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Make-or-Buy Decisions with Coalition Formation

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Make-or-Buy Decisions with Coalition Formation*

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Abstract

This paper examines not only an entrant's decision, but also the incumbent's decision, on which size network facility is made by forming a coalition when faced with a given input price. We formally model coalition formation and examine the effect of input prices on the firm's make-or-buy decisions through the equilibrium coalition-formation structure. We then show the possibility for inefficient coalition formation, even though entrants make efficient make-or-buy decisions, irrespective of its level.

Keywords: Coalition; input price; make-or-buy decision

JEL classification: L13, L22, L43, L90.

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1 Introduction

An important decision for new suppliers (entrants) in network industries, such as telecommunications, natural gas and electricity, is whether to buy (or lease) key elements of an incumbent's network, or to start their own networks from scratch. Needless to say, input prices (or access charges) are a key factor for the new supplier's decision on whether to buy or make. In fact, regulatory authorities have been very concerned with how to determine input prices, or access charges, in order to induce effective competition through appropriate investment incentives in network infrastructure. Controversy concerning forward-looking rules as investment incentives for technological progress in the telecommunications industry is already well-remembered.[1]

In this respect, Sappington (2004) provides a remarkable result. He demonstrates that input prices need not reflect the cost of an efficient incumbent supplier in order to induce efficient make-or-buy decisions when there are strategic downstream considerations. The reasoning is as follows. When an entrant buys an incumbent's key element, the incumbent acts in the production stage as if its unit production cost includes the input price. This is because, roughly speaking, an increase in its production reduces the profit generated from access, which means that the input price is the opportunity cost of an increase in its output. Anticipating this, and comparing the strength of its position in the production stage between two regimes ("make" and "buy"), the entrant's decision becomes one that, when its production cost is lower than that of the incumbent, makes a key element by itself and vice versa; that is, it is an efficient decision from the social point of view.

However, we should note that the level of input price is crucial not only for an entrant's decision on whether to buy or make, but also for an incumbent supplier's

[1] See Sidak and Spulber (1997), Laffont and Tirole (2000), Noam (2002), de Bijl and Peitz (2002) for the controversy concerning the forward-looking rule.

decision on which size network is to be built in the beginning. This is especially so when a new infrastructure is required in a developing region, such as the construction of gas pipelines or a new local fiber-optic network in a rural area. In fact, we have already observed some coalitions in the construction of network facilities or in R&D activity in network industries. For example, in Japan a gas pipeline from Fuji to Gotenba in Shizuoka prefecture involved cooperation between three companies (i.e., Tokyo Gas Co. Ltd., Shizuoka Gas Co. Ltd., and Teikoku Petroleum Co. Ltd.). See also InfoCom Research, Inc. (2004) for cooperative telecommunication investment in the construction of local fiber-optic cabling.

In this paper, we provide an inefficient equilibrium generated according to the level of an input price, when not only entrants, but also the incumbent, are allowed to construct a network facility by forming a coalition. That is, compared to Sappington's (2004) result, we show that the level of an input price *does* matter, even though entrants make an efficient make-or-buy decision, irrespective of level. This is because it affects an incumbent supplier's incentive to form a coalition.

There is already an extensive literature concerning the so-called "make-or-buy" decision.[2] This paper contributes to the literature as follows. When faced with an input price, many earlier studies of make-or-buy decisions focused only on entrants' decisions. By contrast, we examine not only entrants' decisions, but also an incumbent's decision on which size of network facility should be made by forming a coalition formation, when faced with a given input price. In particular, we formally model the process of coalition formation and examine the effect of input prices on all of the firms' make-or-buy decisions with an equilibrium coalition-formation structure. In other words, we deal with the effect of input prices on both make-or-buy decisions and coalition formation structure, *endogenously* and *simultaneously.*

[2]The transaction cost approach to the vertical boundaries of the firm broadly deals with this issue. See Chapter 3 of Besanko, Dranove, Shanley, and Schaefer (2004) for an introductory exposition.

