Collusion, Bargaining and Welfare

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Abstract: I analyse the welfare effects of collusion when there is bargaining between downstream firms and upstream agents (firms or unions). I examine both the case where bargaining is over a uniform input price and the case where bargaining is over a two-part tariff and I allow for two different collusive rules. I find that collusion between downstream firms can often raise consumer surplus and overall welfare relative to the Cournot-Nash outcome. Whether this occurs or not depends on the type of collusive rule, the degree of product differentiation, the distribution of bargaining power and the upstream agents' preferences.

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1. Introduction.

The traditional view that collusion between firms is detrimental for welfare has recently been challenged by a number of theoretical studies. One line of research has focused on models of semi-collusion (see, for instance, Fershtman and Gandal 1994; Brod and Shivakumar 1999; Fershtman and Pakes 2000). This work has shown that semi-collusion can have ambiguous welfare effects. In particular, if collusion on price increases the firms' incentives to make cost-reducing or quality-enhancing investments (a common result in many, although not all, theoretical models), then the welfare gains from these investments may more than compensate for the welfare losses due to the increase in price and reduction of output. Another line of research has explored the links between the intensity of price competition and market structure (Selten 1984, Sutton 1991, Symeonidis 2002a). This literature has emphasised that collusion generally leads to a less concentrated market structure than competition. Although these studies have not been mainly concerned with welfare results, one implication of this literature is that welfare may be higher when firms collude. This will happen if the welfare gain due to the increase in product variety under collusion more than compensates for the welfare loss caused by the rise in price and the consequent fall in output.

The present paper proposes a third mechanism that could lead to the reversal of the standard result on the welfare effects of collusion: the presence of bargaining between downstream firms and upstream agents (firms or unions) over the price of an input (such as labour, or an intermediate good, or even the final good in the case of manufacturers selling to distributors). My definition of bargaining covers the special cases where one or the other of the parties has all the bargaining power and effectively chooses unilaterally the input price. The results therefore of the paper are not specific to the presence of bargaining; they are valid also for bilateral oligopolies where input prices are not determined in bargaining.

In the model developed in this paper, two downstream firms compete by non-cooperatively setting quantities in a horizontally differentiated product market. Each of the two firms also bargains with an upstream agent and the bargaining process is represented by the asymmetric Nash bargaining solution. In this context the bargained input prices depend, among other things, on the competitive regime facing firms (or bargaining units). This raises the possibility of welfare results that are qualitatively different from those of a corresponding model in which input prices are taken as exogenous.

More specifically, when bargaining over a uniform input price occurs prior to the quantity competition stage, the game is a two-stage game with a non-cooperative symmetric equilibrium between bargaining units in the first stage followed by a non-cooperative symmetric equilibrium between downstream firms in the second stage. If the collusive rule is such that inefficient firms do not gain too much from collusion, the bargained input price is lower when the downstream firms collude than in the absence of collusion. And if these cost savings due to collusion are significant, then collusion may increase consumer surplus and total welfare. Moreover, when bargaining is over a two-part tariff rather than over a uniform input price, the positive welfare effects of collusion between downstream firms are even more pronounced. In both cases, then, we may obtain a reversal of the standard result that collusion between firms is detrimental for welfare.

The paper is structured as follows. In sections 2 and 3, I examine a benchmark case where colluding firms maximise joint profits (or each firm maximises a weighted average of its own profit and its rival’s profit). In section 4, I assume that colluding firms maximise joint profits subject to a constraint that requires them both to reduce output relative to their respective Cournot output by exactly the same amount. Of course, this collusive technology is rather ad hoc, as are many others. The purpose of the analysis in section 4 is simply to check the robustness of the benchmark results to a change in collusive technology that implies a different distribution of collusive profits between firms. In both cases, I identify conditions under which standard welfare results of oligopoly theory are reversed: collusion may increase rather than reduce consumer surplus and total welfare. The final section concludes.

2. The benchmark model with bargaining over the input price.

Consider an industry with two firms, each producing and selling to consumers one variety of a differentiated product. Preferences are described by the utility function of a representative consumer[1]

$$U = \alpha(x_1 + x_2) - \beta(x_1^2 + x_2^2) - \beta\sigma x_1 x_2 + M. \tag{1}$$

The x_i's are the quantities demanded of the different varieties of the product in question, while $M = Y - p_1 x_1 - p_2 x_2$ denotes expenditure on outside goods. This utility function implies that the consumer spends only a small part of her income on the industry's product (which also ensures that the maximisation of U has an interior solution) and hence income effects on the industry under consideration can be ignored and partial equilibrium analysis can be applied. The parameter σ, $\sigma \in (0,2)$, is an

[1] This is a standard quadratic utility function and it has previously been used, sometimes with small variations, by Spence (1976), Dixit (1979), Vives (1985), Shaked and Sutton (1990), Sutton (1997, 1998), and Symeonidis (2002a, 2002b),

inverse measure of the (exogenous) degree of horizontal product differentiation: in the limit as $\sigma \to 0$ the goods become independent, while in the limit as $\sigma \to 2$ they become perfect substitutes. The parameter σ is a basic taste parameter and cannot be influenced by firms in the industry. It can be seen as an industry-specific measure of the degree to which demand is diversified among users with different preferences or requirements. Alternatively, it may reflect the degree of fragmentation of demand caused by transport costs or trade barriers. Finally, α and β are positive scale parameters.

The inverse demand function for variety i is given by

$$p_i = \alpha - 2\beta x_i - \beta\sigma x_j \tag{2}$$

in the region of quantity spaces where prices are positive, and the demand function is

$$x_i = \frac{2(\alpha - p_i) - \sigma(\alpha - p_j)}{\beta(2-\sigma)(2+\sigma)} \tag{3}$$

in the region of prices where quantities are positive. It can be easily seen that x_i is linear and decreasing in p_i, and linear and increasing in p_j.

Let firm i have marginal cost of production w_i, where $w_i < \alpha$. In particular, we assume that only one input, L, is used in the production of variety i and has a unit price equal to w_i. This input can be labour, in which case w_i is the wage rate; or it can be an intermediate product sold by upstream manufacturers to downstream manufacturers; or it can be the final product, in which case the downstream firms are distributors. In any case, there are constant returns to scale, so that $x_i = L_i$.

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among others. Shaked and Sutton (1990) discuss how this utility function can also be derived by aggregating the preferences of heterogeneous groups of consumers.

Competition in the industry is described by a two-stage non-cooperative game as follows.[2] At stage 1, each downstream firm i forms a bargaining unit with an upstream agent (firm or union) and bargains over w_i. Although each bargain is independent, we also allow for interaction at this stage: the set of w_i that we obtain is the outcome of a non-cooperative Nash equilibrium between the two bargaining units. At stage 2, the downstream firms compete in quantities given the values of w_i from stage 1. In what follows I derive the pure strategy subgame-perfect equilibrium of this game. Note that the bargaining covers only the input price, not the level of output (or employment) of the downstream firm. This seems a natural assumption to make when the upstream agents are firms, and it is also a common assumption in models of union-firm bargaining (as it is consistent with much of the empirical evidence). The case of bargaining over both input price and output is discussed briefly in my concluding remarks. I also assume in this section that the input prices are linear tariffs. The implications of allowing for bargaining over two-part tariffs are discussed in section 3.

I assume in this section that the colluding downstream firms maximise joint profits (or each firm maximises a weighted average of its own profit and its rival's profit). An important feature of this collusive technology is that inefficient firms gain

[2] See also Horn and Wolinsky (1988), Dowrick (1989), Dobson (1997), Petrakis and Vlassis (2000), Naylor (2002), Correa-López and Naylor (2003), among others. In addition, von Ungern-Sternberg (1996) and Dobson and Waterson (1997) analyse a slightly different setup, where all the downstream firms bargain simultaneously with a single supplier. Inderst and Wey (2002, 2003) allow for a more complex bargaining process between downstream and upstream firms. All these papers analyse models with a similar structure to the one presented here (i.e. two-stage oligopoly games with a bargaining stage followed by a product market competition stage), but none of them examines the welfare effects of collusion between (downstream) firms.

relatively little, if anything, from collusion. Of course, this collusive rule (which has also been used, among others, by Shubik 1980, Brod and Shivakumar 1999, and Symeonidis 2000) is not intended as an exact description of firm behaviour, but rather it serves as a benchmark case which helps to highlight some rather unexpected effects of collusion that would occur whenever the collusive technology is such that inefficient firms gain relatively little from collusion.

