frac{\hat{x}^2}{2}\right)-u_b\left(\frac{\phi(0)}{2}\right)>u_b\left(\frac{\hat{x}^1}{2}+\frac{\hat{x}^2}{2}\right)-u_b\left(\frac{\hat{x}^1}{2}\right),$$

i.e.,

$$u_b\left(\frac{\hat{x}^1}{2}\right)>u_b\left(\frac{\phi(0)}{2}\right).$$

Thus, one has $\hat{x}^1>\phi(0)$. Since $\phi(0)\geq x^N$ by (7), (9), and WR, one has $\hat{x}^1>x^N$, which leads to a contradiction. *Q.E.D.*

We have derived our results in a sequential bargaining environment. Our modeling choice is motivated by the fact that real-world negotiations often seem to take place sequentially. The central result that a buyers' alliance yields buyer power, however, does not rely on this modeling choice. In an earlier working paper version (Chae and Heidhues 1999a), we modeled input-market negotiations in such a way that each bargaining problem is resolved according to the Nash bargaining solution taking it as given that all other bargaining problems are resolved.[26] Under this alternative modeling choice, forming an alliance is profitable under the same set of conditions as the ones used to prove Theorem 1 in this paper. One advantage of the sequential approach adopted in this paper is that the equilibrium is unique. Thus the comparison of the outcomes for integrated bargaining and independent bargaining is made easy.

26. That in each bilateral negotiation players take the outcome of all other bargaining problems as given is a standard cooperative modelling approach for input-market negotiations (see, e.g. Chipty and Snyder (1999), Horn and Wolinsky (1988b), Dobson and Waterson (1997)). For a noncooperative foundation, see Bjoernerstedt and Stennek (2001).

4. Welfare Consequences

So far, we have focused on how the downstream alliance structure affects buyer power. Within the model of the previous section, buyer power has only distributive consequences and has no efficiency consequences. In this section, we will touch on this issue by providing a simple incomplete contract example in which buyer power has efficiency consequences.[27]

Example 4. Consider two buyers whose preferences satisfy [SF and WR] or [WF and SR]. Either they have formed a buyers' alliance or they are staying independent. Suppose they face two sellers who can exert effort in order to increase the likelihood of producing a high quality input. Assume that *the sellers' effort choices are noncontractable*. A buyer's vN-M utility function is denoted $U(x)$, while a seller's vN-M utility function is $U(x) - e$, where e is the seller's effort level. By exerting effort e, a seller can produce a high quality input with probability $p = f(e)$. Denote the inverse function of f by g, i.e., $e = g(p)$.

For simplicity, we set the value of a low quality input to be zero and suppose that each buyer values the high quality input at a value π. Furthermore, let $g(0) = 0, g' > 0, g'' > 0$, and $g(1) > U(\pi)$.

After the quality of the input is determined, the sellers negotiate with the buyers. A seller who produced a low quality input, receives a payoff of zero. In the case where only one seller produced a high quality input, the seller gets a share $\pi/2$ if he faces an independent buyer and gets a share $\alpha \le \pi/2$ if he faces a buyers' alliance. Similarly, if both sellers have produced a high quality

27. For different approaches on this issue, see Chae and Heidhues (1999b) and Inderst and Wey (2003).

input, each seller gets a share $\pi/2$ when facing an independent buyer and gets a share $\beta < \pi/2$ otherwise. Thus a seller's effort choice satisfies $g'(p) = U(\pi/2)$ when facing independent buyers and satisfies

$$g'(p) = f(e^*)U(\beta) + \{1 - f(e^*)\}U(\alpha) < U(\pi/2)$$

otherwise, where e^* is the other seller's effort. Hence, a seller's effort decreases when facing a buyers'alliance, which is socially undesirable in this example.

It should be noted in the above example that if the buyers rather than the sellers had to make a noncontractable effort choice, then a buyers' alliance would increase social welfare. A general lesson from the above example is that the alliance structure affects bargaining power and thereby investment incentives and industry development.