Allowing a coalition formation procedure, we then show the possibility for inefficient coalition formation when the input price at which a firm can buy is below the unit production cost it incurs when making the input itself. The result suggests an additional drawback of the forward-looking rule proposed in regulatory policy debates, because the rule usually requires that the access price is lower than current production cost because of prospective technological progress.

The remainder of the paper is structured as follows. Section 2 introduces the setup of a triopoly model with coalition formation. Section 3 derives the coalition formation equilibrium of the model. Some concluding remarks are made in Section 4.

2 The Model

The model we examine in this paper is based on Bloch (1995). For the purpose of analytical tractability, we consider the simplest market structure that allows for a coalition and access to a network facility, i.e., a *triopolistic* market where 3 firms produce a homogeneous good.

The inverse demand function is assumed to be linear, and is given by

$$P = \alpha - Q$$

where P denotes the market price, the constant $\alpha > 0$, and $Q \equiv \sum_{i=1}^{3} q_i$ where q_i is firm i's output.

The three firms have linear cost functions, with firm i's marginal cost being c_i. Let us assume that all firms can decrease their production cost by forming a coalition. While examples of this type of coalition include cooperation in R&D activities and a common standard a group of firms adopt, the cooperative construction of a network facility may be the most relevant example in network industries. In fact, and as discussed in Section 1, some coalitions for the construction of network facilities are already found in the Japanese gas industry. Specifically, we assume $c_i \equiv \lambda - \mu d(i)$ where $\lambda, \mu > 0$ and $d(i)$ is the size (i.e., the number of firms) of a coalition to which firm i belongs. That is, the larger the size of an association, the lower the marginal cost.

Suppose an access charge w is announced by a regulator, so that it is taken as given by firms.[3] Representing an output of firm j that accesses a firm i's network by q_{ji} when firm i constructs a network facility with a coalition of size $d(i)$, firm i's profit is

$$\pi_i = (\alpha - Q - (\lambda - \mu d(i)))\, q_i + [w - (\lambda - \mu d(i))] \frac{1}{d(i)} \sum q_{ji}, \tag{1}$$

where the second term is zero if there is no access to that network. From (1) it is apparent that the effect of access to a coalition differs from participation in a coalition, in the sense that access does not contribute to the reduction of production cost for the coalition members, but to an increase in their profits from the payment of the access charge.

When firm i accesses firm j's network, the profit is

$$\pi_i = (\alpha - Q - w)\, q_{ij}. \tag{2}$$

We consider a two-stage game. In the first stage, given a level of access charge w, each firm decides whether it constructs a network facility within a coalition, or accesses a network that has already been constructed. In the second stage, each firm determines output and participates in Cournot competition.

In the coalition stage, following Bloch (1996) and Brown and Chiang (2003),

[3] We do not discuss how to determine the level of access charge in detail. Only the exogeneity of the access charge from the firms' standpoint is essential for the derivation of our results.

we analyze a sequential game of coalition formation that is considered to reflect cooperative agreements in many real business environments. In the sequential game, one of the firms is chosen as the initiator and proposes the formation of a coalition.[4] Each prospective member of the coalition responds in turn to this offer. If all firms in the coalition accept the offer, the coalition is formed and the procedure is repeated among the remaining firms. If one of the prospective members rejects the offer, it becomes the initiator in the next round. An important feature of the game is that once a coalition has been formed, the game is played by the remaining players, which implies a high degree of commitment in play.

When applying a sequential coalition formation game to our setting, some further assumptions are required. First, a singleton coalition, i.e., a firm's independent construction of a network facility, is allowed. Second, a firm can have access to a network facility by paying the access charge w if some network facilities already exist when it makes a decision. Finally, for the purposes of analytical tractability, we assume that if multiple coalitions of the same size already exist when a firm decides to access that size of coalition, it accesses the one first formed in time sequence.