At the second-stage subgame, then, firm i chooses x_i to maximise $\Pi_i = \pi_i + \lambda\pi_j$, where

$$\pi_i = (p_i - w_i)x_i = (a - 2\beta x_i - \beta\sigma x_j - w_i)x_i, \tag{4}$$

and the parameter λ, $\lambda\in[0,1]$, can be thought of either as a continuous measure of the degree of collusion (in which case the implication is that each firm maximises the sum of its own profit and a fraction λ of the other firm's profit) or as a discreet parameter that can take only two values, namely $\lambda = 0$ (corresponding to the Cournot-Nash equilibrium) and $\lambda = 1$ (corresponding to perfect collusion).[3] In what follows λ

[3] Intermediate values of λ represent imperfect collusion and may be justified by reference to some implicit dynamic model of collusion, a reduced-form representation of which is the quantity competition subgame of the present model. What also justifies the use of λ as a reduced-form measure of collusion is its properties in the final-stage subgame: it can be checked that the equilibrium price, price-cost margin and profit in the second-stage subgame increase and the equilibrium quantity falls as λ rises (the degree of collusion increases). None of the other exogenous variables that affect profit have properties similar to those of λ in the second-stage subgame. Of particular interest in this respect are the properties of σ, since this has often been used as a measure of the intensity of competition. It can be checked that a fall in σ, i.e. an increase in the degree of product differentiation, increases *both* the equilibrium price and the equilibrium quantity in the second-stage subgame.

will often be treated as a continuous variable, but it will be useful to bear in mind that all the results are exactly the same if λ can only take two values, 0 and 1.

The assumption that λ is exogenous is made necessary by the fact that it is difficult to model the collusive process explicitly or endogenise all decisions made by firms and upstream agents in the present model. This assumption is not unreasonable, given the well-known multiplicity of possible equilibria in models of infinitely repeated games. Moreover, the exogeneity assumption is justifiable in certain empirical contexts. This is the case when significant changes in the intensity of competition occur as a result of exogenous institutional changes such as economic integration or the introduction of effective cartel policy. In any case, the main focus of the present paper is to compare welfare properties of different competitive regimes, and it is natural that these regimes should be taken as exogenous in this context.

Solving the system of the two first-order conditions and using also the inverse demand function we obtain the Cournot-Nash equilibrium values of x_i and p_i in the second-stage subgame as functions of w_i and w_j:

$$\begin{aligned} \hat{x}_i &= \frac{4(a-w_i)-\sigma(1+\lambda)(a-w_j)}{\beta[4-\sigma(1+\lambda)][4+\sigma(1+\lambda)]} \\ \hat{p}_i &= w_i + \frac{[8-\sigma^2\lambda(1+\lambda)](a-w_i)-2\sigma(1-\lambda)(a-w_j)}{[4-\sigma(1+\lambda)][4+\sigma(1+\lambda)]}. \end{aligned} \tag{5}$$

It can be seen that $\hat{x}_i$ is decreasing in w_i and increasing in w_j. Also, $\hat{p}_i$ is increasing in both w_i and w_j.

At stage 1 of the game, the downstream firm i and the upstream agent (firm or union) i form a bargaining unit and set w_i so as to maximise the Nash product

$$\Omega_i = \left[(w_i - w_0)^{2(1-\gamma)}\hat{x}_i^{2\gamma}\right]^{\varphi}\left[(\hat{p}_i - w_i)\hat{x}_i\right]^{1-\varphi}. \tag{6}$$

The parameter $\varphi \in [0,1]$ is a measure of the bargaining power of the upstream agent relative to that of the downstream firm. It depends on the relative degrees of impatience and risk aversion of the two parties, so it is taken here as exogenous. Thus the value $\varphi = 1$ corresponds to the case where an upstream agent chooses w_i to maximise its utility (and there is effectively no bargaining), while $\varphi = 0$ corresponds to the case where w_i is set by the downstream firm. The interpretation of w_o depends on the identity of the upstream agent: it is either the wage that the union would obtain in a competitive non-unionised labour market or the unit cost of the upstream firm. Note also that the utility of the upstream agent is given by $U_i = (w_i - w_0)^{2(1-\gamma)} x_i^{2\gamma}$, where $\gamma \in [0,1]$. Recall that $x_i = L_i$ in this model. Hence when the upstream agent is a union, γ denotes the relative strength of union preferences for wages over employment. Note that the value $\gamma = ½$ corresponds to the case where the union aims to maximise the total rent (or the wage bill if $w_o = 0$). When the upstream agent is a firm, profit maximisation implies $\gamma = ½$. We rule out the special case where $\gamma = 0$ *and* $\varphi = 1$ in what follows, since in this case $w^* = \alpha$ (see equation (8) below) and firms produce zero output.

The first-order condition for the choice of w_i by bargaining unit i can be written as:

$$\frac{2\varphi(1-\gamma)(\hat{p}_i - w_i)\hat{x}_i}{w_i - w_0} + (1-\varphi+2\varphi\gamma)(\hat{p}_i - w_i)\frac{\partial \hat{x}_i}{\partial w_i} + (1-\varphi)\hat{x}_i \frac{\partial(\hat{p}_i - w_i)}{\partial w_i} = 0 . \tag{7}$$

As pointed out above, the values of w_i and w_j that we obtain at stage 1 of the game are the outcome of a non-cooperative Nash equilibrium between the two bargaining units. In other words, w_i is the Nash solution to the bargaining problem between downstream firm i and its upstream agent given that both expect the input price w_j to be agreed between downstream firm j and its upstream agent. Note that we do not allow for collusion between bargaining units.[4] Solving for the (symmetric) equilibrium we obtain:

$$w^* = w_0 + \frac{2\varphi(1-\gamma)(2+\sigma\lambda)\left[4-\sigma(1+\lambda)\right](a-w_0)}{K}, \tag{8}$$

where

$$\begin{aligned} K = {} & 2\varphi(1-\gamma)(2+\sigma\lambda)\left[4-\sigma(1+\lambda)\right] + 4\left[1-\varphi(1-2\gamma)\right](2+\sigma\lambda) \\ & + (1-\varphi)\left\{2(2-\sigma) + (2-\sigma\lambda)\left[2+\sigma(1+\lambda)\right]\right\} > 0. \end{aligned} \tag{9}$$

From equation (8) we obtain

$$\frac{\partial w^*}{\partial \lambda} = \frac{-4\sigma\varphi(1-\gamma)\left\{4\varphi\gamma(2+\sigma\lambda)^2 + \sigma(1-\varphi)\left[8\lambda + \sigma(1+\lambda)^2\right]\right\}(a-w_0)}{K^2}, \tag{10}$$

which is negative for all $\sigma\in(0,2)$, $\varphi\in(0,1]$, $\gamma\in[0,1)$. This establishes our first result:

Proposition 1. *When downstream firms and upstream agents bargain over a uniform input price and $\varphi\in(0,1]$ and $\gamma\in[0,1)$, the input price decreases in the degree of collusion parameter λ. For $\varphi = 0$ or $\gamma = 1$, the input price is independent of λ and equal to w_o.*

Recall that the value $\lambda = 0$ corresponds to the Cournot-Nash equilibrium, while $\lambda = 1$ corresponds to perfect collusion between downstream firms. Hence Proposition 1 implies that the input price is generally higher in the Cournot-Nash equilibrium than under perfect collusion between downstream firms.

[4] Centralised bargaining is equivalent to perfect collusion between bargaining units. I do not examine this case here, partly because it is known that the competitive regime facing downstream firms has no effect on equilibrium outcomes under fairly general conditions when firms participate in centralised bargaining prior to competing in the downstream market (see Dowrick 1989, Dhillon and Petrakis 2002). Allowing for imperfect collusion between bargaining units should not change the qualitative results of this section, at least when the degree of such collusion is low.

Proposition 1 holds for any values of $\varphi\in(0,1]$ and $\gamma\in[0,1)$. It holds even when the upstream agents have all the bargaining power ($\varphi = 1$) or care only about the input price ($\gamma = 0$) (but recall that we have ruled out the case where $\gamma = 0$ *and* $\varphi = 1$). This result may seem counterintuitive. One might think that since collusion between downstream firms increases downstream profit, it should allow upstream agents to appropriate a larger rent through a higher input price. This argument, however, fails to take into account the way collusion changes the incentives of the parties during the negotiations through its effect on the marginal returns of a change in the input price.

In particular, the intuition for Proposition 1 hinges on the way changes in the input price affect upstream utility and downstream profit.[5] Consider first the downstream firm's incentives during the negotiations. It is easy to check that a unit increase in w_i always decreases the equilibrium profit of downstream firm i when starting from a symmetric equilibrium with $w_i = w_j$. Moreover, the effect of a unit change in w_i on profit is larger (in absolute value) the higher the value of λ, i.e. $\frac{\partial}{\partial\lambda}\left|\frac{\partial\hat{\pi}_i}{\partial w_i}\right| > 0 \;\; at \;\; w_i = w_j = w.$ In other words, downstream profit is more sensitive to a change in the input price the higher the degree of collusion. This result is driven by the fact that, under the collusive rule of this section, an increase in the input price of one downstream firm shifts production to the other downstream firm to such an extent that the high-cost firm gains relatively little (or, if the asymmetry is too large, even loses) from collusion. Thus the downstream firm within each bargaining unit has a stronger incentive to avoid a high input

[5] See Correa-López and Naylor (2003) for a similar argument, and Symeonidis (2000) for an analogous mechanism in the context of a vertical differentiation model.

price and will be more resistant to increases in w proposed by the upstream agent the higher the degree of collusion (assuming that the downstream firm has some bargaining power, i.e. for $\varphi \neq 1$; if the downstream firm has no bargaining power, then the mechanism just described is not relevant). This contributes to input prices being lower the higher the value of λ.