That the increase of buyer power can have efficiency consequences has been the topic of some of recent works, even though this literature does not deal with alliance. For instance, Chen (2003) develops a model to investigate Galbraith's countervailing power hypothesis. In the first stage of his model, a single supplier sets a price for a competitive fringe of a given downstream market. He then negotiates a two-part tariff with a given large downstream buyer that has a production cost advantage over the competitive fringe. Finally, the large downstream buyer set the product price in the final goods market (and the competitive fringe firms supply the good up to the point where marginal cost equals the market price). Chen models buyer power through an *exogenous* bargaining power parameter that determines the share of the (second stage) surplus which the buyer can extract from the seller. His model shows that an increase in buyer power can increase total surplus because it gives an incentive for the seller to lower the retail price he sets for the competitive fringe and thereby leads to a lower product market price. He thus shows that the consequences of retail buyer power can indeed be advantageous for the consumer as envisioned by Galbraith - even though his mechanism differs. Chen's model, however, does not explain the causes of buyer power as it is an exogenous parameter in his model.[28] By providing a model in which the buyer power depends endogenously on the alliance structure, we provide a complementary insight that justifies the use of his model in addressing antitrust questions.

As another example, consider the paper by Iyer and Villas-Boas (2003) on channel coordination. They investigate the relationship between a supplier and a retailer in an incomplete contract environment in which demand is uncertain, the retail price is unobservable by the supplier, and there is nonspecificability of the product. In their model, an initial contract is written, the retailer sets a price, demand is realized, and then the supplier and retailer renegotiate the terms at which the retailer buys the input to satisfy actual demand. Within this model, an inefficiency arises that is similar to the double markup problem. Hence, if the bargaining power of the buyer rises, the channel coordination (or the joint profits) increase. Iyer and Villas-Boas (2003), however, model the buyer power through an *exogenous* parameter and thus cannot predict how the organization of the downstream market affects the extend of channel coordination. This question, which is obviously important from an antitrust perspective, can be addressed if one uses the complementary insights that we have developed in the current paper.

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28. In an extension of his basic model, Chen allows the downstream firm to choose the number of local markets it serves and assumes that the downstream firms' buyer power increases in the number of local markets in which it is active. Our model provides condition under which the buyer power does increase endogenously and is thus complementary to his result.

5. Conclusion

In this paper, we provide a novel explanation as to why downstream mergers or buyers' cooperatives can increase buyer power. Throughout, we focused on the case of downstream alliance that does not affect the product market outcome. While we view this mainly as a modeling device that allows us to abstract from well-known benefits of monopolization in a product market, we will now briefly discuss two industry examples in which abstracting from product market competition may be taken literally.

In the US cable industry, a downstream firm is typically a monopolist. A MSO can thus be naturally viewed as an alliance across independent local markets. Under this assumption, Chipty and Snyder (1999) tested whether their bargaining model - in which players negotiate over the incremental pie (taking it as given that all other negotiations are settled in equilibrium) - can explain mergers in the cable industry. Based on their model and data on supplier 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 downstream firms bargain. Hence a merger would lower the share that the downstream firms could receive.

Why then do cable company mergers occur? According to Chipty and Snyder, mergers must lead to (non-specified) efficiency gains. Upstream suppliers should gain from a downstream merger according to this efficiency gain explanation.[29] In contrast, in our model, upstream pro-

29. This explanation, however, conflicts with our arm-chair observation that independent broadcasters actively lobby against relaxing national ownership restrictions on MSOs.

gram suppliers should be hurt by the increase in cable operators' buyer power. This suggests a simple empirical test to differentiate between these two theories.

In the European agricultural sector, the EU determines prices for and/or quantities of numerous agricultural products. In this system, a buyers' cooperative in the input market cannot affect the product market. Thus an input supplier can be viewed as bargaining with a given farmer or farmers' cooperative over the fixed quasi-rent generated by his input. This may make the sector especially appealing for future empirical work aimed at testing between our and other buyer power theories that abstract from product market competition.

In an empirical study on wholesale pharmaceuticals, Ellison and Snyder (2001) finds that "Price discounts depend more on the ability to substitute among alternative suppliers than on sheer buyer size. In particular, hospitals and HMOs, which can use restrictive formulae to enhance their substitution opportunities beyond those available for drugstores, obtain substantially lower prices. Chain drugstores only receive a small size discount relative to independents, at most two percent on average, and then only for products for which drugstores have some substitution opportunities (i.e., not for on-patent branded drugs)." Even though Ellison and Snyder interpret their result as an evidence favoring "collusion models" of countervailing power over existing bargaining models, this conclusion should be interpreted carefully, for bargaining power of merged buyers would depend on the nature of competition on the seller side even in bargaining models. Given their result, however, it remains a theoretical challenge to determine qualitatively and/or quantitatively how the structure of competition on both sides of the market affects the bargaining advantage of an alliance.