The second assumption is an important property of network industries in reality, and is a crucial departure from Bloch's (1995) model. Note, however, that even when we make an additional choice of access, we can apply the result of Propositions 4.2 and 4.3 from Bloch (1996): any symmetric stationary perfect equilibrium coalition structure *in a symmetric game* coincides with a subgame perfect equilibrium coalition structure in a coalition-size choice game. (In the coalition-size choice game, firms announce size sequentially and the game continues until the sum of sizes reaches or exceeds the number of firms.) We apply this result in order to obtain the equilibrium of our game.

[4] We note that the ordering of the firms is exogenously determined. See Okada (1996) for an analysis of random proposers.

3 The Equilibrium

3.1 The Nash production and associated reduced profit

Given the coalition structure with access determined in the first stage, we need to find the Nash equilibrium in the production stage. Since we consider a triopolistic market, Nash production and the associated reduced profits are easily derived. Firm i's Nash production of a triopoly with a linear cost and a linear demand is generally represented by $q_i = (1/4)\left[\alpha - 3c_i + \sum_{j \neq i} c_j\right]$. Substituting the relevant production costs of firms in a coalition structure with access determined in the first stage, we obtain the Nash production in a given coalition structure with access. Table 1 shows the Nash production and the associated reduced profit for each coalition structure with or without accesses ($i = 1, 2, 3$).

[Insert Table 1 around here.]

Note that π_i^{11} is identical to π_i^{31}. This is because the marginal effect of cost reduction generated by a grand coalition (i.e., the benefit of forming a grand coalition) cancels out the marginal effect of fierce competition in the following production stage (i.e., the cost of forming a grand coalition) in our model.

3.2 Coalition formation or access?

Let us now examine a firm's decision about whether or not it forms a coalition to construct a network facility. In our model, the choice of access makes the problem complicated, since a firm needs to decide which incumbent network facility it has access to. The following lemma is useful for deriving the equilibrium coalition formation when a firm has choice of access.

Lemma 1 *Consider the last firm (i.e., Firm 3) which has only two alternatives, i.e., a 1-firm coalition and access to an incumbent network facility. The firm chooses access (a 1-firm coalition) if* $w \leq (>) \lambda - \mu$*, irrespective of the size of an incumbent network facility.*

Proof. We need to check all cases in which Firm 3 needs to make a decision. Suppose a 2-firm coalition is already constructed. If Firm 3 chooses access, its profit is

$$\pi_3^{22} = \frac{1}{16}\left[\alpha + 2(\lambda - 2\mu) - 3w\right]^2,$$

whereas its profit is

$$\pi_3^{32} = \frac{1}{16}\left[\alpha - \lambda - \mu\right]^2.$$

if it forms a 1-firm coalition.

It is apparent that $\pi_3^{22} \geq (<) \pi_3^{32}$ if and only if $w \leq (>) \lambda - \mu$. When two 1-firm coalitions already exist, Firm 3's decision is determined by comparing π_3^{53} and π_3^{61}. Similarly, when Firm 1 constructs a 1-firm coalition and Firm 2 accesses it, π_3^{42} and π_3^{52} should be compared. In all the cases, we ensure that Firm 3 prefers access to a 1-firm coalition if and only if $w \leq (>) \lambda - \mu$. ■

The result of the lemma is intuitively appealing: if the level of access charge is smaller than the unit production cost achieved under a 1-firm coalition, a firm that is allowed to form a 1-firm coalition always prefers access. As shown below, this result is useful in our sequential coalition formation game.