Consider next the upstream agent's point of view. An increase in w_i raises the utility of the upstream agent for any given level of output. However, the higher the degree of collusion, the lower the level of output, and therefore the lower the effect of a unit increase in w_i on the utility of the upstream agent. As a result, the upstream agent will be less anxious to achieve a higher w the higher the degree of collusion. Furthermore, an increase in w_i reduces the equilibrium output of downstream firm i and thus decreases the utility of the upstream agent. The effect of a unit change in w_i on output is larger (in absolute value) the higher the value of λ, i.e. $\frac{\partial}{\partial \lambda}\left|\frac{\partial \hat{x}_i}{\partial w_i}\right| > 0$. Thus output is more sensitive to a change in the input price the higher the degree of collusion (again, this is driven by the collusive rule). For this reason too the upstream agent within each bargaining unit will be more reluctant to propose increases in w the higher the degree of collusion (assuming that the upstream agent cares about employment, i.e. for $\gamma \neq 0$). These mechanisms reinforce the mechanism working through the effect of w on downstream profit. As a result, input prices are lower the higher the value of λ.

Proposition 1 raises the possibility that the welfare effects of collusion are different in the present model than in the standard oligopoly model where input prices are not determined in bargaining. In particular, the fact that the input price generally decreases (and never increases) in the degree of collusion implies that consumer surplus might be higher under collusion than under Cournot behaviour. Formally, the total effect of a change in λ on consumer surplus is given by $\frac{dCS}{d\lambda} = \frac{\partial CS}{\partial \lambda} + \frac{\partial CS}{\partial w^*}\frac{\partial w^*}{\partial \lambda}$. The first term on the right-hand-side captures the direct effect of collusion on consumer surplus, while the second term captures the indirect effect working through the change in the input price. It is straightforward to check that $\frac{\partial CS}{\partial \lambda} < 0$ and $\frac{\partial CS}{\partial w^*} < 0$, and we also know that $\frac{\partial w^*}{\partial \lambda} \leq 0$, so the total effect can be ambiguous.

On the other hand, there is no ambiguity with regard to the effect of a change in λ on downstream profit. Profit would be higher the higher the degree of collusion in the absence of bargaining (i.e. if the input price was independent of the competitive regime), and the fact that the input price decreases as the degree of collusion increases when there is bargaining strengthens the positive effect of collusion on downstream profit. Finally, the effect of a change in λ on the utility of the upstream agents can be decomposed into three different effects. In particular, collusion between downstream firms will reduce upstream utility because of the fall in the input price and the negative direct effect on output, but there will also be an indirect positive effect on output working through the reduction of the input price – and this will increase utility. The total effect is potentially ambiguous.

I now explore these intuitive ideas more formally. Equilibrium consumer surplus, aggregate downstream profit, and aggregate upstream agent utility are, respectively, given as

$$CS^* = 2\alpha x^* - 2\beta(x^*)^2 - \beta\sigma(x^*)^2 - 2p^* x^* \tag{11}$$

$$\Pi^* = 2(p^* - w^*)x^* \tag{12}$$

and

$$U^* = 2(w^* - w_0)^{2(1-\gamma)}(x^*)^{2\gamma}, \tag{13}$$

where x^* and p^* are the equilibrium values of x and p in the two-stage game and are given by equations (5) after setting $w_i = w_j = w^*$:

$$x^* = \frac{a - w^*}{\beta[4 + \sigma(1+\lambda)]}, \qquad p^* = w^* + \frac{(a - w^*)(2 + \sigma\lambda)}{4 + \sigma(1+\lambda)}. \tag{14}$$

The next result shows that consumer surplus may be higher or lower at the Cournot-Nash equilibrium than under perfect collusion:

Proposition 2. *When downstream firms and upstream agents bargain over a uniform input price and the products are close substitutes, consumer surplus is lower at the Cournot-Nash equilibrium than under perfect collusion between downstream firms if upstream agents have significant bargaining power and place considerable weight on the input price argument in their utility function. Consumer surplus is higher at the Cournot-Nash equilibrium than under perfect collusion if upstream agents either have little bargaining power or place little weight on the input price argument in their utility function.*

Proof. See the Appendix.

In the special case where $\gamma = ½$, i.e. the upstream agents are rent-maximising unions or profit-maximising firms, then: for $\sigma = 2$, $CS^*(\lambda = 0) - CS^*(\lambda = 1) < 0$ when $\varphi \in (0.8, 1]$, and hence for $\sigma \to 2$, $CS^*(\lambda = 0) - CS^*(\lambda = 1) < 0$ when φ is sufficiently large. Note that Proposition 2 holds when σ is close to 2. On the other hand, it is easy to check that in the limit as $\sigma \to 0$ (i.e. as the products become independent), consumer surplus is always higher at the Cournot-Nash equilibrium than under perfect collusion.[6] For intermediate values of σ, analytical results are difficult to derive, but numerical results suggest that Proposition 2 holds as long as the products are not too differentiated, while for low values of σ consumer surplus is always lower under collusion.

The intuition for Proposition 2 should be clear in light of Proposition 1. As pointed out above, the equilibrium input price is lower under perfect collusion between downstream firms than at the Cournot-Nash equilibrium in the present model (unless $\varphi = 0$ or $\gamma = 1$, in which case the input price is always equal to w_o). A lower input price increases consumer surplus, everything else being equal. When the products are close substitutes (σ is close to 2), and the upstream agents have significant bargaining power (φ is large) and place considerable weight on the input price argument in their utility function (γ is small), the indirect positive effect of collusion on consumer surplus working through the fall in the bargained input price dominates the direct negative effect of collusion on consumer surplus.[7]

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[6] To show this, note first that for $\sigma = 0$, $CS^*(\lambda = 0) = CS^*(\lambda = 1)$. Then take the derivative of $CS^*(\lambda = 0) - CS^*(\lambda = 1)$ with respect to σ and evaluate it at $\sigma = 0$. The resulting expression is positive, suggesting that $CS^*(\lambda = 0) > CS^*(\lambda = 1)$ for σ close to 0.

[7] The reason is that $w^*(\lambda = 0) - w^*(\lambda = 1)$ is larger when σ and φ are large and γ is small. Note that $\partial CS/\partial\lambda$ is larger in absolute value and $\partial CS/\partial w^*$ is smaller in absolute value when σ is large, and this tends to strengthen the direct effect of collusion on consumer surplus and to weaken the indirect effect for large σ, all else being equal. However, the positive effect of σ on $w^*(\lambda = 0) - w^*(\lambda = 1)$ dominates, and thus $CS^*(\lambda = 0) - CS^*(\lambda = 1) < 0$ for large σ. $\partial CS/\partial\lambda$ and $\partial CS/\partial w^*$ are independent of φ and γ, so the effect of these variables on $CS^*(\lambda = 0) - CS^*(\lambda = 1)$ is driven by their effect on $w^*(\lambda = 0) - w^*(\lambda = 1)$.

Next, I consider the effect of collusion on the aggregate downstream profit. For any *given* input price, aggregate downstream profit is higher the higher the degree of collusion – which is the standard result of oligopoly models without bargaining (at least when the number of varieties in the market is fixed and firms do not make cost-reducing or quality-enhancing investments). Since the equilibrium input price in the present model is generally lower (and never higher) the higher the degree of collusion, and a lower input price raises downstream profit, it is clear that the standard result will be reinforced. In particular:

Proposition 3. *When downstream firms and upstream agents bargain over a uniform input price, the aggregate profit of the downstream firms increases in the degree of collusion parameter λ for all $\lambda \in [0,1)$.*

Proof. See the Appendix.

It follows from the above that the sum of consumer surplus and aggregate downstream profit will be higher under perfect collusion than at the Cournot-Nash equilibrium when φ and σ are large and γ is small. More specifically:

Proposition 4. *When downstream firms and upstream agents bargain over a uniform input price and the products are close substitutes, the sum of consumer surplus and aggregate downstream profit is lower at the Cournot-Nash equilibrium than under perfect collusion between downstream firms if upstream agents have significant bargaining power and place considerable weight on the input price argument in their utility function. It is higher at the Cournot-Nash equilibrium than under perfect collusion if upstream agents either have little bargaining power or place little weight on the input price argument in their utility function.*

Proof. See the Appendix.