Another issue our paper dealt with is the welfare consequences of the increased buyer power through alliance. We provided a simple example where alliances, which change buyer power, have an effect on investment incentives and industry development. In this example, there is an initial investment decision with contractual incompleteness and the investing firm faces a hold-up problem as the benefits from investment will partially be shared with their bargaining partners.

There has been a growing concern on the causes and consequences of buyer power among antitrust authorities and we submit that our paper helps to clarify these important issues. A full understanding of these issues, however, requires more future research efforts.

Appendix

Proof of Equation (7). From equations (4) and (5), one has

$$y_b - z_b = y_s - z_s .$$

Thus, using (2) and (3), one obtains

$$2\left[\frac{y_b}{2} - \left\{c_b\left(p, \frac{y_b}{2} + \frac{x^1}{2}, \frac{x^1}{2}\right) - \frac{x^1}{2}\right\}\right] = y_s - c_s(p, y_s, 0)\,,$$

i.e.,

$$2 \cdot \frac{\frac{y_b}{2} + \frac{y^1}{2} - c_b\left(p, \frac{y_b}{2} + \frac{y^1}{2}, \frac{y^1}{2}\right)}{1-p} = \frac{y_s - c_s(p, y_s, 0)}{1-p}.$$

Thus

$$2 \cdot \lim_{p \to 1} \frac{\frac{y_b}{2} + \frac{y^1}{2} - c_b\left(p, \frac{y_b}{2} + \frac{y^1}{2}, \frac{y^1}{2}\right)}{1-p} = \lim_{p \to 1} \frac{y_s - c_s(p, y_s, 0)}{1-p}.$$

By L'Hopital's rule,

$$2 \cdot \frac{\partial}{\partial p} c_b\left(1, \frac{y_b}{2} + \frac{y^1}{2}, \frac{y^1}{2}\right) = \frac{\partial}{\partial p} c_s(1, y_s, 0)\,,$$

from which (7) follows. *Q.E.D.*

Proof of Equation (8). In the unique subgame perfect equilibrium, the equilibrium payoff vector $(x^1, \pi - x^1)$ can be obtained as follows:

Let (y_b, z_s) be the equilibrium payoff vector when the buyer is the initial proposer, and let (z_b, y_s) the equilibrium payoff vector when the seller is the initial proposer. If the breakdown probability is $1 - q$, then

$$u_b\left(\frac{z_b}{2} + \frac{\phi^p(z_b)}{2}\right) = qu_b\left(\frac{y_b}{2} + \frac{\phi^p(y_b)}{2}\right) + (1-q)u_b\left(\frac{\phi^p(0)}{2}\right),$$

$$u_s(z_s) = qu_s(y_s).$$

That is,

$$\frac{z_b}{2} + \frac{\phi^p(z_b)}{2} = c_b\left(q, \frac{y_b}{2} + \frac{\phi^p(y_b)}{2}, \frac{\phi^p(0)}{2}\right), \tag{12}$$

$$z_s = c_s(q, y_s, 0). \tag{13}$$

The solution can be obtained by combining these with the feasibility conditions

$$y_b + z_s = \pi, \tag{14}$$

$$z_b + y_s = \pi. \tag{15}$$

Since p and q are independent, we will first take the limit as p approaches 1. Thus replace $\phi^p(y_b)$ and $\phi^p(z_b)$ by $\phi(y_b)$ and $\phi(z_b)$, respectively, in (12).

$$\frac{z_b}{2} + \frac{\phi(z_b)}{2} = c_b\left(q, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right), \tag{16}$$

Let $\Phi(z_b) \equiv (z_b/2) + \phi(z_b/2)$. Then the function Φ is increasing due to the assumption that S^1 is convex, and one has $z_b = \Phi^{-1}\left(c_b\left(q, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right)\right)$. Since $y_b - z_b = y_s - z_s$ from (14) and (15), one has

$$y_b - \Phi^{-1}\left(c_b\left(q, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right)\right) = y_s - c_s(q, y_s, 0).$$

i.e.,

$$\frac{y_b - \Phi^{-1}\left(c_b\left(q, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right)\right)}{1-q} = \frac{y_s - c_s(q, y_s, 0)}{1-q}.$$

Thus

$$\lim_{q \to 1} \frac{y_b - \Phi^{-1}\left(c_b\left(q, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right)\right)}{1-q} = \lim_{q \to 1} \frac{y_s - c_s(q, y_s, 0)}{1-q},$$