Following Lemma 1, we can divide the original problem into two cases according to the level of access charge. First, consider the case in which $w > \lambda - \mu$. In this case, Firm 3 chooses a 1-firm coalition whenever it has a chance to move. What about the decision of Firm 2? When Firm 2 has a chance to move (i.e., when Firm 1 offers a 1-firm coalition), it has three alternatives; a 2-firm coalition, a 1-firm coalition, and access to Firm 1's (1-firm) network facility. Lemma 1 can then be applied to Firm 2's decision: when comparing the two alternatives of a 1-firm coalition and access to Firm 1's network, it prefers a 1-firm coalition. It is also easy to ensure that given Firm 3's decision to form a 1-firm coalition, a 2-firm coalition is preferred to a 1-firm coalition by comparing π_2^{31} with π_2^{61}. Hence, Firm 2 chooses a 2-firm coalition. Then, consider Firm 1's decision. Expecting Firm 3's and Firm 2's decisions, it obtains π_1^{11} (π_1^{31}, π_1^{61}, respectively) when choosing a 3-firm coalition (a 2-firm coalition, 1-firm coalition, respectively). Comparing the three profits, we ensure that Firm 1 chooses a grand coalition or a 2-firm coalition. Therefore, the market structure of a grand coalition, or that of a 2-firm coalition with a 1-firm coalition, emerges in the case where $w > \lambda - \mu$.[5]

Next, examine the case in which $w \leq \lambda - \mu$. In this case, Firm 3 prefers access to a 1-firm coalition, irrespective of the size of the incumbent coalitions. Consider Firm 2's decision. Since Firm 3 accesses Firm 1's 1-firm coalition even when Firm 2 forms a 1-firm coalition, Firm 2 prefers access to Firm 1's network to a 1-firm coalition by applying Lemma 1. Then, Firm 2's profit when choosing access to Firm 1's network is

$$\pi_2^{42} = \frac{1}{16}\left[\alpha + (\lambda - \mu) - 2w\right]^2,$$

while the profit when choosing a 2-firm coalition is

$$\pi_2^{31} = \frac{1}{16}\left[\alpha - \lambda + 3\mu\right]^2$$

Comparing π_2^{42} with π_2^{31} gives the following result.

$$\pi_2^{42} \gtreqless \pi_2^{31} \iff w \lesseqgtr \lambda - 2\mu.$$

That is, when $\lambda - 2\mu < w \leq \lambda - \mu$, Firm 2 forms a 2-firm coalition. On the other

[5] This result is consistent with Bloch (1995).

hand, when $\lambda - 2\mu \geq w$, Firm 2 accesses Firm 1's network.

Lastly, consider Firm 1's decision when $w \leq \lambda - \mu$. When choosing a 3-firm coalition, it obtains a profit of π_1^{11}. When choosing a 2-firm coalition, its profit is π_1^{21}, since Firm 3 chooses access. When choosing a 1-firm coalition, its profit depends on Firm 2's decision, which, in turn, depends on the level of w. When $\lambda - 2\mu < w \leq \lambda - \mu$, Firm 1's profit is π_1^{32}, since Firm 2 forms a 2-firm coalition. On the other hand, when $\lambda - 2\mu \geq w$, Firm 1's profit is π_1^{41}, since Firm 2 and Firm 3 access its network facility. Accordingly, we need to examine the equilibrium for the two cases according to the level of access charge.

Consider the case where $\lambda - 2\mu < w \leq \lambda - \mu$. It is apparent that π_1^{11} is larger than π_1^{32}. Next, let us compare π_1^{11} and π_1^{21}. Note that π_1^{21} is an increasing function of w as long as $2\alpha - [5w - 3(\lambda - 2\mu)] > 0$, which is naturally assumed. As $w \to \lambda - 2\mu$, $\pi_1^{21} \to \frac{1}{16}[\alpha - \lambda + 2\mu]^2$, which is less than π_1^{11}. On the other hand, as $w \to \lambda - \mu$, $\pi_1^{21} \to \frac{1}{16}[\alpha - \lambda + 3\mu]^2 + \frac{1}{8}\mu[\alpha - \lambda - \mu]$, which is larger than π_1^{11}. Hence, there exists a unique w^* such that π_1^{11} is equal to π_1^{21}.