When $\gamma = ½$, i.e. the upstream agents are rent-maximising unions or profit-maximising firms, then $(CS^* + \Pi^*)(\lambda = 0) - (CS^* + \Pi^*)(\lambda = 1) < 0$ as $\sigma \to 2$ for $\varphi \in (\varphi_0, 1]$, where $\varphi_0 \approx 0.30$. Note that although Proposition 4 requires that σ is close to 2, numerical analysis suggests that the results are the same for *all* values of σ. In particular, $(CS^* + \Pi^*)(\lambda = 0) - (CS^* + \Pi^*)(\lambda = 1) < 0$ when φ is large and γ small, and positive otherwise.[8]

Finally, I examine the effect of the competitive regime on the utility of the upstream agents and on overall welfare. The effect of a change in λ on aggregate upstream agent utility $U^* = 2(w^* - w_0)^{2(1-\gamma)}(x^*)^{2\gamma}$ can be decomposed into three different effects as follows:

$$\begin{aligned}\frac{\partial U^*}{\partial \lambda} &= 4(1-\gamma)(w^* - w_0)^{2(1-\gamma)-1}(x^*)^{2\gamma}\frac{\partial w^*}{\partial \lambda} + 2(w^* - w_0)^{2(1-\gamma)}2\gamma(x^*)^{2\gamma-1}\frac{\partial x^*}{\partial \lambda} \\ &\quad + 2(w^* - w_0)^{2(1-\gamma)}2\gamma(x^*)^{2\gamma-1}\left(\frac{\partial x^*}{\partial w^*}\frac{\partial w^*}{\partial \lambda}\right).\end{aligned} \tag{15}$$

The first term stands for the effect of a change in λ on the equilibrium input price w^*. As we know from Proposition 1, this effect is negative (or, in two special cases, zero). The second term captures the direct effect of a change in λ on the equilibrium level of output x^*. This term is also negative, since output is lower under collusion for any given level of w. The third term captures the indirect effect

[8] It is easy to show this analytically for $\sigma \to 0$ (i.e. as the products become independent). First note that for $\sigma = 0$, $(CS^* + \Pi^*)(\lambda = 0) = (CS^* + \Pi^*)(\lambda = 1)$. Then take the derivative of $(CS^* + \Pi^*)(\lambda = 0) - (CS^* + \Pi^*)(\lambda = 1)$ with respect to σ and evaluate it at $\sigma = 0$. The resulting expression is negative if φ is large and γ small (in fact, not too large), and positive otherwise.

of a change in λ on x^* that works through the change in the input price. Since we have $\frac{\partial x^*}{\partial w^*} < 0$ and $\frac{\partial w^*}{\partial \lambda} \leq 0$, this term is positive or zero.

As it turns out, the sign of $\partial U^*/\partial\lambda$ is unambiguously negative in the present model:

Proposition 5. *When downstream firms and upstream agents bargain over a uniform input price and $\varphi\in(0,1]$ and $\gamma\in[0,1)$, the aggregate upstream agent utility decreases in the degree of collusion parameter λ. For $\varphi = 0$ or $\gamma = 1$, the upstream agent utility is independent of λ (and equal to zero).*

Proof. See the Appendix.

Overall welfare is given by $W^* = CS^* + \Pi^* + U^*$. It is difficult to derive analytical results for W^*. Numerical results suggest that W^* can be higher or lower in the Cournot-Nash equilibrium than under perfect collusion between downstream firms, depending on the values of σ, φ and γ. In particular, total welfare is higher in the collusive equilibrium when φ and σ are relatively large and γ takes intermediate values. It is higher under Cournot behaviour when φ and σ are relatively small and γ is either large or small. It is not difficult to understand why $W(\lambda = 0) < W(\lambda = 1)$ when φ and σ are large: these are also the parameter values for which $(CS^* + \Pi^*)(\lambda = 0) < (CS^* + \Pi^*)(\lambda = 1)$. The reason why γ must take intermediate values for total welfare to rise under collusion (even though $(CS^* + \Pi^*)(\lambda = 0) < (CS^* + \Pi^*)(\lambda = 1)$ is more likely to occur when γ is small) must be that the effect of a change in λ on U^* is weaker for intermediate than for small values of γ, so it is then also less likely to offset any effect of a change in λ on CS^* and Π^*.

3. The benchmark model with bargaining over two-part tariffs.

The assumption that input prices are linear tariffs is not controversial when the upstream agents are unions: it seems reasonable to model wage negotiations as being over a uniform wage (or a wage structure that specifies a wage for each type of employee). However, the assumption may be too restrictive when the upstream agents are firms. The problem is that uniform price contracts are generally inefficient, and upstream firms are less constrained than unions by institutional or other factors when specifying a contract with downstream firms. This does not invalidate the approach adopted in the previous section to the extent that uniform price contracts are widely observed in practice. Still, one would want to analyse how the welfare results described in the previous section might change when one allows for non-linear price contracts between upstream and downstream firms.

In this section I extend the basic model of the previous section to allow for bargaining over two-part tariffs. The structure of demand is the same as in the previous section, but the profit function of downstream firm i is now given by $\pi_i = S(p_i - w_i)x_i - F_i$, where $F_i \geq 0$ is a lump sum transfer from downstream firm i to its upstream supplier. At stage 2 of the two-stage game, the downstream firms compete in quantities given the unit input prices and fixed fees set at stage 1. We allow for different degrees of collusion in the second-stage subgame. At stage 1, each downstream firm i bargains independently over w_i and F_i with an upstream firm. The values of w_i and F_i are chosen so as to maximise

$$\Omega_i = \left[(w_i - w_0)x_i + F_i\right]^{\varphi}\left[(p_i - w_i)x_i - F_i\right]^{1-\varphi}, \tag{16}$$

taking as given the values of w_j and F_j (that is, w_i, w_j, F_i and F_j are the outcome of a non-cooperative Nash equilibrium between the two bargaining units). Note that each firm's objective in the negotiations within a bargaining unit is to maximise its profit. Finally, once again I do not allow for collusion between bargaining units.

In this context, if the upstream firms have all the bargaining power, i.e. $\varphi = 1$, each upstream firm i will choose w_i to maximise the joint profit of itself and its buyer subject to equations (5) and to a zero-profit condition for the buyer (whose profit will be appropriated through the fixed fee). Solving for the Nash equilibrium between the two upstream firms we obtain $w = w_0 - \dfrac{(\alpha - w_0)\sigma[\sigma + \lambda(4+\sigma)]}{16 + 4\sigma - \sigma^2(1+\lambda)}$ and $F = \dfrac{16(2+\sigma\lambda)(\alpha - w_0)^2}{\beta[16 + 4\sigma - \sigma^2(1+\lambda)]^2}$. If, on the other hand, the downstream firms have all the bargaining power, i.e. $\varphi = 0$, each downstream firm i will choose w_i to maximise the joint profit of itself and its supplier subject to equations (5) and to a zero-profit condition for the supplier. At equilibrium, $w = w_0 - \dfrac{(\alpha - w_0)\sigma[\sigma + \lambda(4+\sigma)]}{16 + 4\sigma - \sigma^2(1+\lambda)}$ and $F = \dfrac{4[4\sigma\lambda + \sigma^2(1+\lambda)](\alpha - w_0)^2}{\beta[16 + 4\sigma - \sigma^2(1+\lambda)]^2}$. In what follows, I focus on the more general (and interesting) case where $\varphi \in (0,1)$. The first-order conditions for the choice of w_i and F_i are given, respectively, by

$$\begin{aligned} &\varphi[(\hat{p}_i - w_i)\hat{x}_i - F_i]\left[(w_i - w_0)\frac{\partial \hat{x}_i}{\partial w_i} + \hat{x}_i\right] \\ &\qquad + (1-\varphi)[(w_i - w_0)\hat{x}_i + F_i]\left[(\hat{p}_i - w_i)\frac{\partial \hat{x}_i}{\partial w_i} + \hat{x}_i\frac{\partial(\hat{p}_i - w_i)}{\partial w_i}\right] = 0, \end{aligned} \tag{17}$$

and

$$\varphi[(\hat{p}_i - w_i)\hat{x}_i - F_i] - (1-\varphi)[(w_i - w_0)\hat{x}_i + F_i] = 0\ , \tag{18}$$

where $\hat{x}_i$ and $\hat{p}_i$, the equilibrium values in the second-stage subgame, are given by equations (5). Combining (17) and (18), we obtain

$$\varphi\left[(\hat{p}_i - w_i)\hat{x}_i - F_i\right]\left\{\left[(\hat{p}_i - w_i) + (w_i - w_0)\right]\frac{\partial \hat{x}_i}{\partial w_i} + \hat{x}_i + \hat{x}_i\frac{\partial(\hat{p}_i - w_i)}{\partial w_i}\right\} = 0 \ . \tag{19}$$

It can be seen from (19) that the equilibrium w is independent of φ. This is a general result: it holds irrespective of the specific values of $\hat{x}_i$ and $\hat{p}_i$, and does not depend on the linearity of the model. Solving for the (symmetric) equilibrium, we obtain:

$$w^{**} = w_0 - \frac{(\alpha - w_0)\sigma\left[\sigma + \lambda(4+\sigma)\right]}{16 + 4\sigma - \sigma^2(1+\lambda)} \tag{20}$$

$$F^{**} = \frac{4(\alpha - w_0)^2\left[8\varphi + 4\lambda\sigma + \sigma^2(1-\varphi)(1+\lambda)\right]}{\beta\left[16 + 4\sigma - \sigma^2(1+\lambda)\right]^2} \tag{21}$$