By L'Hopital's rule,

$$\frac{\frac{\partial}{\partial q} c_b\left(1, \frac{y_b}{2} + \frac{\phi(y_b)}{2}, \frac{\phi(0)}{2}\right)}{\Phi'(y_b)} = \frac{\partial}{\partial y} c_s(1, z_s, 0).$$

from which (8) follows. *Q.E.D.*

Proof that HARA Preferences satisfy SF and WR. First, we establish that $\frac{\partial \mu(x+d, d)}{\partial d} < 0$ for $x > 0$. One has

$$\mu(x+d, d) \;=\; \frac{\frac{1-\gamma}{\gamma}\left\{\left(\frac{a(x+d)}{1-\gamma}+b\right)^{\gamma}-\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}\right\}}{a\left(\frac{a(x+d)}{1-\gamma}+b\right)^{\gamma-1}}$$

$$= \frac{1-\gamma}{a\gamma}\left\{\left(\frac{a(x+d)}{1-\gamma}+b\right)^{\gamma}-\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}\right\}\left(\frac{a(x+d)}{1-\gamma}+b\right)^{1-\gamma}$$

$$= \frac{1-\gamma}{a\gamma}\left\{\left(\frac{a(x+d)}{1-\gamma}+b\right)-\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}\left(\frac{a(x+d)}{1-\gamma}+b\right)^{1-\gamma}\right\},$$

and thus

$$\frac{\partial\mu(x+d,d)}{\partial d} \;=\; \frac{1-\gamma}{a\gamma}\left\{\frac{a}{1-\gamma}-a\left(\frac{a(x+d)}{1-\gamma}+b\right)^{-\gamma}\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}\right.$$
$$\left.-\frac{\gamma a}{1-\gamma}\left(\frac{a(x+d)}{1-\gamma}+b\right)^{1-\gamma}\left(\frac{ad}{1-\gamma}+b\right)^{\gamma-1}\right\}.$$

First, consider the case where $0<\gamma<1$. In this case, we have $\frac{\partial\mu(x+d,d)}{\partial d}<0$ if and only if

$$1-(1-\gamma)\left[\frac{\frac{ad}{1-\gamma}+b}{\frac{a(x+d)}{1-\gamma}+b}\right]^{\gamma}-\gamma\left[\frac{\frac{ad}{1-\gamma}+b}{\frac{a(x+d)}{1-\gamma}+b}\right]^{\gamma-1}<0.$$

This is equivalent to

$$\left(\frac{a(x+d)}{1-\gamma}+b\right)^{\gamma}+\gamma\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}<\left(\frac{ad}{1-\gamma}+b\right)^{\gamma}+\gamma\left(\frac{ad}{1-\gamma}+b\right)^{\gamma-1}\left(\frac{a(x+d)}{1-\gamma}+b\right).$$

Note that for $x = 0$ the left hand side is equal to the right hand side. Furthermore,

$$\frac{\partial LHS}{\partial x} = \gamma\left(\frac{a(x+d)}{1-\gamma}+b\right)^{\gamma-1}\frac{a}{1-\gamma},$$

while

$$\frac{\partial RHS}{\partial x} = \gamma\left(\frac{ad}{1-\gamma}+b\right)^{\gamma-1}\frac{a}{1-\gamma}.$$

Thus we have $\frac{\partial LHS}{\partial x} < \frac{\partial RHS}{\partial x}$, which establishes that $\frac{\partial \mu(x+d, d)}{\partial d} < 0$ for $x > 0$. Similarly, one can show that SF is satisfied for the cases where $\gamma = 0$ and $\gamma < 0$.

Next, we establish that $\frac{\partial^2}{\partial x^2}\mu(x, 0) < 0$. From above, one has

$$\mu(x, 0) = \frac{1-\gamma}{a\gamma}\left\{\left(\frac{ax}{1-\gamma}+b\right) - b^{\gamma}\left(\frac{ax}{1-\gamma}+b\right)^{1-\gamma}\right\}.$$

Hence,

$$\frac{\partial}{\partial x}\mu(x, 0) = \frac{1}{\gamma}\left\{1-(1-\gamma)\left[\frac{b}{\frac{ax}{1-\gamma}+b}\right]^{\gamma}\right\} > 0,$$

and thus

$$\frac{\partial^2}{\partial x^2}\mu(x, 0) = ab^{\gamma}\left(\left(\frac{ax}{1-\gamma}+b\right)^{-(1+\gamma)} > 0.\right)$$

Hence, SR is satisfied. *Q.E.D.*

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