Next, consider where $\lambda - 2\mu \geq w$. In this case, we need to compare π_1^{11}, π_1^{21}, and π_1^{41}. Since π_1^{21} is an increasing function of w and as $w \to \lambda - 2\mu$, $\pi_1^{21} \to \frac{1}{16}[\alpha - \lambda + 2\mu]^2 (< \pi_1^{11})$, π_1^{21} is not chosen by Firm 1. At $w = \lambda - 2\mu$, $\pi_1^{41} = \frac{1}{16}[\alpha - \lambda - \mu]^2 - \frac{1}{2}\mu[\alpha - \lambda + 3\mu]$, which is less than π_1^{11}, as long as $\alpha - (\lambda - 2\mu) > 0$, which is naturally assumed. Note that

$$\frac{\partial \pi_1^{41}}{\partial w} = \frac{1}{4}[\alpha - 3(\lambda - \mu) + 2w] + \frac{1}{2}[\alpha + 3(\lambda - \mu) - 4w]. \tag{3}$$

The sign of (3) can be assumed to be positive. Hence, we can conclude that Firm 1 chooses a 3-firm coalition in the case where $\lambda - 2\mu \geq w$.

[Insert Figure 1]

Figure 1 summarizes the results derived thus far. The figure illustrates the equilibrium strategy of Firm 1 for a given level of access charge w. (In the figure, the horizontal axis represents the level of w, and the vertical axis represents Firm 1's profit associated with a coalition strategy.) According to Figure 1, the grand coalition, which is most efficient from a welfare point of view, can be achieved, except for $w \in (w^*, \ \lambda - \mu)$. In fact, for $w \in (w^*, \ \lambda - \mu)$, Firm 1 forms a 2-firm coalition, and Firm 3 accesses its network. This means that when a regulator announces an access charge that is a little less than the unit production cost for a 1-firm coalition, a firm does not have enough incentive to reduce the unit production cost. We report this result as a proposition.

Proposition 1 *When a regulator announces an access charge $w \in [0, w^*]$ or $w \geq \lambda - \mu$, a grand coalition is formed. On the other hand, when $w \in (w^*, \ \lambda - \mu)$, a 2-firm coalition with access holds.*

The intuition for this is as follows. Suppose the level of access charge is sufficiently low. All followers then prefer access to an incumbent's network to a coalition formed by themselves. What size coalition should Firm 1 propose?[6] If it offers a grand coalition, not only its own production cost, but also those of all other members of the coalition are reduced by a large amount, so that fierce competition follows in the production stage. Otherwise the prospective followers access its network. Then, and since the access charge is sufficiently low, it cannot expect positive profits generated by access. Accordingly, Firm 1, i.e., the first mover incumbent, has an incentive to form a grand coalition that involves both entrants when the access charge is sufficiently low.

On the other hand, suppose the level of the access charge is sufficiently high. All followers then prefer a coalition by themselves. In that case, the result of Proposition

[6] Note that each firm can make an offer of forming a coalition involving subsequent firms (i.e., entrants) or they can reject its offer . Again, and following the results of Propositions 4.2 and 4.3 in Bloch (1996), in the symmetric coalition formation game there exists an equilibrium for every possible coalition structure at which entrants accept the corresponding offers of incumbents.

1 in Bloch (1995) applies to our model: there exists a unique equilibrium coalition structure in which the size of the largest coalition is the integer closest to $(3n+1)/4$, where n is the number in a market. (In our model, $n = 3$.)

Suppose then that the level of access charge is in the intermediate range of $w \in (w^*, \lambda - \mu)$ in Figure 1. Note that the access charge is lower than the unit production cost under a 1-firm coalition, whereas it is higher than that under a 2-firm coalition. According to lemma 1, Firm 3 prefers access to an incumbent's network whichever size it would be. In addition, and according to the argument preceding Proposition 1, Firm 2 prefers a 2-firm coalition, which includes Firm 3, to access when $\lambda - 2\mu < w \leq \lambda - \mu$. That is, if Firm 1 proposes a 1-firm coalition, Firm 2 forms a 2-firm coalition. However, this proposal is apparently not attractive for Firm 1, because it makes the other two firms more efficient than Firm 1 itself, so that Firm 1 cannot obtain a high profit in the production stage.