Note that $w^{**} < w_0$, and that the above expressions are actually valid for all $\varphi\in[0,1]$, including the special cases $\varphi = 1$ and $\varphi = 0$. Straightforward calculations yield:

$$\frac{\partial w^{**}}{\partial \lambda} = \frac{-32\sigma(2+\sigma)(a - w_0)}{\left[16 + 4\sigma - \sigma^2(1+\lambda)\right]^2} < 0 \tag{22}$$

and

$$\frac{\partial F^{**}}{\partial \lambda} = \frac{4\sigma\left[4(16 + \lambda\sigma^2) + 4\sigma(8 - \varphi\sigma) + (1-\varphi)\sigma^3(1+\lambda)\right](a - w_0)^2}{\beta\left[16 + 4\sigma - \sigma^2(1+\lambda)\right]^3} > 0\,, \tag{23}$$

for all $\sigma\in(0,2)$, $\lambda\in[0,1]$ and $\varphi\in[0,1]$. Hence:

Proposition 6. *When downstream and upstream firms bargain over two-part tariffs, the unit input price decreases and the fixed fee increases in the degree of collusion parameter λ.*

The intuition for the first part of Proposition 6 is similar to that already discussed for the case of bargaining over a uniform input price. In particular, both the downstream and the upstream firm within each bargaining unit will be more reluctant to propose or accept increases in w the higher the degree of collusion because of the effect this will have on the downstream and upstream profit, respectively. As a result, the unit input price will be lower the higher the value of λ. On the other hand, the level of the fixed fee has no effect on output, and it has the same effect on profit whatever the competitive regime. The reason for the positive effect of λ on F is simply that a higher degree of collusion generates more rents for the downstream industry for any given level of F, and the upstream firms can then appropriate more of those rents through a higher fixed fee.

Equilibrium consumer surplus, aggregate downstream profit, and aggregate upstream agent utility are, respectively, given as

$$CS^{**} = 2\alpha x^{**} - 2\beta(x^{**})^2 - \beta\sigma(x^{**})^2 - 2p^{**}x^{**} \tag{24}$$

$$\Pi^{**} = 2(p^{**} - w^{**})x^{**} - 2F^{**} \tag{25}$$

and

$$U^{**} = 2(w^{**} - w_0)x^{**} + 2F^{**}, \tag{26}$$

where p^{**} and x^{**} are given by equations (5) after setting $w_i = w_j = w^{**}$:

$$x^{**} = \frac{a - w^{**}}{\beta[4 + \sigma(1+\lambda)]}, \qquad p^{**} = w^{**} + \frac{(a - w^{**})(2 + \sigma\lambda)}{4 + \sigma(1+\lambda)}. \tag{27}$$

Note that consumer surplus, total profit $(\Pi^{**} + U^{**})$ and total welfare $(CS^{**} + \Pi^{**} + U^{**})$ are independent of F^{**} and hence also of φ. This is due to the fact that (i) changes in fixed costs have no effect on marginal costs or quantities produced at equilibrium, and (ii) marginal costs are independent of the relative bargaining power of upstream and downstream firms.

The welfare effects of collusion are, in principle, ambiguous when downstream firms bargain with upstream firms over two-part tariffs before competing in quantities in the downstream market. Take, first, consumer surplus. Although this is independent of the fixed fee, it is a function of the input price. The total effect of a change in λ on consumer surplus is the sum of a direct effect and an indirect effect, the latter working through the change in the input price. The former effect is negative, while the latter is positive (since $\frac{\partial CS}{\partial w^{**}} < 0$ and $\frac{\partial w^{**}}{\partial \lambda} < 0$), so the total effect is potentially ambiguous. If the effect of λ on the equilibrium input price is sufficiently strong, consumer surplus will increase with the degree of collusion.

The aggregate downstream profit depends not only on output sold and the unit input price w, but also on the fixed fee F. For any given input price and fixed fee, aggregate downstream profit is always higher the higher the degree of collusion – this is the standard result in oligopoly theory. Moreover, the equilibrium unit input price falls as the degree of collusion rises in the present model, and a lower input price raises downstream profit, thus reinforcing the standard result. Finally, the equilibrium fixed fee rises as the degree of collusion rises, and a higher fixed fee reduces downstream profit, thus working against the standard result. Hence the overall effect of a change in λ on downstream profit can be ambiguous, depending on the relative strength of the direct effect and the two indirect effects mentioned above.

If the effect working through the fixed fee is sufficiently strong, the standard result of oligopoly theory will be reversed.

Finally, consider the effect of a change in the competitive regime on the profit of the upstream firms. This effect can be decomposed into four different effects as follows:

$$\frac{\partial U^{**}}{\partial \lambda} = 2x^{**}\frac{\partial w^{**}}{\partial \lambda} + 2(w^{**} - w_0)\frac{\partial x^{**}}{\partial \lambda} + 2(w^{**} - w_0)\left(\frac{\partial x^{**}}{\partial w^{**}}\frac{\partial w^{**}}{\partial \lambda}\right) + 2\frac{\partial F^{**}}{\partial \lambda}. \quad (28)$$

The first three terms are already familiar and their signs are the same as in the previous section. The fourth term captures the (positive) effect of a change in λ on the equilibrium fixed fee F^{**}. The overall effect of a change in λ on U^{**} is potentially ambiguous.

As it turns out, all these effects are unambiguous in the present model. What is interesting is that the effects are the *opposite* of those obtained from standard oligopoly models without a bargaining stage (and without endogenous number of varieties or endogenous choice of investments). In particular:

Proposition 7. *When downstream and upstream firms bargain over two-part tariffs and $\varphi \in (0,1)$:*

- *(i)* *The aggregate downstream profit and the aggregate profit of the upstream firms both decrease in the degree of collusion parameter λ.*
- *(ii)* *Consumer surplus, the sum of consumer surplus and aggregate downstream profit, and total welfare all increase in the degree of collusion parameter λ.*

Proof. From equations (20), (21), (24), (25), (26) and (27) we obtain:

$$CS^{**} = \frac{16(2+\sigma)(\alpha - w_0)^2}{\beta\left[16 + 4\sigma - \sigma^2(1+\lambda)\right]^2} \quad (29)$$

$$\Pi^{**} = \frac{8(1-\varphi)\left[8-\sigma^2(1+\lambda)\right](\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^2} \tag{30}$$

$$U^{**} = \frac{8\varphi\left[8-\sigma^2(1+\lambda)\right](\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^2}. \tag{31}$$

Hence:

$$\frac{\partial CS^{**}}{\partial\lambda} = \frac{32\sigma^2(2+\sigma)(\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^3} > 0 \tag{32}$$

$$\frac{\partial \Pi^{**}}{\partial\lambda} = -\frac{8(1-\varphi)\sigma^3\left[4+\sigma(1+\lambda)\right](\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^3} < 0 \tag{33}$$

$$\frac{\partial(CS^{**}+\Pi^{**})}{\partial\lambda} = \frac{8\sigma^2\left\{8-\sigma^2(1+\lambda)+\varphi\sigma\left[4+\sigma(1+\lambda)\right]\right\}(\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^3} > 0 \tag{34}$$

$$\frac{\partial U^{**}}{\partial\lambda} = -\frac{8\varphi\sigma^3\left[4+\sigma(1+\lambda)\right](\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^3} < 0 \tag{35}$$

$$\frac{\partial(CS^{**}+\Pi^{**}+U^{**})}{\partial\lambda} = \frac{8\sigma^2\left[8-\sigma^2(1+\lambda)\right](\alpha - w_0)^2}{\beta\left[16+4\sigma-\sigma^2(1+\lambda)\right]^3} > 0, \tag{36}$$

for all $\sigma\in(0,2)$, $\lambda\in[0,1]$ and $\varphi\in(0,1)$. □

Note that when $\varphi = 1$, Π^{**} is always equal to zero and all the other results are the same as above. When $\varphi = 0$, U^{**} is always equal to zero and all the other results are the same as above.

In summary, we obtain a complete reversal of the standard results of oligopoly theory. Collusion in the downstream market reduces both downstream and upstream profit. Moreover, it increases consumer surplus, the sum of consumer surplus and downstream profit, and total welfare. Although these results have been derived here in the context of a duopoly with linear demand, the mechanisms that drive them are obviously much more general.

Why do the welfare implications of collusion in the downstream market depend on whether bargaining is over a two-part tariff or a linear tariff? Two remarks are in order in this regard. First, the introduction of a fixed fee implies that there is an additional indirect effect of a change in the degree of collusion between downstream firms on downstream profit (but not on consumer surplus), working through the change in the fixed fee. This effect – which is absent when bargaining is over a linear tariff – is negative, since a larger fixed fee decreases the profit of the downstream industry and the fixed fee is larger the higher the value of λ. This is the reason why downstream profit decreases in λ when bargaining is over a two-part tariff (Proposition 7), even though it increases in λ when bargaining is over a linear tariff (Proposition 3).