Therefore, we only need to check which is better for Firm 1, forming a grand coalition or forming a 2-firm coalition. If Firm 1 proposes a grand coalition, all firms can be efficient, so that the highest equilibrium production associated with the lowest equilibrium price holds in a triopoly (i.e., a *fierce* competition). On the other hand, if Firm 1 proposes a 2-firm coalition, it obtains a positive profit generated by access (because $w > \lambda - 2\mu$ and Firm 3 accesses its network), whereas the profit generated by its own production decreases.[7] In our triopoly model, a positive profit generated by access overcomes a decrease in the profit generated by its own production. Therefore, Firm 1 prefers a 2-firm coalition to a grand coalition.

Proposition 1 implies that there exists a threshold access charge between the unit production cost under a 2-firm coalition and that under a single firm coalition, and that above this threshold, a first mover (i.e., an incumbent) has an incentive to allow the last entrant access to its 2-firm coalition. The reason is not hard to

[7] This is because, even though the equilibrium profit is higher than that in the case of a grand coalition, its own production decreases.

find. If the first mover declares a single firm coalition, the second mover prefers a 2-firm coalition that includes itself and the last mover to access the first mover's network. The first mover, however, is damaged in the production competition stage because of its higher unit production cost when compared to its rivals forming a 2-firm network coalition. On the other hand, if the first mover declares a grand coalition, not only its own output, but also that of the other firms, expands because the unit production cost of each member of a coalition is monotonically decreasing in the total number of its members in our model. This means that the market price decreases, which again damages the first mover's profit.

However, if the first mover forms a 2-firm coalition including itself and the second mover, then the last entrant produces less output than under a grand coalition, because the entrant's unit production cost, which is the access charge, is higher than the production cost under a grand coalition. Then, the total output of the triopoly is less, which implies a higher equlibrium price, than that under a grand coalition, and the first mover can additionally obtain a positive access profit. Therefore, it has an incentive to declare a 2-firm coalition.

Two additional remarks are made. First, on the surface, lemma 1 in this paper and proposition 1 of Sappington (2004) (i.e., "because of strategic downstream considerations, entrants always undertake efficient make or buy decisions, regardless of the prices at which they are authorized to buy inputs from incumbent suppliers") appear to be contradictory. This is, however, not the case, since Sappington's (2004) statement holds in *the coalition formation equilibrium in our model.* In particular, for all $w \in (w^*,\ \lambda - \mu)$, Firm 3, whose unit production cost is $\lambda - \mu$, has access to the network of Firm 1, whose unit production cost is $\lambda - 2\mu$: Firm 3 undertakes an efficient decision from a social point of view. The same intuition as Sappington's applies to our result: when Firm 3 accesses Firm 1's network, Firm 1 acts in the production stage as if its unit production cost is w. This is because when Firm 1 produces one unit in the production stage, it incurs not only the physical cost (i.e., $\lambda - 2\mu$), but also the opportunity cost (i.e., $w - (\lambda - 2\mu)$), which is the profit from selling the input to Firm 3. That is, Firm 3's decision on whether to buy or make affects the effective unit production cost of Firm 1. Anticipating this, Firm 3 makes its decision. The point is that Lemma 1 in this paper refers to an entrant's decision rule in any situation, including off-the-equilibrium. Conversely, Sappington's (2004) proposition 1 states the equilibrium result generated from an entrant's decision when downstream competition follows its decision.