Second, the introduction of a fixed fee implies that each bargaining unit can be more efficient in its choice of a unit input price. In particular, the equilibrium unit input price is lower than it would have been in the absence of the fixed fee (in fact, it is lower than the unit cost of the upstream firm). A lower input price increases consumer surplus, everything else being equal. It follows that the indirect effect of a change in λ on consumer surplus working through the change in the unit input price should be stronger when bargaining is over a two-part tariff than when it is over a linear tariff. Now recall that this indirect effect is the reason why collusion between downstream firms may cause consumer surplus to rise in a bargaining framework. This is part of the reason why consumer surplus always increases in the value of λ when there is bargaining over a two-part tariff (Proposition 7), even though it may increase or decrease in the value of λ when there is bargaining over a linear tariff (Proposition 2).

Although the results of this and the previous section have been derived on the assumption that firms collude in a specific way, they are likely to hold under any collusive rule that causes inefficient firms to gain relatively little from collusion. The next section examines to what extent these results are robust to alternative collusive rules, in particular rules that imply a more even distribution of the collusive profit between the downstream firms.

4. An alternative collusive rule.

In this section I modify the collusive rule to ensure that all firms gain substantially from collusion irrespective of their cost structure. There are several collusive rules that can be used for this purpose, but only a few of them allow for explicit analytical results in the present model. Since all these rules are essentially ad hoc, the choice of specific rule is not of great importance. The purpose of the present exercise is not to develop an elaborate model of collusion but rather to examine to what extent the non-standard welfare results of the previous two sections may continue to hold in circumstances where the extra profit from collusion is distributed more evenly among the colluding firms.

In particular, I assume in this section that colluding firms maximise joint profits subject to a constraint that requires them both to reduce output relative to their respective Cournot output by exactly the same amount. Formally, under collusion, at the second-stage subgame firms i and j choose x_i and x_j to maximise

$$\Pi_i = \pi_i + \pi_j = (a - 2\beta x_i - \beta\sigma x_j - w_i)x_i + (a - 2\beta x_j - \beta\sigma x_i - w_j)x_j \,, \tag{37}$$

subject to

$$x_i - x_i^{COURNOT} = x_j - x_j^{COURNOT} \,,$$

where $x_i^{COURNOT}$ is given by equations (5) after setting λ = 0, and similarly for $x_j^{COURNOT}$. Solving this maximisation problem and using also the inverse demand functions we obtain the collusive equilibrium values of x_i and p_i in the second-stage subgame as functions of w_i and w_j:

$$x_i^{COLL} = \frac{(8+\sigma)(a-w_i) - 3\sigma(a-w_j)}{4\beta(4-\sigma)(2+\sigma)}$$

$$p_i^{COLL} = w_i + \frac{(8-\sigma)(a-w_i) - \sigma(a-w_j)}{4(4-\sigma)}. \tag{38}$$

It can be seen that x_i^{COLL} is decreasing in w_i and increasing in w_j. Also, p_i^{COLL} is increasing in both w_i and w_j.

As before, there are two possible scenarios for stage 1 of the game. Let us first examine the case of bargaining over a uniform input price. The first-order condition for the choice of w_i by bargaining unit i is again given by equation (7), where $\hat{x}_i$ and $\hat{p}_i$ are now given, respectively, by x_i^{COLL} and p_i^{COLL} under downstream collusion and by $x_i^{COURNOT}$ and $p_i^{COURNOT}$ under downstream Cournot-Nash behaviour.

As pointed out in section 2, the values of w_i and w_j that we obtain at stage 1 of the game are the outcome of a non-cooperative Nash equilibrium between the two bargaining units. Solving for the (symmetric) equilibrium we obtain, under collusion:

$$w^{*COLL} = w_0 + \frac{2\varphi(1-\gamma)(4-\sigma)(a-w_0)}{8-\sigma\varphi(2-3\gamma)}, \tag{39}$$

and, under Cournot-Nash behaviour:

$$w^{*COURNOT} = w_0 + \frac{\varphi(1-\gamma)(4-\sigma)(a-w_0)}{4-\sigma\varphi(1-\gamma)}. \tag{40}$$

It is easy to check that

$$w^{*COLL} - w^{*COURNOT} = \frac{-\varphi^2\gamma(1-\gamma)\sigma(4-\sigma)(a-w_0)}{[8-\sigma\varphi(2-3\gamma)][4-\sigma\varphi(1-\gamma)]}, \tag{41}$$

which is negative for all $\sigma\in(0,2)$, $\varphi\in(0,1]$, $\gamma\in(0,1)$. Thus:

Proposition 8. *When downstream firms and upstream agents bargain over a uniform input price and $\varphi\in(0,1]$ and $\gamma\in(0,1)$, the input price is lower under collusion than under Cournot-Nash behaviour by downstream firms. For $\varphi = 0$ or $\gamma = 0$ or $\gamma = 1$, the input price is independent of λ.*

Once again, the intuition hinges on the way changes in the input price affect upstream utility and downstream profit. Thus it is easy to check that $\left|\frac{\partial \pi_i^{COLL}}{\partial w_i}\right| > \left|\frac{\partial \pi_i^{COURNOT}}{\partial w_i}\right|$, that is, profit is more sensitive to a change in the input price when downstream firms collude than when they do not. This is part of the reason why collusion is associated with a lower input price. Proposition 8, then, suggests that a key property that drives many of the welfare results of the present paper holds even in circumstances where the collusive profit is split relatively evenly between the colluding firms.

Although collusion between downstream firms is associated with a lower input price than Cournot-Nash behaviour, the indirect welfare effects of collusion working through changes in the input price are not sufficiently strong under the collusive rule of this section, at least when bargaining is over a linear tariff. Thus the welfare results are standard. Analytical results for consumer surplus are difficult to obtain, but numerical results suggest that $CS^{*COLL} < CS^{*COURNOT}$. Moreover, it is easy to check that for any given w, downstream profit is higher under collusion than under Cournot-Nash behaviour by downstream firms; since w is lower under collusion than in the Cournot-Nash equilibrium and downstream profit increases as w falls, it follows that $\Pi^{*COLL} - \Pi^{*COURNOT} > 0$. Finally, numerical results suggest that $(CS^{*COLL} + \Pi^{*COLL}) < (CS^{*COURNOT} + \Pi^{*COURNOT})$. For the special case where $\gamma = ½$, we also have $W^{*COLL} < W^{*COURNOT}$.

I now examine the second possible scenario for stage 1 of the game, i.e. the case of bargaining over a two-part tariff. When there is collusion between downstream firms, and for the general case where $\varphi \in (0,1)$ (but setting $\gamma = ½$), the first-order conditions for the choice of w_i and F_i are given by equations (17) and (18), where $\hat{x}_i$ and $\hat{p}_i$ are now given, respectively, by x_i^{COLL} and p_i^{COLL} under downstream collusion and by $x_i^{COURNOT}$ and $p_i^{COURNOT}$ under downstream Cournot-Nash behaviour. As in section 3, the equilibrium w is independent of φ. Solving for the (symmetric) equilibrium, we obtain, under collusion:

$$w^{**COLL} = w_0 - \frac{2\sigma(\alpha - w_0)}{8 - \sigma} \tag{42}$$

$$F^{**COLL} = \frac{(8+\sigma)(8\varphi + 4\sigma - 3\varphi\sigma)(\alpha - w_0)^2}{4\beta(2+\sigma)(8-\sigma)^2}\ , \tag{43}$$

and, under Cournot-Nash behaviour:

$$w^{**COURNOT} = w_0 - \frac{\sigma^2(a - w_0)}{16 + 4\sigma - \sigma^2} \tag{44}$$

$$F^{**COURNOT} = \frac{4(\alpha - w_0)^2\left[8\varphi + \sigma^2(1-\varphi)\right]}{\beta(16 + 4\sigma - \sigma^2)^2}\ . \tag{45}$$

It is easy to check that

$$w^{**COLL} - w^{**COURNOT} = \frac{-\sigma(32 - \sigma^2)(a - w_0)}{(8-\sigma)(16 + 4\sigma - \sigma^2)} < 0 \tag{46}$$

$$F^{**COLL} - F^{**COURNOT} = \frac{\sigma(\alpha - w_0)^2}{\beta(2+\sigma)(8-\sigma)^2(16+4\sigma-\sigma^2)^2} \times$$
$$\left[8192 + 3072\sigma - 256(2+\varphi)\sigma^2 - 16(6-\varphi)\sigma^3 - 8(2-3\varphi)\sigma^4 + (4-3\varphi)\sigma^5\right] > 0 \tag{47}$$

for all $\sigma \in (0,2)$ and $\varphi \in [0,1]$. Hence:

Proposition 9. *When downstream and upstream firms bargain over two-part tariffs, the unit input price is lower and the fixed fee higher under collusion than under Cournot-Nash behaviour by downstream firms.*

The intuition for Proposition 9 is similar to that already discussed for Proposition 6. The welfare effects of collusion between downstream firms are as follows:

Proposition 10. *When downstream and upstream firms bargain over two-part tariffs and $\varphi \in (0,1)$, consumer surplus, the aggregate downstream profit, the aggregate profit of the upstream firms and total welfare are higher under collusion than under Cournot-Nash behaviour by downstream firms.*

Proof. From equations (24), (25), (26), (27), (42), (43), (44) and (45) we obtain:

$$CS^{**COLL} = \frac{(8+\sigma)^2(\alpha - w_0)^2}{4\beta(2+\sigma)(8-\sigma)^2} \tag{48}$$

$$CS^{**COURNOT} = \frac{16(2+\sigma)(\alpha - w_0)^2}{\beta(16+4\sigma-\sigma^2)^2} \tag{49}$$

$$\Pi^{**COLL} = \frac{(1-\varphi)(64-16\sigma-3\sigma^2)(\alpha - w_0)^2}{2\beta(2+\sigma)(8-\sigma)^2} \tag{50}$$

$$\Pi^{**COURNOT} = \frac{8(1-\varphi)(8-\sigma^2)(\alpha - w_0)^2}{\beta(16+4\sigma-\sigma^2)^2} \tag{51}$$

$$U^{**COLL} = \frac{\varphi(64-16\sigma-3\sigma^2)(\alpha - w_0)^2}{2\beta(2+\sigma)(8-\sigma)^2} \tag{52}$$

$$U^{**COURNOT} = \frac{8\varphi(8-\sigma^2)(\alpha - w_0)^2}{\beta(16+4\sigma-\sigma^2)^2}. \tag{53}$$

Hence:

$$CS^{**COLL} - CS^{**COURNOT} = \frac{\sigma^2(1024+128\sigma-144\sigma^2+8\sigma^3+\sigma^4)(\alpha-w_0)^2}{\beta(2+\sigma)(8-\sigma)^2(16+4\sigma-\sigma^2)^2} > 0 \tag{54}$$

$$\Pi^{**COLL} - \Pi^{**COURNOT} = \frac{\sigma^3(1-\varphi)(256-16\sigma-24\sigma^2+3\sigma^3)(\alpha-w_0)^2}{2\beta(2+\sigma)(8-\sigma)^2(16+4\sigma-\sigma^2)^2} > 0 \tag{55}$$

$$U^{**COLL} - U^{**COURNOT} = \frac{\sigma^3\varphi(256-16\sigma-24\sigma^2+3\sigma^3)(\alpha-w_0)^2}{2\beta(2+\sigma)(8-\sigma)^2(16+4\sigma-\sigma^2)^2} > 0 \tag{56}$$

and therefore also $W^{*COLL} > W^{*COURNOT}$ for all $\sigma \in (0,2)$ and $\varphi \in (0,1)$. □

Note that when $\varphi = 1$, Π^{**} is always equal to zero and all the other results are the same as above. When $\varphi = 0$, U^{**} is always equal to zero and all the other results are the same as above.

In summary, when downstream firms bargain with upstream firms over two-part tariffs before competing in quantities in the downstream market, and collusion takes the form assumed in this section, collusion in the downstream market increases consumer surplus, downstream and upstream profit, and total welfare. Intuitively, the introduction of a fixed fee implies that each bargaining unit can be more efficient in its choice of a unit input price. In particular, the equilibrium unit input price is lower than it would have been in the absence of the fixed fee. Thus the indirect positive effect of collusion on consumer surplus working through the change in the unit input price is stronger when bargaining is over a two-part tariff than when it is over a linear tariff. Since this indirect effect is the reason why collusion between downstream firms may cause consumer surplus to rise in a bargaining framework, consumer surplus increases with collusion when bargaining is over a two-part tariff even though it decreases with collusion when bargaining is over a linear tariff.

6. Concluding remarks.

I have analysed the welfare effects of collusion between downstream firms when there is bargaining between downstream firms and upstream agents (firms or unions). I have examined both the case of bargaining over a linear tariff and the case of bargaining over a two-part tariff. A key result in this context, which seems to be quite general, is that collusion will be associated with a lower bargained input price whenever the collusive rule is such that inefficient firms do not obtain a high fraction of the collusive profits. On the other hand, collusion will be associated with a higher input price if inefficient firms gain too much from collusion relative to efficient firms. In the latter case, the welfare results of collusion are standard. But in the former case, that is, when collusion results in a lower input price, collusion may well have unexpected welfare implications, such as an increase in consumer surplus and total welfare. The reason is that the negative effect of collusion on the input price generates an indirect positive effect of collusion on consumer surplus that may offset the standard direct negative effect of collusion on consumer surplus. In fact, I have shown that this is the case under two different collusive rules.

I have not analysed in this paper the case where not only the input price but also the level of output (or employment) is determined through bargaining. This is a plausible alternative to the present model when the upstream agents are unions, especially since there is some empirical evidence of “efficient” bargaining between firms and unions. Bargaining over both input prices and output levels is a general form of non-linear pricing, so it might be relevant also for markets where downstream firms obtain their inputs from upstream suppliers under general non-linear contracts. However, it is clear that the input price cannot be lower under collusion than at the Cournot-Nash equilibrium in this case. When the input price and the level of output are set simultaneously rather than sequentially, the choice of input price is not complicated by strategic considerations, so the mechanism I described in this paper to provide intuition for Proposition 1 (and other results) is no longer relevant. Instead, w is now higher the higher the degree of collusion simply because there are then more rents to be shared between upstream agents and downstream firms for any given level of w. Furthermore, output is lower under collusion for essentially the same reason as in the standard oligopoly model without bargaining, namely because the colluding bargaining units boost joint profits by restricting output for any given level of w. These effects imply that the effect on consumer surplus and overall welfare will be similar to the standard welfare results of oligopoly theory.

An important assumption of the model is that a downstream firm and its upstream agent are already locked into bilateral relations when they bargain over the input price (and possibly the level of output). This assumption is fairly uncontroversial when the upstream agents are unions (see the discussion in Horn and Wolinsky 1988). One way to justify this assumption when the upstream agents are firms would be to assume that, prior to reaching an agreement on price (and possibly output), the two parties have already made some relation-specific investments that prevent them from breaking up. It is not unreasonable to assume that these investments might represent long-run decisions, while decisions about the bargained input price or the level of output would be easier to reverse in the short to medium term. If so, the structure of the game analysed in the present paper would be valid whatever the identity of the upstream agent.

Although some of the specific welfare results of the present model may be due to its particular structure and the functional forms and collusive rules used, many of the economic mechanisms than underlie these results are far more general. For instance, the fact that the bargained input price is lower under collusion than at the Cournot-Nash equilibrium is central to the welfare results of the paper, but it is not specific to the linear demand system or even to the presence of bargaining. Thus a lower input price under collusion may also obtain when downstream firms are facing an upward-sloping supply curve for their input under conditions of perfect competition in the input market. Collusion between downstream firms would then imply that a lower level of output is produced, thus reducing the demand for inputs and resulting in a lower input price at equilibrium. Within a bargaining framework, Dowrick (1989) has argued out that the effect of collusion on wages is ambiguous because of two different and opposing effects: on the one hand, collusion increases profit margins and hence the ability of unions to push for higher wages; on the other hand, collusion reduces output and increases competition between unions for shares in employment, and this tends to push wages down.

Clearly, then, there are a number of mechanisms that could lead to input prices being lower under collusion relative to the absence of collusion. Unfortunately, there is very little empirical evidence on the effect of collusion on wages or other input prices. Symeonidis (2003) examines the impact of cartel policy on wages (and productivity) using a panel data set of UK manufacturing industries over 1954-1973. The introduction of cartel laws in the UK in the late 1950s caused an intensification of price competition in previously cartelised manufacturing industries, but it did not affect those industries which were not cartelised. The econometric results from a comparison of the two groups of industries provide no evidence of any effect of collusion on wages of manual or non-manual workers across industries. These results are certainly consistent with the view that collusion may increase wages in some industries and reduce them in others. And to the extent that collusion is associated with a lower input price, its welfare implications are potentially ambiguous. In particular, when collusion causes a significant reduction in input prices, it is likely to be beneficial for consumers and for society as a whole.

This paper has examined conditions under which standard welfare results in oligopoly theory can be reversed. It thus extends the recent “revisionist” literature that questions the traditional view that collusion between firms is unambiguously detrimental for welfare.