Second, even though an entrant, i.e., Firm 3, always undertakes an efficient decision in the two-stage equilibrium, the equilibrium itself is not always efficient. In fact, it is easy to confirm that, for all $w \in (w^*,\ \lambda - \mu)$, the social welfare (i.e., consumer surplus plus producer surplus) in the equilibrium is $SW^* = (1/32)\left[3\alpha - 2(\lambda - 2\mu) - w\right]\left[5\alpha - 6(\lambda - 2\mu) + w\right]$, which is less than that under a grand coalition, $SW^{**} = (15/32)\left[\alpha - (\lambda - 3\mu)\right]^2$.[8] This inefficiency stems from an incumbent's incentive to form a coalition. In this sense, the price at which entrants are authorized to buy key inputs from incumbent suppliers *does* matter.

4 Concluding Remarks

This paper examines not only the entrants' decision, but also an incumbent's decision, on which size network facility is made by forming a coalition when faced with a given input price. We formally model the coalition formation procedure and examine the effect of input prices on all of the firms' make-or-buy decisions through an equilibrium coalition-formation structure. We then showed the possibility of an inefficient coalition formation, even though entrants make an efficient make-or-buy decision irrespective of level. Our results suggest an additional drawback of the forward-looking access-pricing rule whereby firms are allowed to form a coalition in

[8] Indeed, we can easily show that $\Delta SW(w) \equiv SW^{**}(w) - SW^{*}(w) > 0$ for $\forall w \in [\lambda - 2\mu, \lambda - \mu]$.

order to reduce their production cost by a joint research venture, or by constructing a common network facility.

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		Nash Production	The Reduced Profits
Case 1: a 3-firm coalition	each firm	$q_i^{11} = \frac{1}{4}[\alpha - (\lambda - 3\mu)]$	$\pi_i^{11} = \frac{1}{16}[\alpha - (\lambda - 3\mu)]^2$
Case 2: a 2-firm coalition + one firm access	a firm that forms a 2-firm coalition	$q_i^{21} = \frac{1}{4}[\alpha - 2(\lambda - 2\mu) + w]$	$\pi_i^{21} = \frac{1}{16}[\alpha - 2(\lambda - 2\mu) + w]^2 + \frac{1}{8}[w - (\lambda - 2\mu)][\alpha + 2(\lambda - 2\mu) - 3w]$
	an access firm	$q_i^{22} = \frac{1}{4}[\alpha + 2(\lambda - 2\mu) - 3w]$	$\pi_i^{22} = \frac{1}{16}[\alpha + 2(\lambda - 2\mu) - 3w]^2$
Case 3: a 2-firm coalition + a 1-firm coalition	a firm that forms a 2-firm coalition	$q_i^{31} = \frac{1}{4}[\alpha - (\lambda - 3\mu)]$	$\pi_i^{31} = \frac{1}{16}[\alpha - (\lambda - 3\mu)]^2$
	a firm that forms a 1-firm coalition	$q_i^{32} = \frac{1}{4}[\alpha - \lambda - \mu]$	$\pi_i^{32} = \frac{1}{16}[\alpha - \lambda - \mu]^2$
Case 4: a 1-firm coalition + two firms access	a firm that forms a 1-firm coalition	$q_i^{41} = \frac{1}{4}[\alpha - 3(\lambda - \mu) + 2w]$	$\pi_i^{41} = \frac{1}{16}[\alpha - 3(\lambda - \mu) + 2w]^2 + \frac{1}{2}[w - (\lambda - \mu)][\alpha + (\lambda - \mu) - 2w]$
	an access firm	$q_i^{42} = \frac{1}{4}[\alpha + (\lambda - \mu) - 2w]$	$\pi_i^{42} = \frac{1}{16}[\alpha + (\lambda - \mu) - 2w]^2$

Table 1: The Nash Production and the Associated Reduced Profits

		Nash Production	The Reduced Profits
Case 5: two 1-firm coalitions + one firm access	a firm that forms a 1-firm coalition with access of a firm	$q_i^{51} = \frac{1}{4}[\alpha - 2(\lambda - \mu) + w]$	$\pi_i^{51} = \frac{1}{16}[\alpha - 2(\lambda - \mu) + w]^2 + \frac{1}{4}[w - (\lambda - \mu)][\alpha + 2(\lambda - \mu) - 3w]$
	a firm that forms a 1-firm coalition without access of a firm	$q_i^{52} = \frac{1}{4}[\alpha - 2(\lambda - \mu) + w]$	$\pi_i^{52} = \frac{1}{16}[\alpha - 2(\lambda - \mu) + w]^2$
	an access firm	$q_i^{53} = \frac{1}{4}[\alpha + 2(\lambda - \mu) - 3w]$	$\pi_i^{53} = \frac{1}{16}[\alpha + 2(\lambda - \mu) - 3w]^2$
Case 6: three 1-firm coalitions	each firm	$q_i^{61} = \frac{1}{4}[\alpha - (\lambda - \mu)]$	$\pi_i^{61} = \frac{1}{16}[\alpha - (\lambda - \mu)]^2$

Table 1 (continued): The Nash Production and the Associated Reduced Profits

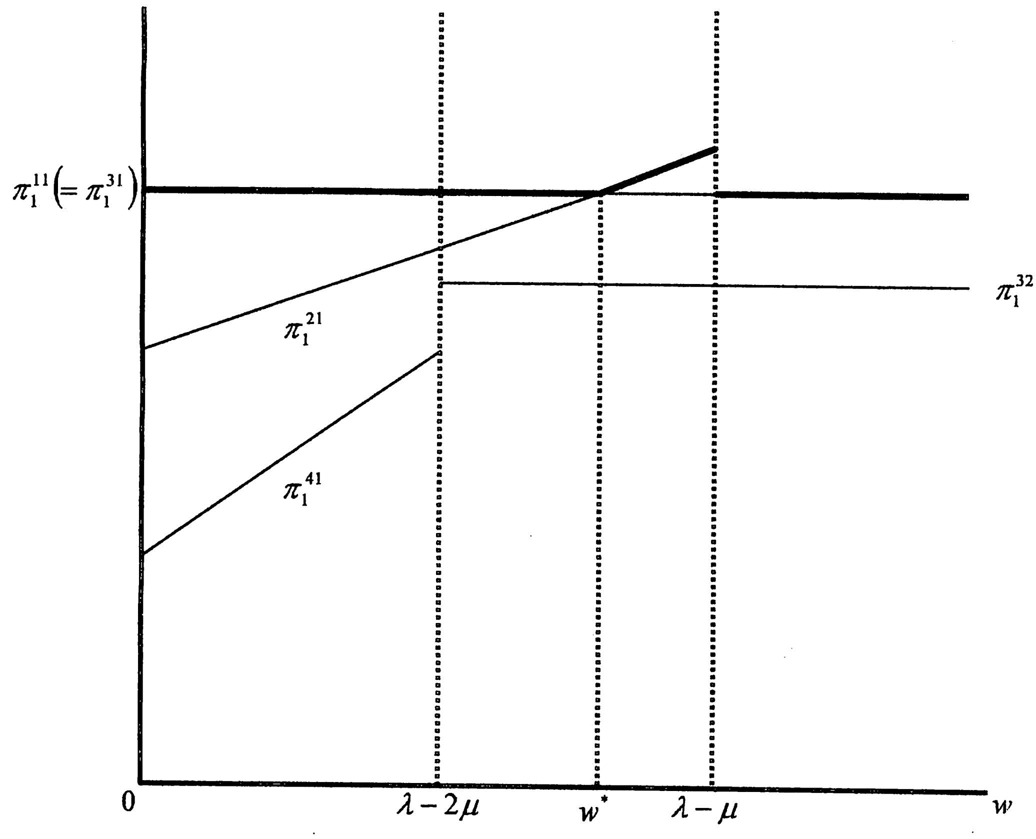

Figure 1: The Equilibrium Profit of Firm 1