APPENDIX

Proof of Proposition 2. From equations (8), (11) and (14) we obtain

$$CS^*\Big|_{\lambda=0} = \frac{16(2+\sigma)[1-\varphi(1-\gamma)]^2(\alpha-w_0)^2}{\beta(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2} \tag{A1}$$

$$CS^*\Big|_{\lambda=1} = \frac{[4-\sigma(1-\varphi)-4\varphi(1-\gamma)]^2(\alpha-w_0)^2}{4\beta(2+\sigma)[4-\sigma-\sigma\varphi(1-2\gamma)]^2} \tag{A2}$$

and

$$\Delta CS^* = CS^*\Big|_{\lambda=0} - CS^*\Big|_{\lambda=1} = \frac{G(\alpha-w_0)^2}{4\beta(2+\sigma)(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2[4-\sigma-\sigma\varphi(1-2\gamma)]^2}, \tag{A3}$$

where

$$G = 64(2+\sigma)^2[1-\varphi(1-\gamma)]^2[4-\sigma-\sigma\varphi(1-2\gamma)]^2$$
$$-(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2[4-\sigma(1-\varphi)-4\varphi(1-\gamma)]^2.$$

The sign of ΔCS^* can be positive or negative depending on the values of σ, φ and γ. It is easy to check that $\Delta CS^*(\sigma = 2, \varphi = 0) = \Delta CS^*(\sigma = 2, \gamma = 1) = 7(\alpha-w_0)^2/144\beta > 0$. By continuity, whenever $\sigma \to 2$ and either φ is close or equal to 0 or γ is close or equal to 1 (or both), we have $\Delta CS^* > 0$. Moreover, for $\sigma = 2$, $\partial\Delta CS^*/\partial\varphi = \dfrac{-8[1-\varphi(1-\gamma)](1-\gamma)(a-w_0)^2}{9\beta[2-\varphi(1-\gamma)]^3} < 0$ for all $\varphi\in[0,1]$, $\gamma\in[0,1)$, and $\partial\Delta CS^*/\partial\gamma = \dfrac{8\varphi[1-\varphi(1-\gamma)](a-w_0)^2}{9\beta[2-\varphi(1-\gamma)]^3} > 0$ for all $\varphi\in(0,1]$, $\gamma\in[0,1]$. It follows that for $\sigma = 2$, as φ rises and γ falls starting from ($\varphi = 0$, $\gamma = 1$), ΔCS^* decreases. To complete the proof we only need to show that ΔCS^* is negative when $\sigma \to 2$, $\varphi \to 1$, $\gamma = 0$, or $\sigma \to 2$, $\varphi = 1$, $\gamma \to 0$ (recall that we rule out the case $\varphi = 1$, $\gamma = 0$). This is straightforward to check. For instance, $\Delta CS^*(\sigma = 2, \varphi = 1, \gamma = 0.1) = \Delta CS^*(\sigma = 2, \varphi = 0.9, \gamma = 0) < 0$, so by continuity $\Delta CS^* < 0$ when $\sigma \to 2$, $\varphi \to 1$, $\gamma = 0$, or $\sigma \to 2$, $\varphi = 1$, $\gamma \to 0$. □

Proof of Proposition 3. The total effect of a change in λ on downstream profit is given by $\dfrac{d\Pi}{d\lambda} = \dfrac{\partial\Pi}{\partial\lambda} + \dfrac{\partial\Pi}{\partial w^*}\dfrac{\partial w^*}{\partial\lambda}$. It is easy to check that $\dfrac{\partial\Pi}{\partial\lambda} > 0$ for $\lambda\in[0,1)$, $\dfrac{\partial\Pi}{\partial w^*} <$

0, and we also know that $\frac{\partial w^*}{\partial \lambda} < 0$ for $\varphi \in (0,1]$, $\gamma \in [0,1)$. Hence $\frac{d\Pi}{d\lambda} > 0$ for $\lambda \in [0,1)$.

(When $\lambda = 1$ and either $\varphi = 0$ or $\gamma = 1$, $\frac{d\Pi}{d\lambda} = 0$.) □

Proof of Proposition 4. From equations (8), (11), (12) and (14), we obtain

$$\left.(CS^* + \Pi^*)\right|_{\lambda=0} = \frac{16(6+\sigma)[1-\varphi(1-\gamma)]^2(\alpha - w_0)^2}{\beta(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2} \tag{A4}$$

$$\left.(CS^* + \Pi^*)\right|_{\lambda=1} = \frac{3[4-\sigma(1-\varphi)-4\varphi(1-\gamma)]^2(\alpha - w_0)^2}{4\beta(2+\sigma)[4-\sigma-\sigma\varphi(1-2\gamma)]^2} \tag{A5}$$

and

$$\begin{aligned}\Delta(CS^* + \Pi^*) &= \left.(CS^* + \Pi^*)\right|_{\lambda=0} - \left.(CS^* + \Pi^*)\right|_{\lambda=1} \\ &= \frac{J(\alpha - w_0)^2}{4\beta(2+\sigma)(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2[4-\sigma-\sigma\varphi(1-2\gamma)]^2},\end{aligned} \tag{A6}$$

where

$$\begin{aligned}J = {} & 64(2+\sigma)(6+\sigma)[1-\varphi(1-\gamma)]^2[4-\sigma-\sigma\varphi(1-2\gamma)]^2 \\ & -3(4+\sigma)^2[4-\sigma\varphi(1-\gamma)]^2[4-\sigma(1-\varphi)-4\varphi(1-\gamma)]^2.\end{aligned}$$

The sign of $\Delta(CS^* + \Pi^*)$ can be positive or negative depending on the values of σ, φ and γ. It is easy to check that $\Delta(CS^* + \Pi^*)(\sigma = 2, \varphi = 0) = \Delta(CS^* + \Pi^*)(\sigma = 2, \gamma = 1) = 5(\alpha - w_0)^2/144\beta > 0$. By continuity, whenever $\sigma \to 2$ and either φ is close or equal to 0 or γ is close or equal to 1 (or both), we have $\Delta(CS^* + \Pi^*) > 0$. Moreover, for $\sigma = 2$, $\partial\Delta(CS^* + \Pi^*)/\partial\varphi = \frac{-16[1-\varphi(1-\gamma)](1-\gamma)(a-w_0)^2}{9\beta[2-\varphi(1-\gamma)]^3} < 0$ for all $\varphi \in [0,1]$, $\gamma \in [0,1)$, $\partial\Delta(CS^* + \Pi^*)/\partial\gamma = \frac{16[1-\varphi(1-\gamma)](a-w_0)^2}{9\beta[2-\varphi(1-\gamma)]^3} > 0$ for all $\varphi \in (0,1]$, $\gamma \in [0,1]$. It follows that for $\sigma = 2$, as φ rises and γ falls starting from $(\varphi = 0, \gamma = 1)$, $\Delta(CS^* + \Pi^*)$ decreases. To complete the proof we only need to show that $\Delta(CS^* + \Pi^*)$ is negative when $\sigma \to 2$, $\varphi \to 1$, $\gamma = 0$, or $\sigma \to 2$, $\varphi = 1$, $\gamma \to 0$. This is straightforward to check:

$\Delta(CS^* + \Pi^*)(\sigma = 2,\ \varphi = 1,\ \gamma = 0.1) = \Delta(CS^* + \Pi^*)(\sigma = 2,\ \varphi = 0.9,\ \gamma = 0) < 0$, so by continuity $\Delta(CS^* + \Pi^*) < 0$ when $\sigma \to 2$, $\varphi \to 1$, $\gamma = 0$, or $\sigma \to 2$, $\varphi = 1$, $\gamma \to 0$. □

Proof of Proposition 5. Rearranging the expression in (15), we obtain:

$$\frac{\partial U^*}{\partial \lambda} = 4(w^* - w_0)^{2(1-\gamma)-1}(x^*)^{2\gamma-1}\left\{\gamma(w^* - w_0)\frac{\partial x^*}{\partial \lambda} + \left[(1-\gamma)x^* + \gamma(w^* - w_0)\frac{\partial x^*}{\partial w^*}\right]\frac{\partial w^*}{\partial \lambda}\right\}. \quad \text{(A7)}$$

Since $\dfrac{\partial x^*}{\partial \lambda} < 0$ and $\dfrac{\partial w^*}{\partial \lambda} < 0$ for all $\varphi \in (0,1]$, $\gamma \in [0,1)$, we only need to show that the term in brackets is positive in order to prove that $\partial U^*/\partial \lambda < 0$. Let H denote that term. Using (8) and (14) we obtain

$$H = \frac{(1-\gamma)L(\alpha - w_0)}{\beta[4 + \sigma(1+\lambda)]K}, \quad \text{(A8)}$$

where $K > 0$ is given by equation (9) and

$$L = (1-\varphi)\{16 + \lambda\sigma[4 - \sigma(1+\lambda)]\} + 2\varphi\gamma\sigma(1+\lambda)(2+\sigma\lambda) > 0. \quad \text{(A9)}$$

Hence H is positive for all $\sigma \in (0,2)$, $\lambda \in [0,1]$, $\varphi \in (0,1]$, and $\gamma \in [0,1)$. When $\varphi = 0$ or $\gamma = 1$, equation (8) gives $w = w_o$, and hence $U^* = 0$. □

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